The Oregon Jobs Project: A Guide to Creating Jobs in Next-Generation Manufacturing

A Letter from the American Jobs Project

It is no secret that America's middle class is in crisis; of the millions of jobs lost during the recession, most were good-paying, middle-class jobs.[1] Unfortunately, many of the jobs created during the recovery have been in low-skill, low-paying occupations.[2] It is true that the United States is unlikely to attract the traditional manufacturing jobs of the past, but our research shows that with innovative policies and a smart focus on industrial sectors, states can become global hubs of innovation and create new jobs in advanced industries that capitalize on each state's strengths.

Our analysis starts with identifying the biggest market opportunity of our era. The world has embarked on a historic energy transformation, and the growing demand for advanced energy and its enabling technology draws on "the mother of all markets" for U.S. businesses to build and sell those solutions.[3] Strategically minded businesspeople are taking advantage of this accelerating market and seeing outsized returns. In 2016, the private sector reported $1.4 trillion in global advanced energy revenues, which is equal to that of the global apparel sector and nearly twice as much as the global airline industry.[4] And jobs? At least 9.8 million people were employed in the global advanced energy sector in 2016, and the growing market could support over 14 million additional jobs by 2030.[5] The question for the United States is: Where will those new jobs be created?

START QUOTE BOX
At least 9.8 million people were employed in the global advanced energy industry in 2016, and the growing market could support 24 million jobs by 2030.[6]
END QUOTE BOX

We believe that our states are the answer to this question. If countries across the globe are seeking solutions for growing energy needs, how can U.S. businesses take advantage of this demand and build products locally that can be exported to the world? And how can we equip Americans with the skills those businesses need?

The American Jobs Project gives policymakers the tools to spur economic growth and create good-paying jobs in their states. Our analyses chart pathways designed to accelerate and expand a state's advanced energy economy. We propose innovative solutions built on extensive research and tailored to each state. These solutions are written with an eye towards streamlining bureaucracy and are seasoned with the principles of competition, local control, and fewer regulations.

The American Jobs Project empowers state and local leaders to build prosperous and equitable advanced energy economies that will transform our nation's energy future. If these recommendations are adopted, hard-working Americans will be among the first to benefit.

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About Us

The American Jobs Project

The American Jobs Project is a nonprofit, nonpartisan, think-and-do tank focused on creating good-paying jobs in advanced energy and manufacturing through bottom-up, data-driven, 360° economic development. Our experts tailor best practice strategies for bolstering advanced energy and manufacturing, identify assets across the value chain, estimate an industry's job-supporting potential, and support stakeholder-led initiatives by communicating ideas and analyses. Through engagement with a broad cross-section of stakeholders, we develop a shared vision of effective strategies to leverage the unique competitive advantages offered by each state and generate positive economic impacts.

Oregon State University, Advantage Accelerator

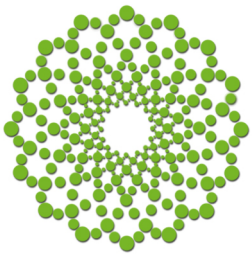
The OSU Advantage Accelerator was created in 2013 to help develop high-growth, innovative products and services by taking companies through all phases of the startup process. We assist faculty, staff, students, and the broader community in commercializing research and concepts. Our staff, mentors, and student interns work directly with innovators and entrepreneurs to explore markets, develop products, and obtain customers. We share the greater vision of Oregon State University to create a collaborative, inclusive, and caring community that strives for equity and equal opportunity in everything we do; that creates a welcoming environment and enables success for people from all walks of life; and that shares common, fundamental values grounded in justice, civility, and respect while looking to our diversity as a source of enrichment and strength.

Oregon State University
Advantage Accelerator

Lewis & Clark Law School, Green Energy Institute

The Green Energy Institute is part of Lewis & Clark Law School's Environmental, Natural Resources, and Energy Law Program. Our mission is to develop comprehensive, effective strategies to further the transition to a 100 percent renewable energy grid. Our analyses and recommendations aim to hasten the energy transition by strengthening existing policies, eliminating barriers, and promoting innovative and ambitious new strategies to support renewable energy deployment across the region.

Because a successful transition to renewable energy will require the participation of all stakeholders in the energy market, the Green Energy Institute is devoted to revealing the common interests that all energy-market stakeholders share. We believe that investing in renewables can be a win-win situation, generating jobs, profits, and environmental benefits simultaneously.



GREEN ENERGY INSTITUTE

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Executive Summary

Next-generation manufacturing is a significant economic opportunity for job growth in Oregon, having the potential to support an annual average of over 65,000 jobs through 2030. Next-generation manufacturing includes technologies, tools, and techniques built on the integration of information technology and operational machinery, enabling manufacturers to become more energy efficient through reduced waste and improved productivity. Oregon can capitalize on this opportunity by bolstering education and training, access to capital, the innovation ecosystem, value chain build-out, and local market growth.

The American Jobs Project was born of two problems: the loss of middle-income jobs and congressional paralysis in the United States. It seeks to address these problems by taking advantage of one of the biggest market opportunities of our era—the advanced energy industry—and building states' manufacturing capacity to capitalize on increasing global demand. While some economic indicators show that Oregon has made great strides towards recovery since the recession, other indicators suggest full recovery is still a long way off. In particular, middle-wage jobs, the poverty rate, and caseloads for needs-based programs are only 50 percent recovered to pre-recession levels. Efforts to foster good-paying manufacturing jobs and to strengthen talent development tailored for the needs of industry could bolster the state's economy.

Extensive research, including more than sixty interviews with stakeholders and experts in Oregon, has identified next-generation manufacturing (NGM) technology as a promising economic engine and job creator. Next-generation manufacturing is a unique opportunity for Oregon because of skyrocketing global demand, fertile cluster assets, complementary industries, and the unique expertise of its workforce.

In NGM, industrial facility equipment and manufacturing machinery are integrated with information and communications technology. Through increased visibility, responsiveness, and precise control of industrial processes, NGM technology can help manufacturers improve building efficiency, reduce waste material, and boost productivity. Two examples of NGM technology are 3D printing (additive manufacturing), which can produce parts with less input material than traditional methods, and the Industrial Internet of Things (IoT), which optimizes production through frequent and instantaneous communication among a manufacturer's production facilities, transportation system, and software networks. In addition to reduced costs and faster time to market, NGM technology can bring about substantial increases in energy efficiency up and down the supply chain. This makes NGM a major feature of the advanced energy landscape.

Next-Generation Manufacturing Technology

Networked Industrial Process Equipment

- HVAC, refrigeration, lighting, electricity management, and production and logistics
- Embedded with sensors and controls, and connected with software

Precision Manufacturing Machinery

- Computer numerical control (CNC) machines and 3D printers
- Automatically produce goods from input materials based on digital designs

Oregon is poised to become a leader in NGM technology; state and local leaders could realize this potential through strategies that both leverage Oregon's competitive advantages and strategically target areas for growth:

- **Capitalize on increasing technology demand.** Global demand for networked industrial equipment and precision manufacturing machines is exploding, with some market segments expected to grow by a factor of nine over the next seven years.
- **Leverage Oregon's culture of energy efficiency and innovation.** The state's large, active, and vocal community of energy efficiency NGOs provides expertise, connections, and other support to NGM technology manufacturers and end users.
- **Channel the innovative energy of Oregon's research organizations.** Oregon's institutions of higher education, commercial development labs, and nonprofits conduct cutting-edge research and provide commercialization support to emerging fields that accelerate NGM's development.
- **Mobilize the state's tech-savvy workers.** With high numbers of software engineers, web developers, and industrial technicians, Oregon has the fourth-highest proportion of technical workers in the nation, and a head start on building a workforce to support a growing NGM technology industry.
- **Build on complementary business capacity.** Oregon's sensors, controls, and software platform supplier capacity, already supported by fifty-three firms, can grow synergistically with the state's large and growing manufacturing industries, including semiconductors and aerospace.
- **Stand on Oregon's advanced energy and business policy commitments.** Oregon's policies, which promote energy efficiency and a business-friendly climate, ensure a willing local market for NGM technologies.
- **Support quality local jobs statewide.** With forward-thinking solutions, next-generation manufacturing could support an average of over 65,000 Oregon jobs annually through 2030.

To realize these opportunities, state and local leaders can pursue strategies that create a strong foundation for industry growth in next-generation manufacturing and help Oregon's businesses grow, innovate, and outcompete regional, national, and global competitors. In today's globalized economy, businesses are more likely to thrive in cities and states that offer a rich innovation

ecosystem, provide fertile ground for capital investment, boast a highly skilled workforce, and offer clear policy signals. With policies that facilitate deployment of NGM technology in the local Oregon market, the state can ensure its startups have access to the early customers that are critical for long-term success. With a dense local network of NGM technology suppliers, Oregon's companies can reap the benefits of increased productivity and operational efficiency that NGM offers, amplifying local job creation and economic growth. Building on this base of localized activity, Oregon's NGM enterprises can tap into markets across the country and internationally, capitalizing on surging global demand for this technology.

Taking advantage of this opportunity offers real benefits for Oregon's economy and residents. Annually through 2030, next-generation manufacturing can support an average of over 65,000 jobs. These include direct jobs from manufacturing and software development; indirect jobs from supplying equipment, materials, and services to manufacturers and developers; and induced jobs from spending in the local economy. This industry offers a diverse array of good-paying jobs that cater to different education and experience levels. Policymakers can support these jobs by seizing the opportunity presented by increasing global demand and overcoming barriers to industry growth.

Summary of Recommendations

The analysis presented in this report culminates in recommendations for Oregon's leaders based on best practices in the United States and abroad. Each recommendation identifies strategies to address barriers to industry growth, or to capitalize on untapped opportunities in the next-generation manufacturing industry. Specifically, Oregon could target challenges in each foundational building block: the innovation ecosystem, access to capital, workforce development, value chain build-out, and local market growth for next-generation manufacturing technology. While the recommendations are intended to be complementary and would be more powerful if adopted as a package, each can also be viewed as a stand-alone option.

Innovation Ecosystem

Enable Statewide Entrepreneur Resource Coordination
Lack of coordination and visibility of Oregon's many startup resources makes it difficult for entrepreneurs to access available support. To ensure emerging next-generation manufacturing firms get the help they need, Oregon could co-fund the expansion of the "Venture Catalyst" model statewide. Each Venture Catalyst could facilitate vital connections between local startups and the training, information, and funding opportunities they need to achieve market viability.

Support Product Testing Resources for Technology Commercialization
Before getting into the hands of their first customers, high-risk technologies must undergo extensive testing and validation. However, Oregon's next-generation manufacturing startups sometimes lack access to adequate testing facilities. By establishing a public access testbed supported by an innovation voucher program, the state could help its next-generation manufacturing startups make it through the "commercialization valley of death."

Foster the Commercialization Culture at Universities
While commercialization of innovations can benefit universities, Oregon lags behind other states in tech transfer. By recommending policies that nurture marketable applications of basic research, the state's Higher Education Coordinating Commission could help Oregon's institutions of higher learning improve industry relations, generate positive publicity, and discover new funding opportunities. Potential measures include recognizing patents as creative scholarship in tenure policies, establishing startup support programs, and supporting entrepreneurial leaves of absence for faculty.

Access to Capital

Increase Access to Long-Term Capital
The long commercialization period faced by some NGM technology startups creates a challenge in accessing traditional sources of capital. Because philanthropic foundations focus on the long-term impact of investments rather than immediate returns, their program- and mission-related investments can dramatically increase probability of success for next-generation manufacturing startups. By designating a specialist to facilitate foundations' investments in Oregon, the state could help unlock millions of dollars in new capital for Oregon's emerging businesses.

Create a Capital Gains Tax Exemption
Oregon's unusually high capital gains tax rate depresses the availability of in-state financing from venture capitalists and angel investors. The state could create a capital gains tax exemption for early-stage investments in companies building next-generation manufacturing technology. Establishing a minimum investment length could help ensure the exemption has a meaningful impact.

Establish Oregon's Capital Locator Tool
Simply figuring out what funding options are available and worthy of pursuit is one of the most difficult challenges facing entrepreneurs. A simple online capital locator tool, modeled on successful applications in other states, could consolidate the in-state entrepreneurial resources available by type and region, saving entrepreneurs valuable time and helping them access capital they may not have found on their own.

Workforce Development

Expand Training Programs and Opportunities for Incumbent Workers
Oregon will need to upgrade its existing workforce to meet growing demand for next-generation manufacturing technology, but the state currently invests little in incumbent worker training. To prevent a skills gap, Oregon could enact a tax credit for businesses that retrain their employees. Successful training incentives in other states offer a model for Oregon to bring its investments in existing workers up to speed.

Create an NGM Industry Council to Coordinate Workforce Training
Oregon's siloed workforce development and education systems make it difficult for employers to find needed talent, and for workers to ensure they have the skills they need to find good-paying jobs. An industry-led workforce development council could facilitate engagement between

employees and training programs. Higher levels of coordination could help the workforce stay current with rapid changes in the next-generation manufacturing industry and help employers build capacity quickly when they are ready to grow.

Increase Work-Based Opportunities for High School Students
To help improve Oregon's relatively low high school graduation rates, the state could increase state funding for work-based learning opportunities. Work-based learning program participation is highly correlated with academic success and can better prepare Oregon's youth for jobs in the next-generation manufacturing industry. By utilizing funds from Measure 98, Oregon could fund this expansion without raising new revenue.

Value Chain

Build a Comprehensive Next-Generation Manufacturing Cluster Partnership
Oregon's diverse community of NGOs relevant to next-generation manufacturing lacks a coordinated action plan for growing the next-generation manufacturing cluster. A public-private partnership could take the lead on enabling collaboration across the value chain in areas such as knowledge sharing, asset growth, policy advocacy, and cluster development. Once a cluster growth plan is in place, the partnership could formalize as a Center of Excellence and coordinate efforts across the next-generation manufacturing industry.

Reinstate and Improve the R&D Tax Credit
While Oregon let its previous R&D tax credit expire, a more narrowly-targeted credit could enable R&D efforts with long-term economic benefit. Key features could be to limit the credit's availability to companies below a certain size or offer a greater incentive for substantially large increases in R&D spending. With the right structure to prevent misuse, an R&D tax credit could help the next-generation manufacturing cluster grow.

Broadcast Oregon's Business Assets
Given its small population and its neighbor to the south, Oregon is often overlooked by business leaders around the country and the world. With increased investment in effectively marketing Oregon's business advantages, the state can bring more next-generation manufacturing firms into its value chain. A redesigned website and well-targeted digital media could get Oregon's brand in front of the small- and medium-sized business executives, which are the state's ideal recruitment targets.

Accelerate Foreign Direct Investment Efforts for Next-Generation Manufacturing
Attracting levels of foreign direct investment commensurate with Oregon's population size could be one of the most effective tools for growing the state's next-generation manufacturing value chain. Potential strategies include engaging more aggressively with existing organizations designed to help increase foreign direct investment, opening more offices overseas, and establishing a state program to help international firms establish successful operations.

Local Market

Create a Next-Generation Manufacturing Showcase Program
As peer behavior is one of the critical factors underlying technology adoption, it is difficult for next-generation manufacturing technologies to gain a foothold in industries where networked equipment and precision machinery remain a rarity. State-funded showcase programs in industries with low next-generation manufacturing penetration could validate the technology's benefits to late adopters and create competitive pressure to adopt new systems and equipment.

Allocate Funding for Embedded Energy Efficiency Experts
Busy manufacturers lack the time and personnel necessary to implement and oversee energy efficiency projects. A state-funded cohort of energy efficiency experts who can be embedded within manufacturing facilities could significantly increase the demand for energy-saving next-generation manufacturing technologies.

Enact an Energy Efficiency Property Tax Incentive
Next-generation manufacturing technologies can produce energy savings up and down the supply chain, yet energy efficiency investments are excluded by the Oregon tax code's renewable energy provisions. By exempting upgrades that increase onsite and downstream energy efficiency from property taxes, Oregon could make it more feasible for manufacturers to install next-generation manufacturing technology.

Introduction

Oregon can tap into the growing global advanced energy market to foster and support good-paying jobs for Oregonians. Through the strategic cluster-based development of the next-generation manufacturing industry, Oregon could support an average of over 65,000 direct, indirect, and induced jobs annually through 2030.

The American Jobs Project aims to spur job creation in the advanced energy industry by identifying state-level economic opportunities and crafting right-fit solutions for in-state growth. This national initiative takes advantage of the accelerating demand for advanced energy and leverages a state's competitive advantages to build robust economic clusters. The American Jobs Project believes that manufacturing is a cornerstone of the U.S. economy—providing workers with good wages and causing a multiplier effect on local revenue and employment—and resolves to support industry jobs that are resistant to offshoring and automation.[7] State and local leaders who seek to capitalize on state resources to create skilled, good-paying jobs can use this report as a foundation for action.

Extensive research and more than sixty interviews with stakeholders and experts in Oregon have identified next-generation manufacturing (NGM) technology as showing particular promise in the state. Oregon's direct access to growing markets on the West Coast and abroad, along with low electricity rates, create favorable conditions for manufacturers. Given its talented workforce, legacy manufacturing companies, and established network of relevant NGOs, Oregon is well positioned to benefit from the rising regional, national, and global demand for NGM technology. Opportunities to leverage these strengths offer real benefits for both Oregon's economy and its residents. Strategic state-level coordination and collaboration could elevate in-state companies in the marketplace and facilitate middle-income job growth. By fostering growth in the NGM industry, Oregon could reasonably support an average of over 65,000 direct, indirect, and induced manufacturing and supply chain jobs from 2018 through 2030 annually.[8]

START QUOTE BOX
By developing the next-generation manufacturing industry in the state, Oregon could support an annual average of over 65,000 jobs from 2018 through 2030.[9]
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START CALL OUT BOX
Advanced Energy Market Opportunity
Demand for advanced energy has soared in recent years and is poised for continued growth. In 2016, investment in the advanced energy sector was $287.5 billion worldwide, nearly five times that of 2004.[10] By 2040, investments are expected to total $7.4 trillion.[11] The advanced energy market is a clear opportunity for increased revenue and job growth.
END CALL OUT BOX

Oregon's Need for Good-Paying Jobs

Along with the rest of the nation, Oregon's citizens suffered significant job losses during the Great Recession.[12] While some economic indicators show that the state has made great strides, other indicators suggest full recovery is still a long way off.[13] In particular, middle-wage job numbers, the poverty rate, and caseloads for needs-based programs are only 50 percent recovered to pre-recession levels.[14] Notably, the number of people aged eighteen to thirty-four living at home is only 10 percent recovered, indicating a continued lack of good-paying job opportunities for young adults.[15]

Meanwhile, the recovery that has taken place has not been widely shared. Despite having a low state unemployment rate, Oregon is still subject to high and rising income inequality. From 2009 to 2013, 66 percent of all income growth in Oregon was captured by the top 1 percent of earners.[16] Since 2013, the income gap between top earners and those earning middle or lower wages has continued to increase.[17]

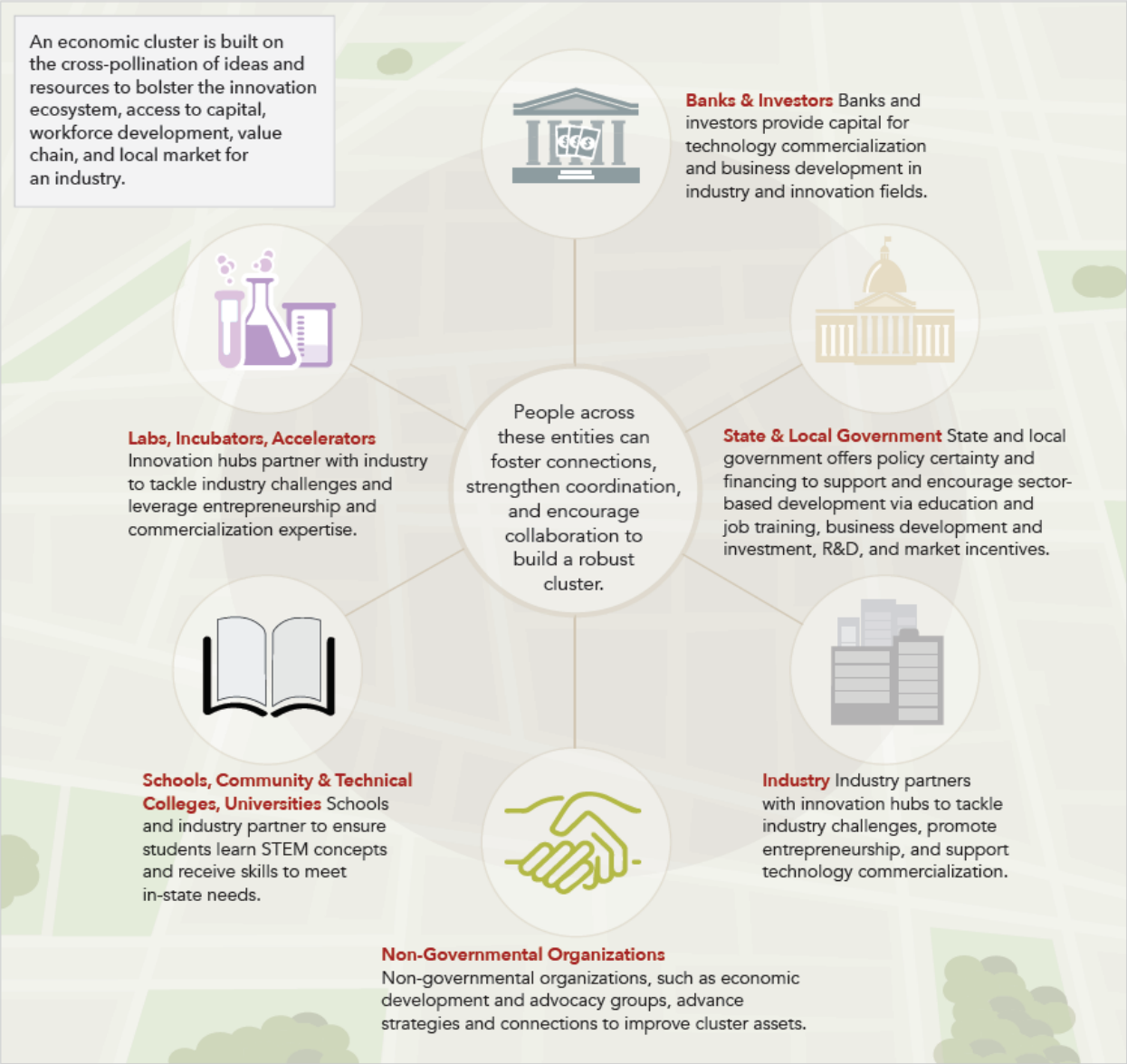
Growing Oregon's manufacturing sector can help address these challenges. Manufacturing jobs in Oregon pay an average of $36.31 per hour, making annual manufacturing salaries some of highest of any Oregon industry.[18] Because manufacturing facilitates a strong labor market with good-paying job opportunities in the local economy, groups facing severe employment barriers and low wages can benefit from the sector's growth.

These figures indicate a need for an economic development approach that continues to equip Oregonians with workforce-ready skills and improves the standard of living.

The Benefits of Cluster-Based Development

Economic clusters are regionally situated groups of interconnected companies and institutions organized around a particular industry. In today's competitive, globalized economy, businesses are more likely to thrive in cities and states that cultivate the foundational building blocks of cluster development: a rich innovation ecosystem, fertile ground for capital investment, a highly skilled workforce, and clear policy signals. Geographic proximity and repeated exchanges of information help foster an environment of coordination and cooperation among these companies and institutions, leveraging both a trained workforce and each actor's unique expertise. By having a close network of suppliers and partners, companies can reap the benefits of increased productivity and operational efficiency, amplifying local job creation and economic growth.[19]

HOW DOES AN ECONOMIC CLUSTER WORK?



Oregon's Economic Opportunity in Next-Generation Manufacturing

Next-generation manufacturing refers to technologies, tools, and techniques built on the integration of information technology and advanced operational machinery. Oregon is well positioned to capitalize on rising market demand for next-generation manufacturing technology given the state's forward-thinking business culture, established network of NGOs supporting energy efficiency and manufacturing innovation, legacy manufacturing, and highly technical workforce.

Next-generation manufacturing is a unique opportunity for Oregon because of skyrocketing global demand, fertile cluster assets, complementary industries, and the unique expertise of its workforce. Oregon is poised to become a leader in NGM technology; state and local leaders could realize this potential through strategies that both leverage Oregon's competitive advantages and strategically target areas for growth.

What Is Next-Generation Manufacturing Technology?

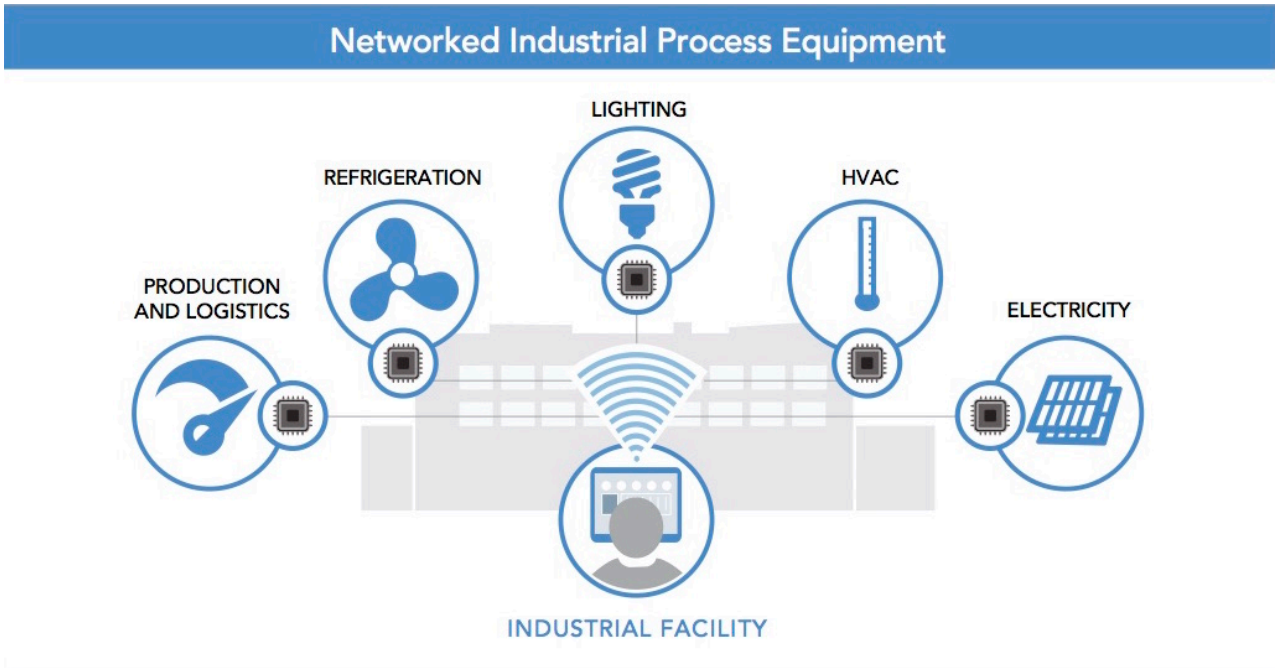
Next-generation manufacturing refers to technologies, tools, and techniques built on the integration of information technology and advanced operational machinery. Sensors, controls, software platforms, and smart production tools can help manufacturers boost productivity and reduce waste through increased visibility, responsiveness, and precise control of industrial processes. In particular, NGM technologies can significantly increase energy efficiency, both within a single facility or throughout a manufacturing supply chain.[20] The high potential for energy savings makes NGM an important component of industrial energy efficiency and a major feature of the advanced energy landscape. Two of the most common forms of NGM are networked industrial process equipment and precision manufacturing machinery.

START CALL OUT BOX
In the United States, an average of 30 percent of the energy used in commercial and industrial buildings is used inefficiently or unnecessarily.[21] Improving the energy efficiency of these facilities by just 10 percent would save a combined $40 billion annually.[22] In total, Oregon's industries can save 23 trillion Btu of energy by 2030 through energy efficiency alone.[23] NGM technology can help Oregon's manufacturers achieve these savings.
END CALL OUT BOX

Networked Industrial Process Equipment

Networked industrial process equipment is embedded with digital sensors and controls and connected with software via a wireless signal. By using networked equipment in their HVAC, lighting, refrigeration, and production systems, manufacturers can collect data on equipment usage, discover value-saving opportunities with machine learning software analysis, and adjust usage remotely in real time, reducing waste and driving productivity.[24] For example, production

machinery that can automatically power down during breaks in production can lead to energy savings of 12 percent for a vehicle body assembly line.[25]



Sensors and controls are rapidly evolving from physical, wire-based systems to wireless, internet-enabled networks that facilitate real-time data analysis. By embedding microchips in machinery, managers can monitor processes, discover opportunities for value, and adjust usage to save energy.

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Oregonian Manufacturer Saves Energy and Reduces Costs with NGM Technology

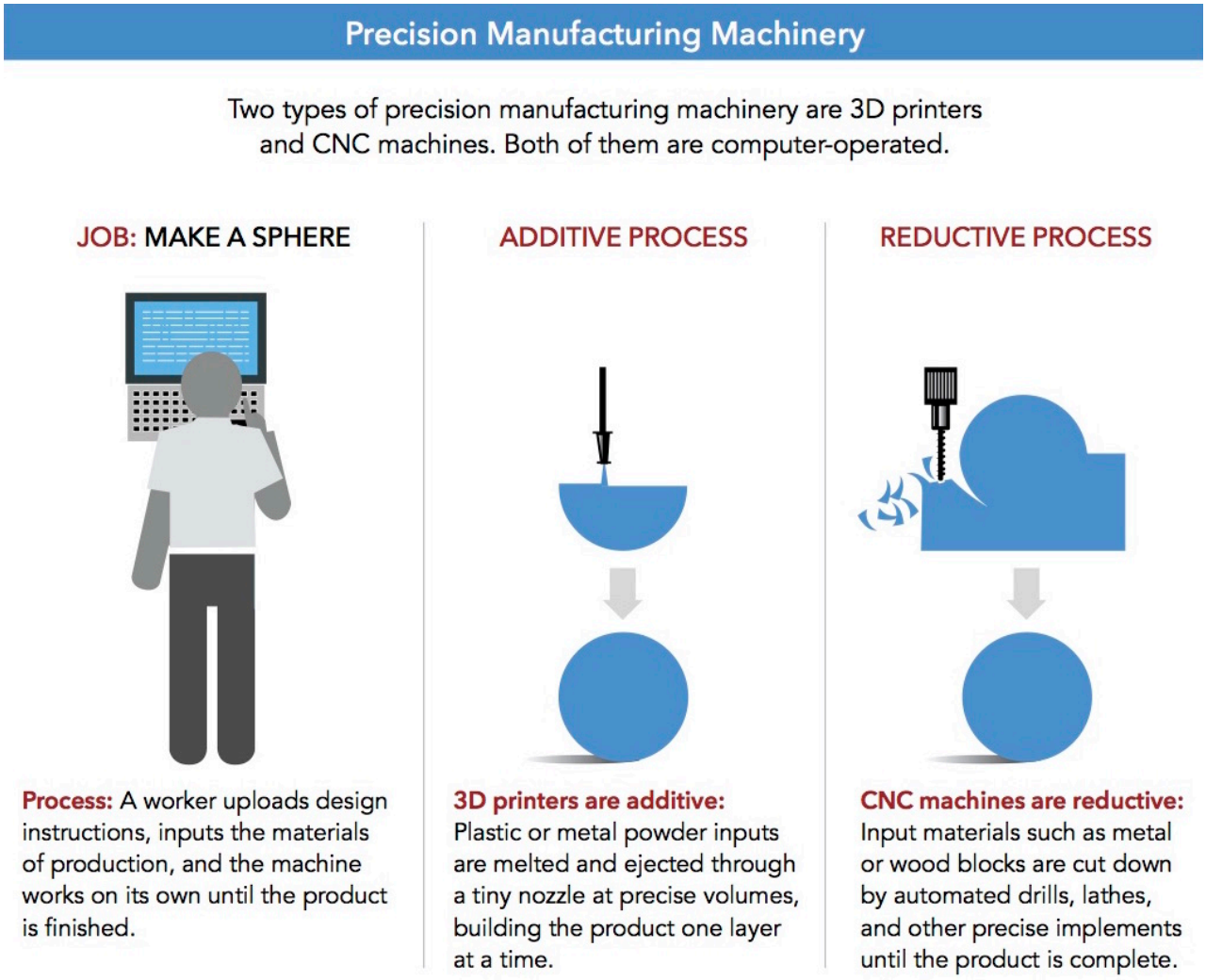
Traditional manufacturing equipment often has only two settings: on and off. Variable frequency drives are a common form of control that allow manufacturers to save energy by adjusting machine usage as conditions require.[26] In Oregon, Maxim Integrated Products, Inc. used this strategy to improve the efficiency of its integrated circuit manufacturing operations. Working with the Energy Trust of Oregon, the manufacturer replaced its air supply unit with a new system that included variable frequency drives.[27] As a result of this project and other energy efficiency measures, Maxim Integrated was able to save an estimated $253,680 annually.[28]

END CALL OUT BOX

Precision Manufacturing Machinery

Precision manufacturing machinery is another way firms can merge next generation software and hardware to make manufacturing processes more efficient. Computer numerical control (CNC) machines, which automate machine tool manufacturing processes, can boost productivity and efficiency with reduced downtime compared to legacy machining equipment.[29] Additive manufacturing, otherwise known as 3D printing, requires up to 50 percent less energy to create products than conventional manufacturing processes, while using far less input material.[30]

Oregon is uniquely positioned to lead the country in NGM technologies. With strategies that maximize Oregon's competitive advantages, policymakers could help ensure Oregon's economy grows with this ascendant industry.



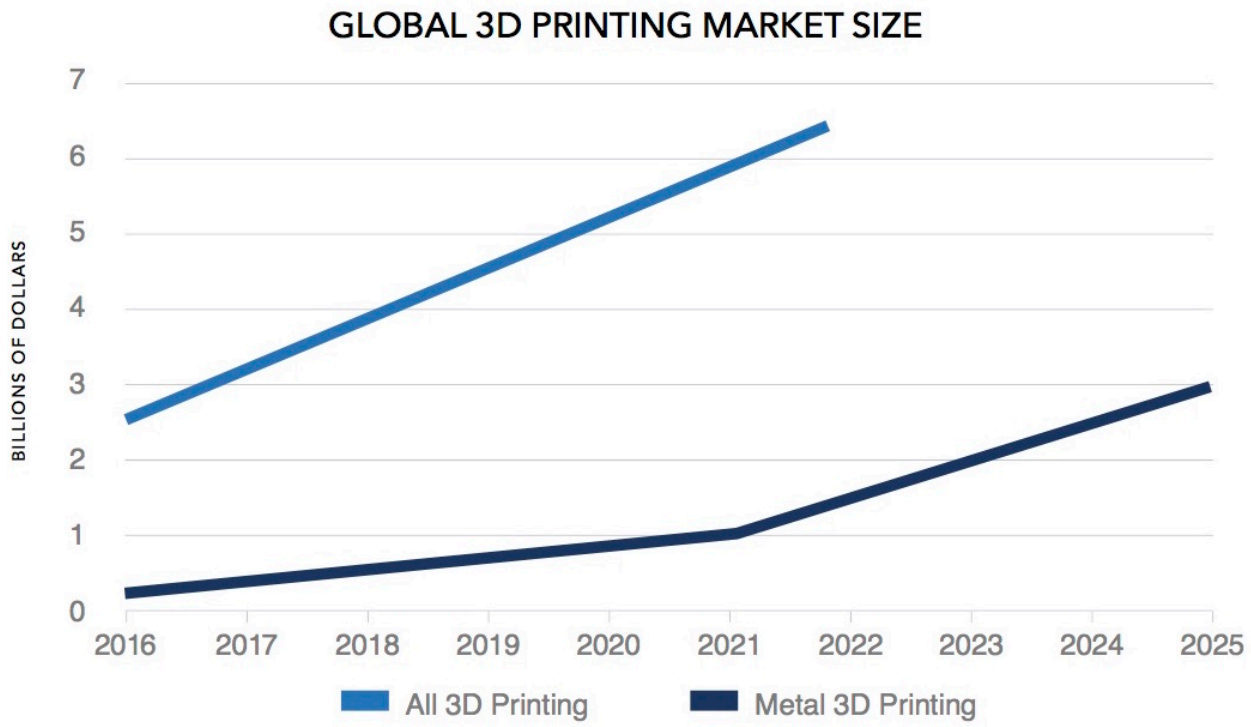
Why Next-Generation Manufacturing in Oregon?

Oregon is poised to increase economic growth and job creation by building on its strengths in the NGM industry. Oregon could capitalize on increasing national and global demand for NGM technology by cultivating its existing value chain, fueling local demand, leveraging its community of energy efficiency NGOs, building on its innovation ecosystem, and competing with a talented and tech-savvy workforce.

Increasing Technology Demand

Surging demand for networked industrial equipment and precision manufacturing machinery creates a massive export opportunity for Oregon. The global market for advanced energy sensors and controls is projected to grow 6.9 percent each year through 2022, and the market for the

Industrial Internet of Things, one of the primary applications for networked industrial equipment, is projected to be worth $933.62 billion by 2025, up from just over $100 billion in 2016.[31] Global revenues for industrial energy management systems software and services are projected to grow 11.4 percent annually through 2024.[32] The global additive manufacturing market is expected to grow by 16.2 percent annually from 2017 through 2021, reaching a total market size of $6.2 billion, while the global metal 3D printing market is expected to reach $2.86 billion by 2025.[33] While 3D printing of plastic parts has a long history, metal 3D printing is rapidly extending the range applications for this technology.[34] With an emerging value chain and a skilled workforce, Oregon is well prepared to serve growing regional, national, and global demand.



START QUOTE BOX
Surging demand for networked industrial equipment and precision manufacturing machinery creates a massive export opportunity for Oregon.
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Promising Value Chain
Oregon has an opportunity to expand its nascent value chain for NGM technologies. Led by anchor firms such as Veris Industries, Cascade Energy, Rigado, and Huntair, a total of fifty-three Oregon firms build the sensors, controls, or software that form the backbone of networked industrial process equipment.[35] Many of these firms export to out-of-state markets.[36] Further down the value chain, Oregon has a thriving industry of precision manufacturing service providers. Many firms across a variety of industries use 3D printers and CNC machines for prototyping and production.[37] Furthermore, the state has a substantial number of energy efficiency consultants and management

providers, many of whom have expertise in using NGM technologies to realize energy savings. See Appendix 2 for a sample list of Oregon companies in the NGM value chain.

START CALL OUT BOX

Next-Generation Manufacturing Bringing Jobs Back to the U.S.

Next-generation manufacturing underlies a national trend toward reshoring, or bringing manufacturing capacity back to the United States from overseas. Networked facilities often require highly trained employees. This workforce structure favors American labor, which is more skilled than in many of the most frequent destinations for outsourcing.[38] As a result, in 2015, 17 percent of U.S. manufacturing executives said they were "actively reshoring," possibly contributing to the steady increase in U.S. manufacturing employment since the Great Recession.[39] An NGM cluster in Oregon could serve the re-emerging domestic manufacturing sector.

END CALL OUT BOX

Emerging Local Market to Jump-Start Deployment

Oregon's critical industries could use NGM technologies to stay competitive while creating crucial early demand for the state's NGM startups. Semiconductor manufacturers, the state's largest industrial employer, rely on heavy HVAC usage in producing silicone wafers.[40] They can capture large savings from sensors, controls, and energy management software.[41] The aerospace and defense industry, Oregon's fastest-growing advanced manufacturing employer, can boost productivity and reduce waste by using 3D printers to build custom metal parts.[42] By networking their refrigeration, HVAC, and lighting systems, food processing firms reduce downtime, efficiently manage equipment, and save energy.[43] Oregon already has 600 metal parts suppliers that could serve as a market for the materials, printers, and other inputs in the emerging field of metal 3D printing.[44] These local industries are a ready-made market for NGM technologies, and they could provide crucial early support to startups on their way to building export-led business models.

Policy Commitments to Energy Efficiency

Oregon's utility and policy commitments to energy efficiency, as well as its business-friendly policy climate, expand the local market for NGM technologies. With programs such as the Energy Trust of Oregon's incentives, the Bonneville Power Administration's energy efficiency program, and Multnomah County's commerical property-assessed clean energy (C-PACE) program, there is funding available for many Oregon manufacturers to install energy-saving NGM technologies.[45] The state's business incentives, including the Strategic Investment Program and Enterprise Zones, facilitate manufacturing growth that could power the NGM market.[46]

Robust Community of Energy Efficiency NGOs

Oregon hosts a well-established community of nonprofits and industry associations that could facilitate the growth of a NGM cluster through their support for industrial energy efficiency.[47] For example, the Energy Trust of Oregon provides financial incentives for the installation of NGM products, and the Industrial Assessment Center at Oregon State University provide assistance to industrial firms for enhancing energy efficiency.[48] In addition, the Northwest Energy Efficiency Alliance, a coalition of over 140 utilities and energy efficiency organizations, uses its broad network to promote the adoption of energy efficiency products.[49] These, and many other organizations, form a robust ecosystem and culture of energy efficiency. They could help ensure

that growing suppliers of networked industrial equipment and precision machinery can find customers for their products.

Vibrant Innovation Ecosystem

Oregon is home to leading research institutions in NGM innovation. In Corvallis, the Advanced Technology and Manufacturing Institute (ATAMI) and HP 3D Open Materials and Applications Lab are the site of critical research into 3D printing techniques and materials.[50] The Oregon Manufacturing Innovation Center (OMIC), founded by Boeing, will pioneer new tools and techniques in areas such as 3D printing and networked industrial equipment that increase productivity and reduce costs.[51] Both the Oregon Nanoscience and Microtechnologies Institute (ONAMI) and Oregon BEST focus on commercializing high-tech research, including NGM, while the Cascadia Cleantech Accelerator channels federal funding to firms that are trying to validate recently commercialized advanced energy technology.[52] Oregon State University and Portland State University both have research centers supporting advances in NGM technologies, while the Oregon Institute of Technology conducts applied research with broader business applications.[53] In addition to Oregon's research institutions, the state's private companies are leading innovators; inventors at companies like Intel and HP have led the nation in patent development.[54] All of these institutions can work together to bring NGM technologies and practices to market.

Tech-Savvy Workforce

Oregon has a ready-made workforce to build intelligent manufacturing solutions that could help the state's industries reduce energy waste and optimize production. Oregon ranked ninth for the fastest growth in technology jobs in 2015.[55] According to the National Science Foundation, Oregon has the fourth-highest number of technical workers in the country as a proportion of its total workforce.[56] In addition, Oregon awarded the twelfth-largest number of science, engineering, and technology degrees as a proportion of total degrees given in 2013, the latest year for which NSF data was available.[57] Oregon also has higher than average concentrations of industrial engineering technicians and other critical occupations.[58]

Opportunity to Support High-Quality Job Growth

The NGM industry could help address Oregon's need for good-paying jobs while offering a diverse array of opportunities catering to different education and experience levels. With forward-thinking solutions, the NGM cluster could support an average of over 65,000 Oregon jobs annually through 2030.[59] This estimate includes direct jobs from manufacturing and software development, indirect jobs from supplying equipment, materials, and services to manufacturers and developers, and induced jobs from spending in the local economy. Notably, this estimate does *not* include any installation, operations, or maintenance jobs. (See Appendix 3 for jobs modeling methodology.) Opportunities for job creation exist beyond those companies that manufacture NGM products; Oregon could also foster local demand and early adopters for these products to support job creation in installation, operations, and maintenance businesses distributed throughout the state.

JOB OPPORTUNITIES IN NEXT-GENERATION MANUFACTURING TECHNOLOGY

Mechanical Engineers
Design and build mechanical tools, engines, and machines.

TYPICAL ENTRY-LEVEL REQUIREMENTS:
Bachelor's Degree

Median Wage in Oregon:
$41.60

Software Developers
Develop the applications that allow people to do specific tasks on a computer or another device or develop the underlying systems that run the devices or control networks.

TYPICAL ENTRY-LEVEL REQUIREMENTS:
Bachelor's Degree

Median Wage in Oregon:
$48.80

Industrial Engineers
Eliminate wastefulness in production with efficient systems that integrate workers, machines, and other inputs to make a product or provide a service.

TYPICAL ENTRY-LEVEL REQUIREMENTS:
Bachelor's Degree

Median Wage in Oregon:
$47.90

Industrial Engineering Technicians
Help industrial engineers use personnel, machines, and materials effectively in production facilities.

TYPICAL ENTRY-LEVEL REQUIREMENTS:
Associate's degree or professional certification

Median Wage in Oregon:
$27.91

Computer-Controlled Machine Tool Operators
Operate computer-controlled machinery to tool metal or plastic parts.

TYPICAL ENTRY-LEVEL REQUIREMENTS:
High School Diploma or Equivalent

Median Wage in Oregon:
$18.36

State Assets to Support Next-Generation Manufacturing Development

The foundational building blocks of a cluster are the innovation ecosystem, access to capital, workforce development, value chain build-out, and local market growth. Oregon has many assets that can be aligned with cluster-based development, including a growing base of next-generation technology and service providers, a record of innovation-friendly policies, support for entrepreneurs, and strong university-based centers of innovation. These assets can be leveraged to grow a next-generation technology cluster, capitalizing on growing national and global demand to export products.

Oregon can capitalize on its strengths in NGM technology by strategically building an economic cluster. Clusters require several foundational building blocks coordinated for growth: education and training for a skilled workforce, access to capital for new and expanding businesses, an innovation ecosystem that cultivates new ideas, a comprehensive value chain, and a local market for Oregon-made goods. When fortified by clear market signals and policy certainty, these assets can position a state as a global supplier in the target cluster's industry vertical, feeding growing national and global demand. This leads to major opportunities for business growth and job creation, catalyzing economic opportunity for thousands of Oregonians.

This section will use these guides to illustrate the state's strengths in each foundational building block and showcase highlights of these significant resources for Oregon's NGM industry. The following visual guides break down the key assets for a robust cluster:

Innovation Ecosystem: Innovation is essential for business and industry competitiveness, and a strong knowledge hub can be a beacon for talent and investment. The innovation ecosystem supports fundamental research across universities and labs, fosters an entrepreneurial culture that seeks to advance and disrupt industries, and brings ideas to market.

Access to Capital: Access to investors or competitively priced non-dilutive capital can be the difference between success or failure for a new and expanding business. It is also important for consistent access to capital across development from the seed and early/growth stages to the late stage. An active investment environment can attract more entrepreneurs and investors to the state.

Workforce Development: Trained and skilled workers are fundamental to industry success, and strategic workforce development can support talent recruitment and retention. Workforce development requires collaboration across schools, businesses, and government offices to integrate STEM education, foster industry-ready skills via apprenticeships and career-integrated curricula, enable stackable credentials that offer multiple entries and exits, and provide resources that match skills to available jobs.

Value Chain: An industry value chain is composed of an array of companies engaged in the manufacturing, sale, marketing, and distribution of technologies. It also includes organizations that

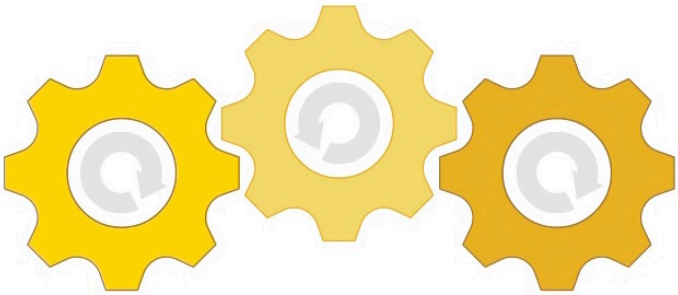
represent business interests across platforms. This base provides a solid foundation from which to attract more companies and customers.

Local Market: Developing a local market for products sends a market signal to businesses that encourages investment in new facilities and employees. High local demand and early adopters can build a local company base that could then expand to regional, national, and global markets. Clear utility and business regulatory environments coupled with resources for project development and end-user adoption can create a strong local market.

OREGON'S INNOVATION ECOSYSTEM ASSETS

Working Together to Bring Ideas to Market

Oregon's university research hubs are engines of progress in the research that powers growth in next-generation manufacturing. Beyond Oregon's nascent commercialization assets, the state's network of accelerators cultivates an innovative spirit and helps get ideas out of the lab and into the market. Key components of an innovation ecosystem are technical, financial, and capacity-building resources that support entrepreneurship, research and development, and commercialization.



Research & Development	Commercialization	Entrepreneurship
• **OSU College of Engineering Energy Efficiency Center:** Coordinates knowledge exchange and trains manufacturers on how to increase productivity. • **Oregon Nanoscience and Microtechnologies Institute (ONAMI) Labs:** Network of research facilities that connects innovators to research expertise and institutional support. • **Advanced Technology and Manufacturing Institute (ATAMI):** Provides facilities to support research, development, and commercialization in advanced manufacturing technology. • **Oregon Manufacturing Innovation Center (OMIC):** Industry sponsored center for research and development in next-generation manufacturing technologies.	• **ONAMI Commercialization Program:** Collaborates with Oregon researchers and university facilities to provide technical guidance and connect startups and small businesses to funding opportunities. • **Oregon BEST:** Supports and funds Oregon cleantech startups by providing focused programs and leveraging resources to promote economic development and job creation in Oregon. • **Oregon InC Commercialization Gap Fund** • **Portland State University**	• **Oregon Entrepreneurs Network** • **OR RAIN/Fertilab** • **Oregon State University Advantage Accelerator** • **Founders Pad** • **Oregon BEST** • **Business Executive Sustainable Training Headquarters (BESThq)** • **Oregon Technology Business Center** • **Starve Ups** • **Portland Incubator Experiment** • **TenX** • **Cascadia CleanTech Accelerator** • **TiE Oregon**

The Oregon Innovation Council (Oregon InC) is a public-private partnership that funds initiatives providing business mentoring, grants, and commercialization support and proof of concept testing. Among other things, Oregon InC funds Oregon BEST, ONAMI, and the Oregon InC Commercialization Gap Fund.

OREGON'S ACCESS TO CAPITAL ASSETS

Investing in New and Growing Businesses

While Oregon offers a variety of grants, angel, venture capital, loan, and investment programs to support businesses at all stages of development, there is a lack of resident capital available for clean tech companies with high capital needs. Oregon's companies also face challenges in navigating the funding spectrum to find sources of capital. Key components of access to capital are diverse and robust funding for seed-stage, early/growth-stage, and late-stage businesses.

Business Oregon offers multiple loan and loan guarantee programs:

The Entrepreneurial Development Loan Fund and the Oregon Business Development Fund make direct loans to companies.

The Oregon Capital Access Program and the Oregon Credit Enhancement Fund catalyze lending to businesses for startup or expansion costs through the use of a loan loss reserve and loan guarantees.

Oregon Industrial Development Bonds offer state-issued tax-exempt bonds for Oregon.

Oregon RAIN offers two accelerators that provide entrepreneurial programming, mentorship, and access to capital.

Crowdfunding is available to startups in Oregon via Hatch Oregon.

Oregon BEST and Business Oregon offer grants to help startups apply for SBIR and STTR grants.

Multiple angel and venture conferences and competitions are held annually to connect companies to investors.

At least 14 resident angel investors and venture capital firms provide funding for startups, such as Portland Seed Fund, Cascade Angels, and Oregon Venture Fund.

Oregon Small Business Development Center Capital Access Team provides specialized advice, support, and training to develop finance strategies and match companies with appropriate funding.

The Oregon Growth Board funds the Oregon Growth Fund and the Oregon Growth Account which provide funding for investment vehicles to increase access to capital for Oregonian companies.

BUSINESS FUNDING SPECTRUM

OREGON'S WORKFORCE DEVELOPMENT ASSETS

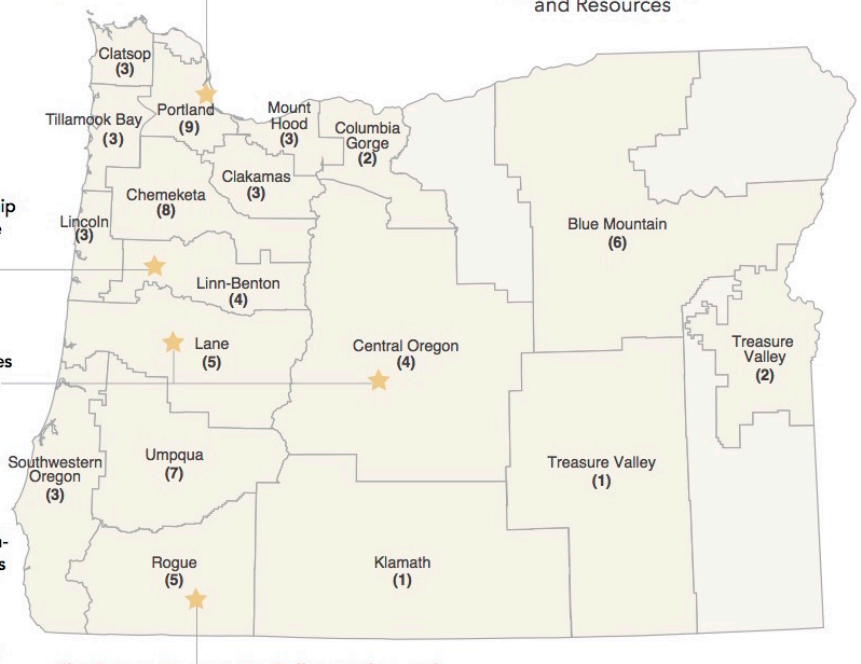
Leveraging Educational Resources to Build an Industry-Ready Workforce

Oregon's research centers, community colleges, universities, and partnerships equip students with a broad range of technical skills. To ensure a full pipeline for the next-generation manufacturing workforce, the state could enhance coordination between educational and training institutions and employers. Key components of workforce development are STEM education, work-integrated learning, flexible career pathways, apprenticeships, skill-matching resources, and interagency cooperation.

The Oregon Manufacturing Innovation Center (OMIC): Coordinates partnerships between higher education and industry, including Boeing, Daimler, and ATI. Provides training and research in fields such as additive manufacturing and alloy development.

Community College District (number of campuses)

Highlighted Programs and Resources



MECOP Inc.: Provides internship opportunities for undergraduate engineering students at state universities, preparing many for careers in next-generation manufacturing.

Apprenti™: The East Cascades Workforce Investment Board and the Lane Workforce Partnership, in collaboration with Technology Association of Oregon, have formed local affiliates of Apprenti™. Apprenti™ is a national organization that registers tech-based apprenticeship programs and provides a pipeline for underrepresented groups to get certification, training, and placement in the tech industry.

The Rogue Community College Advanced Manufacturing Partnership: Aligns degree, certificate, and credential programs to meet the needs of regional manufacturers. Could serve as a model for education/industry collaboration throughout Oregon.

CareersNW.org: Promotes high growth careers to youth by highlighting career paths and providing tools to connect people to training and education programs.

Spotlight on Apprenticeships

Oregon is among the national leaders in participation in the Department of Labor's Registered Apprenticeships program. In 2016, almost 8,000 youths took part in this work-based learning opportunity, the 8th-most per capita in the country. The state can build upon this success to expand work-based learning opportunities in next-generation manufacturing occupations.

OREGON'S VALUE CHAIN ASSETS

Expanding In-State-Industry Capabilities

Oregon has much of its next-generation manufacturing value chain already in place, including sensors and controls manufacturers, software engineers and consultants, and precision manufacturing service providers. The state also has strong industry associations that help facilitate business activity between value chain segments. Within this vibrant, growing ecosystem, Oregon has the opportunity to grow its capacity to build precision manufacturing machines and provide key input resources to end users locally and around the world.

Established Strengths | Growth Opportunities | Resources

Networked Industrial Process Equipment

KEY RESOURCE PROVIDERS

- Software consultants
- Semiconductor manufacturers

Anchor Company: Intel

EQUIPMENT MANUFACTURERS

- Sensors and controls manufacturers
- Makers of software for monitoring, analyzing, and controlling equipment usage

Anchor Companies: Veris Industries, Cascade Energy, Rigado, and Huntair

END-USE FACILITATORS

- Industrial consultants
- Energy management consultants

Anchor Company: Energy350

RESOURCE

Northwest Energy Efficiency Alliance: Coalition of over 140 utility and energy efficiency companies promoting the adoption of next-generation manufacturing technologies and other energy efficiency products.

Precision Manufacturing Machinery

KEY RESOURCE PROVIDERS

- Metal and plastic powder producers
- 3D Imaging providers

EQUIPMENT MANUFACTURERS

- 3D printer and CNC machine manufacturers

END-USE FACILITATORS

- 3D printing and CNC machining service providers

Anchor Companies: Treske Precision Machining, Plural Additive Manufacturing

RESOURCE

HP 3D Open Materials and Applications Lab: Site for 3D printing materials research, development, and certification of compatibility with HP's industrial 3D printers.

OREGON'S LOCAL MARKETS ASSETS

Encouraging Investment in Oregon-Made Goods

Oregon can foster a local market by ensuring that firms can easily do business in the state, customers can access financing for energy efficiency and next-generation manufacturing upgrades, and state and local policies offer clear and transparent goals, rates, and requirements for industrial energy efficiency.

BUSINESS-FRIENDLY CLIMATE

Strategic Investment Program: Large capital projects undertaken by firms in industries with national and global competition are tax exempt above $25 million.

Enterprise Zones for Rural Development: Projects completed in one of 68 statewide "Enterprise Zones"are fully exempt from property taxes for three to five years.

ENERGY REGULATORY ENVIRONMENT

Renewable Portfolio Standard: Requires utilities to pursue cost-effective energy efficiency measures.

Eugene Water and Electric Board Rebates for Energy Efficient Systems: Provides cash rebates for installation of energy efficient systems, including networked HVAC, lighting, and refrigeration equipment.

END-USER & PROJECT DEVELOPMENT RESOURCES

PropertyFit Oregon: Multnomah County allows property owners to obtain low-cost loans for energy efficiency under a Commercial Property-Assessed Clean Energy (C-PACE) program.

Northwest Energy Efficiency Alliance Energy Training: Consortium of utilities providing training to manufacturers on technologies that increase energy efficiency.

Energy Trust of Oregon: Ratepayer-funded non-profit providing cash incentives and technical assistance to manufacturers working to realize energy savings.

Oregon State University Industrial Assessment Center: Provides free energy assessment services to small- and medium-sized manufacturers.

Bonneville Power Administration's Industrial Sector Energy Efficiency Program: Federal power marketing agency that provides reimbursements for projects that increase industrial energy efficiency.

Policy Recommendations

To grow the next-generation industry, state and local leaders can address barriers and capitalize on opportunities across foundational building blocks, such as enabling statewide entrepreneur resource coordination, increasing access to long-term capital, expanding training for incumbent workers, building a next-generation cluster partnership, and creating a next-generation showcase program. These forward-thinking policies, programs, and ideas are intended to serve as stepping stones for discussion and collaboration.

Oregon's leaders can capitalize on the state's competitive strengths and demonstrate their commitment to the NGM by enacting smart, forward-thinking policies and implementing non-legislative solutions. In particular, state and local leaders can apply innovative strategies that address barriers and missed opportunities across foundational building blocks, as noted by the icons. These broad strategies include fostering technology development and commercialization, increasing business access to financial resources, improving workforce training, and growing the in-state value chain. Oregon can also build a local market for NGM products as an opportunity for industry growth. Robust demand near manufacturing facilities can help create synergies that drive innovation, train and retain talent, and attract out-of-state investors.

While all of these policies are designed to foster an NGM technology manufacturing cluster, many are aimed at the broader corporate and innovation environment, which supports all businesses, including those in the NGM industry. Whether taken as a whole or as piecemeal solutions, the following recommendations could attract private investment, stimulate the state's economy, and create good-paying jobs for Oregonians.

Innovation Ecosystem: Builds connective tissue in Oregon's entrepreneurial community and bridges the commercialization gap by coordinating product testing and demonstration resources for NGM businesses.

Access to Capital: Expands available capital for Oregon's NGM startups, especially flexible, long-term funding opportunities to support commercialization.

Workforce Development: Targets talent retention and recruitment through incumbent worker training, work-integrated learning models, industry coordination, and expanded pathways to careers in Oregon's NGM technology industry.

Value Chain: Encourages strategic collaboration across stakeholders to strengthen Oregon's NGM technology industry and attract investment from outside the state.

Local Market: Incentivizes and reduces the barriers to adopting NGM technologies for Oregon manufacturers.

Innovation Ecosystem

Policy 1: Enable Statewide Entrepreneur Resource Coordination

Barrier
Though there are many valuable resources available to startups throughout Oregon, they are not always visible or coordinated. Opportunities to collaborate and leverage mutual resources are missed because startup programs are not aware of the efforts of others and are not referring entrepreneurs to programs that could provide additional assistance.[60] With startup resources widely dispersed and lacking a unifying theme, entrepreneurs have a hard time understanding what resources exist for them and then finding that support.[61] Hardware-focused startups such as those in NGM face particular challenges as they grow, and having streamlined access to expertise and resources is vital to success.[62]

Solution
Oregon could expand on the successful model established by the Oregon Entrepreneurs Network (OEN) (*see case study*) and used by several Oregon entrepreneurial organizations by co-funding a statewide network of Venture Catalysts.

Each Venture Catalyst is a seasoned entrepreneur or investor with extensive experience and is well versed in resources for funding and scaling up.[63] They are described as coaches, connectors, and strategists. Venture Catalysts work at three levels: providing direct services to businesses, addressing critical gaps in the entrepreneurial ecosystem, and coordinating resources amongst stakeholders. A statewide network of Venture Catalysts would be comprised of individuals dedicated to each county throughout the state. Each Venture Catalyst would be charged with traveling throughout their respective counties, connecting startups to resources and promoting collaboration between service providers. They could also disperse news on other regional events, funding opportunities, and industry trends. This statewide network could increase the effectiveness of Oregon's innovation ecosystem by ensuring coordination among organizations and other assets.

In order to ensure that the Venture Catalysts efficiently collaborate and are well informed about available resources and best practices, the state could sponsor monthly or annual conferences. The conference agenda could address best practices employed by entrepreneurial support organizations within Oregon as well as throughout the country.

OEN and the Oregon Community Foundation have recently announced a partnership with plans to expand OEN's Venture Catalyst program to eleven new counties throughout the state, and they are seeking funding for this effort.[64] The Ford Family Foundation also recently supported forming a Venture Catalyst position in the mid-coast region.[65] To ensure the continued success of this model and guarantee access to Venture Catalysts for all Oregonians, state-level partnership and resources are required.

Key Players
Oregon Legislative Assembly, Oregon Entrepreneurs Network, Business Oregon, Local Governments, Foundations, Oregon RAIN, NGOs

Case Study: OEN's Venture Catalysts
In 2009, OEN, in partnership with Economic Development for Central Oregon (EDCO), created the first Venture Catalyst position in Central Oregon.[66] Since then, OEN has supported Venture Catalysts with local partners in Southern Oregon and the South Willamette Valley.[67] These Venture Catalysts identify entrepreneurs throughout rural regions and connect them with training, services, and investors.[68] In addition to raising awareness for business development tools in Oregon, Oregon RAIN and its Venture Catalysts help support startup events like pre-accelerator bootcamps and angel investment conferences.[69] The Venture Catalysts are funded by a combination of municipal governments, private foundations, and other local entities.[70] Venture Catalysts in these three areas have provided services to over 500 companies, which have created 346 jobs and generated over $55 million in revenue since 2016.[71] Since 2014, Venture Catalysts in the South Willamette Valley have helped startups obtain over $15 million of investment capital.[72] From an initial investment of only $450,000, in 2015-2016 Venture Catalysts in the three regions assisted more than 270 companies, directly facilitating $21 million in investment capital and creating 188 jobs.[73]

START QUOTE BOX
"The return on investment for this initiative has been remarkable wherever the model has been deployed, resulting in not only more successful companies and jobs, but also in the development of critical entrepreneurial infrastructure. In Central Oregon alone, the Venture Catalyst position at EDCO has been key in the growth of the Bend Venture Conference and local PubTalks, as well as the establishment of the region's first accelerator, a regional angel fund, and mentor database, to name a few." *Oregon Entrepreneurs Network*[74]
END QUOTE BOX

Policy 2: Support Product Testing Resources for Technology Commercialization

Barrier
For entrepreneurs developing high-risk emerging technologies, the stage between prototype development and commercialization is often not only the most challenging part of starting a company, but most critical for attracting investment and first customers.[75] Known as the "commercialization valley of death," this stage requires extensive testing and validation to de-risk the product and obtain certifications.[76] However, it is nearly always time- and capital-intensive, especially for hardware-focused companies.[77] Testbeds help expedite this process and decrease costs for entrepreneurs by centralizing needed testing equipment.[78] While Oregon has several facilities that could support NGM startup growth, they lack easy accessibility to local businesses and clarity on testing services.

Solution
Oregon could help bridge the commercialization gap by establishing a public access testbed for NGM. The testbed should be clearly accessible to all Oregonians, regardless of university affiliation or membership status. Oregon could look to the Washington Nanofabrication Facility as a model for ensuring flexible and efficient user access (*see case study*). The state could expand an existing facility to include equipment needed for NGM.

START CALL OUT BOX

Existing Facilities with NGM Testbed Potential

- Set to open in 2018, the membership-based Oregon Manufacturing Innovation Center (OMIC) will engage numerous industry and academic partners to develop advanced metal manufacturing technologies.[79] While OMIC is a valuable asset for the metal manufacturing sector, it could target additional critical industry verticals in NGM.[80]
- Located on the Hewlett-Packard campus, OSU's Advanced Technology and Manufacturing Institute (ATAMI) is focused on micromanufacturing and allows companies of all sizes to use its equipment.[81] ATAMI also offers a $1,000 credit for first-time users.[82]
- The Oregon Renewable Energy Center (OREC) located at Oregon Institute of Technology collaborates with industry partners to accelerate clean energy technologies. OREC has the capability to test prototypes, assess process improvements for manufacturing controls, and assist with materials selection.[83]
- OSU's Industrial Sustainability Laboratory has partnered with the national Clean Energy Smart Manufacturing Innovation Institute to provide training and support facilities and is part of a regional effort to innovate and advance smart manufacturing technologies.[84]

END CALL OUT BOX

Oregon could also create an innovation voucher program that facilitates startups' access to the testbed and other state-funded testing facilities. State officials could work closely with the Oregon Manufacturing Innovation Center (OMIC), Advanced Technology and Manufacturing Institute (ATAMI), and the Oregon Manufacturing Extension Partnership (OMEP) to determine the value of resources and services available for voucher compensation. Oregon could model this program after Tennessee's RevV! program (*see case study*). By making vouchers available to all Oregonians, the state could broaden the pipeline of NGM entrepreneurs beyond the university system. The testbed and innovation voucher program could help brand Oregon as an innovation hub for NGM activity and attract additional entrepreneurs and investors to the state. The testbed would work closely with or co-locate with a NGM Center of Excellence (*see Policy 10*) to integrate efforts.

Key Players

Oregon Legislative Assembly, Universities, Industry, NGM Center of Excellence (*see Policy 10*)

Case Study: Washington Nanofabrication Facility

Based out of the University of Washington, the Washington Nanofabrication Facility is a public access resource that houses micro- and nanotechnology testing capabilities and fabrication services. Entrepreneurs and businesses that wish to use the testbed must simply participate in an initial consultation to discuss project feasibility, design, and safety. The Washington Nanofabrication Facility offers à la carte pricing and services to accommodate all user types.[85] All interested users can access the lab if it meets their needs and they accept the user agreements. The facility supports 200 to 250 unique users and over 220 projects each year, with a 3:2 ratio of industrial users from small and large companies to academic users.[86] Through in-house training and expertise, users can use equipment after a few hours, develop processes within days depending on the complexity of the problem, and develop a prototype in three to six months.[87] If the lab lacks a certain capability, lab staff help to facilitate connections to other resources that can fill the identified gap. From 2012 to 2016, this customer service-oriented approach supported a 283 percent increase in the lab's revenue.[88]

Case Study: RevV!
RevV! is a state innovation voucher program that leverages resources and expertise at Oak Ridge National Laboratory (ORNL) to support business growth in Tennessee. Through the program, local manufacturers can receive vouchers to tap into ORNL's capabilities and exceptional facilities in advanced manufacturing demonstration; advanced materials processing, characterization, and fabrication; and computational science.[89] Managed jointly by ORNL and the University of Tennessee, RevV! was initially piloted in 2015 with $2.5 million in state funding as part of a regional cluster development strategy.[90] It has since received a second round of $2.5 million, and in 2018 it will become a permanent program with additional funding from the state.[91] RevV! is open to any business that employs at least ten people and currently manufactures a product.[92] Innovation voucher amounts vary, but some companies have received as much as $125,000 to take advantage of the unique offerings of ORNL.[93]

Case Study: Greentown Labs
In 2011, four MIT graduates founded Greentown Labs in Somerville, Massachusetts as a place where entrepreneurs could affordably build and test their ideas.[94] Today, Greentown Labs provides co-located prototyping, event, and office space to meet the needs of hardware-focused advanced energy startups.[95] Currently, more than seventy startups utilize the space, pioneering solutions for renewable power generation, battery storage, energy efficiency, and other technology areas.[96] Through its Manufacturing Initiative, Greentown Labs connects energy startups with manufacturers across Massachussetts to help establish business relationships.[97] Since its founding, Greentown Labs has incubated over 120 startups, leading to the creation of more than 900 jobs and $260 million in investment.[98] This success facilitated a major expansion in late 2017, when Greentown Labs opened its Global Center for Cleantech Innovation.[99]

START CALL OUT BOX
Spotlight Opportunity: Internet of Things Testbed
The combination of Oregon's substantial manufacturing sector and its access to software giants and creative talent provides Oregon with the opportunity to be a leader in the Internet of Things (IoT).[100] The marriage of software and hardware for the collection and evaluation of data will play an essential role in the NGM industry. With business spending on IoT solutions projected to hit $6 trillion by 2021, the IoT represents a significant market opportunity for Oregon.[101]

A component for testing IoT technologies at an existing NGM testbed could help startups prove their technologies faster, reducing costs and time to market (*see case study*). The IoT testbed could partner with an anchor member (a large corporation with additional capital and resources to leverage) to provide comprehensive product testing and validation. Intel's Israeli branch launched a similar model in 2015 that provides facilities, mentorship, and market analysis to participating startups.[102]

Case Study
Wipro Digital launched a Connected Workforce Safety testbed with the Industrial Internet Consortium (IIC), which evaluates devices such as smart helmets and smart glasses to keep employees safe.[103] The testbed aims to test and validate a connected system and infrastructure of

personal protective equipment, sensors, and wearables.[104] Members of the nonprofit Industrial Internet Consortium have the ability to request access to the testbed to validate their own products.[105]
END CALL OUT BOX

Policy 3: Foster the Commercialization Culture at Universities

Opportunity
Universities with a strong focus on entrepreneurship and commercialization experience numerous benefits, including improved industry relations and funding opportunities, increased regional economic development, and positive publicity for recruitment and retention of faculty and students.[106] While universities continue to be an extensive research resource for enterpreneurs of emerging technologies, faculty members are often more encouraged to publish than they are to explore commercializing research.[107] Currently, only three of the seven public Oregon universities recognize patents as creative scholarship in their tenure policies, but these policies could be bolstered and are only part of the cultural change needed to encourage commercialization endeavors.[108] In the Milken Institute's 2017 report on top universities in tech transfer, Oregon State University and University of Oregon ranked 47th and 63rd, respectively.[109] Oregon's universities have an opportunity to enable the state's innovations to play a larger role in the global economy by embracing a culture that rewards product development and commercialization.

Solution
Oregon's Higher Education Coordinating Commission (HECC) could recommend that public universities adopt incentives to promote university commercialization practices. Recognizing technology transfer and commercialization activities in tenure review processes, instituting faculty mentorship and/or startup support programs, and supporting entrepreneurial leaves of absence are three proven methods for stimulating commercialization at universities.[110] Universities could acknowledge faculty members for authoring patents or accelerating university innovation by expressly including technology transfer activities in the criteria considered for promotion and tenure (*see call-out box*).[111] Oregon universities could also create mentorship and commercialization support programs to help faculty members take their ideas to market. Program services could include connecting faculty members with seasoned entrepreneurs and establishing pre-negotiated relationships with firms used frequently by startups, as seen at The University of Utah and University of California, Los Angeles (*see case study*). Drawing on University of Minnesota's innovative policy, a complementary strategy could be to allow one- to two-year entrepreneurial leaves of absence for faculty, during which fringe benefits are still available and accruable (*see case study*). Any or all of these activities could accelerate commercialization opportunities and foster an active innovation ecosystem at Oregon universities.

Key Players
Universities, Higher Education Coordinating Commission

Case Study: University of Utah
The University of Utah has led the way in creating programs that encourage faculty entrepreneurship. In 2007, The University of Utah launched the Entrepreneur Faculty Scholars (EFS) program to create a broad network of support for faculty members commercializing their

research.[112] The network, comprised of 155 members from all fourteen colleges at The University of Utah, connects seasoned faculty entrepreneur mentors through an online platform and regular meetings to faculty entrepreneurs to guide them through the process of commercializing research.[113] Alongside EFS, The University of Utah's Technology Venture Commercialization offers the Lean Cohort, a seven-week accelerator program to help faculty navigate commercialization.[114] As a result, there is a strong culture of innovation at the university. Between 2012 and 2015, The University of Utah generated $211.8 million in licensing income and recorded sixty-nine startups.[115] The University of Utah was ranked first on the 2017 Milken Institute Innovation Index.[116]

Case Study: University of California, Los Angeles (UCLA)
UCLA recognizes that a strong entrepreneurial culture provides several benefits to the university, including supporting small businesses, generating revenue from licensing intellectual property, and providing job opportunities to their graduate students. Among other innovative programs, UCLA has created a dedicated program for university community members interested in commercialization that has resulted in multiple spin-off companies.[117] The "Startup in a Box" program aims to launch startups using university intellectual property. The program offers pre-negotiated partnerships with local law, accounting, commercial real estate, marketing, web, human resources, insurance, and financial firms.[118] Due in part to this initiative, UCLA was recently ranked first for performance in startups by the Milken Institute.[119] As of fiscal year 2016, UCLA had $65.9 million in revenue from licensing and 1,075 active U.S. patents.[120]

Case Study: University of Minnesota
University of Minnesota's entrepreneurial leave of absence policy allows faculty members up to eighteen months of unpaid leave to explore commercializing university intellectual property without compromising their benefits.[121] While faculty members pursue startup projects, they continue to maintain health benefits, accrue vacation time, and earn other fringe benefits.[122] In addition to the Venture Center, the policy is among a slate of resources that University of Minnesota advanced to maximize the impact of internal research and strengthen connections to the local business community.[123] This effort has fostered a robust startup ecosystem that has included over 120 spin-offs since 2006, with 78 percent still active.[124] University of Minnesota also ranked fourteenth on the Milken Institute's ranking of top universities for technology transfer.[125]

START CALL-OUT BOX
Sample Language for Incorporating Entrepreneurial Activities in Tenure and Promotion Review[126]

- Virginia Polytechnic Institute and State University (Virginia Tech)
    - "Economic contributions and entrepreneurship: 1. Start-up businesses (including competitive grants and contracts such as SBIR awards and other notable business achievements), 2. Commercialization of discoveries, 3. Other...Intellectual properties: 1. Software, 2. Patents, 3. Disclosures (pre-patent)"
- The Ohio State University
    - "… creative works pertinent to the candidate's professional focus:...Inventions and patents, including disclosures, options, and commercial licenses"
- The University of Arizona

- "...integrative and applied forms of scholarship that involve cross-cutting collaborations with business and community partners, including translational research, commercialization activities, and patents"

END CALL-OUT BOX

Access to Capital

Policy 4: Increase Access to Long-Term Capital

Barrier

Early-stage companies and small businesses typically have limited financial capital for growth and development. These companies tend to lack physical assets that can be leveraged for bank loans. This issue is particularly acute for companies developing new energy-related technologies, such as NGM technologies, that may be costly to demonstrate and exhibit longer commercialization periods.[127] For these companies, long-term or patient capital is necessary to grow their technologies into valuable investments.[128]

Solution

One underutilized source of long-term capital is philanthropic foundations. In 2014, Oregon's 878 foundations distributed over $370 million to organizations throughout the state, but the majority of these funds went to nonprofit organizations.[129] Foundations are able to make two kinds of investments that offer long-term capital to companies; these are known as a program-related investment (PRI) and mission-related investment (MRI).[130] Through PRIs and MRIs, foundations can invest in small and growing businesses rather than just awarding grants.[131] Because foundations can prioritize the impact of the investment rather than narrowly looking at the direct market return, they can invest in high-risk, cutting edge technologies and provide capital on longer timelines than traditional financing options.[132]

To develop local and out-of-state sources of PRIs and MRIs, public or private sector leaders could designate and fund a specialist individual or organization to facilitate PRI and MRI investments in the state. The new PRI/MRI specialist could help local foundations navigate the complicated requirements associated with establishing these investment vehicles. They could also work hand-in-hand with the existing NGM startup community to facilitate investments. A potential first step for the PRI specialist could be to perform an audit of the philanthropic capital and existing PRI/MRI market size in Oregon. Providing assistance for the streamlining of PRIs and MRIs could unlock millions of dollars of additional capital for businesses in Oregon's NGM cluster, driving economic growth throughout the state.[133]

Oregon BEST is already exploring ways to harness PRIs to fund early-stage technology development projects in the cleantech sector, and could lead this effort. Other partners could be the Next-Generation Manufacturing Center of Excellence (*see Policy 10*), or Business Oregon.

Key Players

Oregon BEST, NGM Center of Excellence (*see Policy 10*), Business Oregon

Case Study: PRIME Coalition
Launched in mid-2015, PRIME Coalition encourages more foundations to prioritize PRIs by connecting them with budding companies.[134] PRIME is a charity that facilitates investments by working with both philanthropic organizations and early-stage, for-profit clean energy companies.[135] By providing industry expertise and connections to best-in-class companies, PRIME reduces the barriers that make PRIs difficult for foundations.[136] Although PRIME has started small, it has already facilitated investment in eight companies and is currently working on funding an additional four firms.[137]

Case Study: Gates Foundation
In recent years, several organizations have set out to dramatically increase the number of PRIs, especially for energy technology firms.[138] For example, one foundation that has been focusing heavily on PRIs is the Gates Foundation. After making its first PRI in 2009, it now has $1.5 billion dedicated to PRIs around the globe.[139]

START CALL-OUT BOX
Program-Related Investments and Misson-Related Investments
Program-related investments and mission-related investments are investments made by a foundation in the pursuit of its philanthropic goals, not primarily to generate returns.[140] The investment can be a loan, equity investment, or guaranty in a for-profit business or a nonprofit organization.[141] Because generating returns is not a significant purpose, the IRS treats them similar to grants, and they do not jeopardize the foundation's tax status.[142]
END CALL-OUT BOX

Policy 5: Create a Capital Gains Tax Exemption

Barrier
There is a lack of Oregon-based investors and investment funds that provide capital for small- and mid-sized manufacturing companies.[143] To build a vibrant innovation ecosystem, Oregon's next generation of manufacturing entrepreneurs need the financial backing to test new products, identify new markets, and bring their products to market. Incentivizing more Oregon-based angel investors, venture capitalists, and investment funds to provide this critical capital will help keep companies in the state and unlock the strong ties, broad networks, and expertise necessary to grow this cluster.

Solution
Currently, Oregon has the third-highest capital gains tax nationwide—behind only California and New York.[144] High capital gains taxes cut into investors' return, creating a barrier to capital flow. Stronger incentives are needed to coax investors to take the risk of putting money into an early stage company. To keep university innovations and startups local, Oregon could establish a state capital gains tax exemption for investments in early-stage NGM technology companies. This would incentivize capital investments from local accredited investors and equity crowdfunders. Combined with the federal gains tax exemption offered in Oregon's Opportunity Zones, a state capital gains tax exemption could further boost development in these hard-hit areas.[145] To encourage patient capital, the exemption could require a three-year minimum investment, and could extend for up to ten years. Having patient capital gives companies more certainty and helps avoid the "valleys of death" during technology development and commercialization.

Key Players
Oregon Legislative Assembly

Case Study: United Kingdom's Capital Gains Tax Relief
The Enterprise Investment Scheme (EIS) and Seed Enterprise Investment Scheme (SEIS) are tax-based venture capital schemes that provide tax relief to investors in high-risk companies. The EIS started in 1994 with the aim to help small, high-risk companies build capital by offering tax relief to investors.[146] In 2012, the government established the complementary SEIS, which offers tax relief at a higher rate for early-stage investment.[147] Both programs offer complete capital gains tax relief after a three-year investment period.[148] Approximately 22,900 companies have benefited from the EIS, raising over £12.2 billion in funds since the program began in 1994.[149] From 2013 to 2014, SEIS spurred a total of £164 million of investment in 2,000 companies.[150]

Case Study: Virginia's Success with Capital Gains Tax Exemptions
Virginia's Capital Gains Exemption for Technology Businesses allows individual and corporate investors to subtract long-term capital gains from their state tax burden. This exemption applies to investments in early-stage technology, biotechnology, and energy companies with revenues of less than $3 million and with operations principally in Virginia.[151] The venture capital climate for seed-stage companies has significantly improved since 2011, the first year that the exemption could be claimed. Annual investment increased from $49 million in 2012 to $205 million in 2016, while the number of deals also increased.[152]

Case Study: Arizona's Angel Investor Capital Gains Tax Exemption
Since 2013, Arizona has eliminated capital gains taxes on income derived from certified angel investments.[153] This is an additional incentive that builds on an Angel Investor Tax Credit that Arizona has offered since 2006.[154] From 2006 to 2014, 120 small businesses raised roughly $58 million in certified investments.[155] Roughly 100 of the businesses raised follow-on funding totaling over $340 million.[156] The total economic impact since inception has been $1.3 billion, with nearly $333 million coming in 2015 alone.[157] The return on investment of the program has been $2.30 for every $1 invested.[158]

Policy 6: Establish Oregon's Capital Locator Tool

Barrier
For first-time entrepreneurs, navigating the array of funding options to find sufficient capital can be onerous.[159] One reason this process can be so complicated is that investment options vary based on what stage of development the company is in. A company that has yet to develop a prototype would have very different funding options than a company that was nearly ready to go to market with its product. So many entrepreneurs struggle with securing funding that Coursera, the leading provider of online courses, offers a four-week online class focused solely on startup funding.[160] Entrepreneurs in Oregon report difficulty navigating the myriad of financing options available; there is no clear pathway for businesses to access the entrepreneurial resources the state has to offer.[161]

Solution
Oregon's leaders could create a simple online capital locator tool to help entrepreneurs identify the type of capital that is appropriate for their company's maturity level and industry. The tool would consolidate the sources of funding found both in-state and nationally, and filter by industry and maturity level. The tool could also consolidate the in-state entrepreneurial resources available by type and region, such as incubators, accelerators, and mentor programs. Collecting this information in one easy-to-use place and allowing users to filter the information in useful ways could save entrepreneurs valuable time. Furthermore, it could connect entrepreneurs with funding options and entrepreneurial support they may not have found on their own. Oregon's biennial Capital Scan report compiles this information and could form the basis for the website.[162]

Key Players
Business Oregon, Oregon Small Business Development Center Capital Access Team, Oregon Entrepreneurs Network, Oregon BEST, Oregon RAIN, Foundation Community, Oregon Growth Board

Case Study: Michigan Economic Development Corporation's Capital Locator Tool
Michigan has simplified the process of looking for funding by creating a free capital locator tool. Hosted by the Michigan Economic Development Corporation, the tool lists roughly 150 potential sources of capital.[163] The tool divides the sources by category: venture capital firms, commercial banking resources, state programs, federal programs, web resources, business plan competitions, and business services.[164] Entrepreneurs can utilize the tool to narrow down the funding sources by the stage of businesses they fund. Specifically, users can identify whether they are looking for funding for a business in the idea stage, the start-up stage, the growth stage, or the mature stage. Additionally, the tool offers the ability to filter capital sources by thirteen industries, including alternative energy.[165]

Workforce Development

Policy 7: Expand Training Programs and Opportunities for Incumbent Workers

Barrier
As technologies like additive manufacturing, programmable logic controllers, and collaborative robots spread throughout the manufacturing industry, a gap widened between the skills workers have and the skills they will need.[166] In response to this trend, the state has undertaken measures to prepare graduates to work with cutting edge tools, processes, and technologies.[167] Eighty percent of workers that will be needed to fill jobs in ten years are already in the workforce, so training only today's youth will be insufficient for competitiveness.[168] However, Oregon lags behind in investment in incumbent workers. As noted by the Oregon Talent Council, Oregon spent less than $12 million, or about $6 per worker, on retraining per the 2015-2017 biennium, in contrast to the nearly $1.5 billion the state spent on higher education.[169]

Solution
To ensure Oregon has the workforce that its growing NGM industry needs, the state could enact an incentive targeted at retraining incumbent workers. Establishing a $1,250 tax credit for incumbent

worker retraining could help retrain as many as 4,000 workers each year, at a cost of $5 million.[170] The state could offer a larger credit for worker retraining in high-growth, critical industries, such as NGM, and expand eligibility to self-employed workers who enroll in relevant training programs. Worker retraining tax credits in Georgia and Kentucky offer potential models for Oregon (*see case studies*).

Key Players
Oregon Legislative Assembly, Governor's Office, State Board of Education, Oregon Office of Workforce Investments, Bureau of Labor and Industries, Department of Revenue, Next-Generation Manufacturing Cluster Partnership *(see Policy 10)*

Case Study: Georgia Retraining Tax Credit
Georgia's Retraining Tax Credit program offers employers a credit equal to 50 percent of the direct expenses of any eligible retraining program and up to $1,250 per worker per year.[171] The credit is designed to ensure that employers commit some of their own funds to worker retraining and expand the pool of employers and workers who benefit from the program. Employers are given discretion over which training programs are most relevant for their workers; eligible expenses include the costs of instructors or instructional materials, employee wages during retraining, and reasonable travel expenses.[172]

Case Study: Kentucky Skills Training Investment Credit (STIC)
Kentucky offers a tax credit to employers who are ready to commit to investing in their workers. The credit provides $500 per full-time employee (or a maximum of $100,000) to companies in eligible fields, including manufacturing.[173] The credit can be used for a variety of training activities, including employee wages during the training period.

Policy 8: Create An NGM Industry Council to Coordinate Workforce Training

Barrier
Many employers are frustrated with the siloed nature of Oregon's education and workforce development system. In particular, employers have trouble locating needed resources or talent.[174] The NGM industry has trouble finding qualified workers, and keeping up with rapidly evolving industry requirements is a perpetual challenge.[175] The Oregon Talent Council identified three of the biggest problems facing employers: bringing cutting-edge skills into the workplace, quickly upskilling incumbent workers, and creating systems for work-based training and education.[176] Furthermore, many employers feel that Oregon's universities neither effectively engage employers in curriculum development, nor give students exposure to relevant careers.[177]

Solution
To address these difficulties, Oregon could establish and fund an industry-led manufacturing workforce development council. Such an organization could bring together stakeholders from the education and business communities to address the needs of workers and employers. This would help the various regional workforce boards that have identified manufacturing as a key sector strategy to work toward common standards and competencies. Specifically, this council could review and refine industry credential standards and career pathways for success in the NGM industry. With industry involvement, the council could respond promptly to the rapidly changing field of NGM to keep the workforce current. Massachusetts and Kentucky, which have industry-

led councils that coordinate workforce development efforts for manufacturing firms, could serve as models for Oregon.

Key Players
Oregon Legislative Assembly, Governor's Office, Oregon Talent Council, Oregon Office of Workforce Investments, Bureau of Labor and Industries, Unions

Case Study: Massachusetts Advancement Center Workforce Innovation Collaborative (MACWIC)
MACWIC was founded in 2012 to help improve the coordination of manufacturing-related training programs in the state.[178] Led by manufacturing employers of all sizes in collaboration with a number of educational institutions, MACWIC's membership has grown from forty to just over 200 firms.[179] One of MACWIC's core achievements is the Applied Manufacturing Technology Pathway Certification, a five-tiered series of consecutive training modules offered at area community colleges, vocational-technical high schools, and other organizations.[180] This credential pathway includes multiple entry and exit points, provides opportunities for work-based learning, and helps workers progress from as low as middle school level math and reading skills to completing an associate degree in manufacturing technology. The pathway certification is also officially registered as a CNC Machine Operator apprentice program with the state's Division of Apprentice Standards.[181] MACWIC has been recognized as an excellent model of industry-led coordination by MIT, Jobs for the Future, and the Center for Law and Social Policy (CLASP).[182]

Case Study: Kentucky Federation for Advanced Manufacturing Education (KYFAME)
KYFAME is a partnership of regional manufacturers who have created dual-track apprenticeship programs in collaboration with Kentucky's higher education network. KYFAME is divided into regional chapters organized around local manufacturing clusters, allowing programs to be customized to the needs of specific employers and regional economic conditions.[183] Students spend a combined forty hours per week working for a partnership member and taking classes at a community college.[184] Most students earn enough on work days to cover their tuition costs.[185] After five semesters, students receive an A.A.S. in Industrial Maintenance Technology-Advanced Manufacturing Technician Track.[186] KYFAME was named the "Best Career Program in the U.S." in 2013 by the Department of Labor and has been replicated in seven states.[187]

Policy 9: Increase Work-Based Opportunities for High School Students

Barrier
Oregon has room for improvement in preparing youth for the jobs of the future. In the 2014-2015 school year, Oregon graduated only 73.8 percent of its public high school students – the third lowest rate in the country.[188] Minorities, students with disabilities, students in poverty, and men are disproportionately less likely to complete high school on time.[189]

Solution
Offering enrollment in Career and Technical Education (CTE) programs is correlated with higher graduation rates. Oregon's existing CTE programs, which provide students with experiential and work-based learning opportunities, have shown promise: In 2014, 88 percent of CTE-enrolled students graduated from high school, sixteen points higher than the statewide graduation rate.[190] This effect was even stronger among underprivileged groups, such as African-American students,

Hispanic/Latino students, and students living in poverty.[191] This statistic illustrates how hands-on experience can spark student achievement. To ensure the competitiveness of its future workforce and help more students graduate, Oregon could broaden the scope and accessibility of its promising CTE programs.

INSERT QUOTE BOX
"Oregon communities overwhelmingly desire a return to and reinvestment in CTE and CTE-like curriculum that not only provides alternative learning opportunities for students, but also an introduction to the broader opportunities available for students desiring a direct path to employment after graduation."[192] *Oregon's Chief Education Office*
END QUOTE BOX

One way to expand on the promise of CTE programs is to increase state funding for work-based learning opportunities such as youth apprenticeships. To fund this expansion, Oregon could divert resources from Measure 98, a school funding ballot initiative aimed specifically at boosting high school achievement and graduation rates that was approved by voters in 2016. The maximum cost per person of Wisconsin's highly effective Youth Apprenticeship Program is only slightly higher than the per-student funding available in Oregon under Measure 98 (*see case study*).[193] Aimed at high school juniors and seniors, Wisconsin's program could provide a structural model for a similar program in the Beaver State.

Key Players
State Board of Education, Oregon Legislative Assembly, Governor's Office, Oregon Talent Council, Oregon Office of Workforce Investments

Case Study: Wisconsin Youth Apprenticeship Program
With its program originating in the early 1990s, Wisconsin was one of the first states to support youth apprenticeships. Participating students enroll for one or two years and must complete 450 hours of work-based learning annually.[194] As part of the work-based component, students are assigned a worksite mentor who provides them with regular feedback on their work and progress.[195] Many programs also take place year-round, so it is common for students to work over the summer.[196] Supplementary classroom learning is provided by trained instructors with relevant field expertise, and apprenticeships are offered in a wide variety of workplaces, from agriculture to information technology.[197] Each program has learning goals established by local consortia comprised of employers and educators and is overseen by a regional coordinator.[198] With $3.9 million in state funding, matching funds from local consortia, and a cost limit of $900 per student, Wisconsin's Youth Apprenticeship Program will have supported over 4,300 students in the 2017-2018 school year.[199] The program has been remarkably successful in driving outcomes: In 2013, the program resulted in offers of employment to 84 percent of students who completed their apprenticeship.[200]

Value Chain

Policy 10: Build a Comprehensive Next-Generation Manufacturing Cluster Partnership

Barrier
Oregon is home to a vibrant community of nonprofits and industry associations relevant to NGM. Some promote energy efficiency, such as the Energy Trust of Oregon and the Northwest Energy Efficiency Alliance; others, such as OMIC, spearhead advanced manufacturing techniques. Yet no action plan exists for the diverse constituents of the NGM industry to coordinate efforts to grow a cluster.

Solution
Oregon's NGM sector could benefit from the creation of a formal public-private partnership specific to NGM, wherein industry executives partner with existing industry associations, NGOs, and government leaders to engage with stakeholders and create a specific plan for growing the cluster.

The partnership could take the lead on enabling collaboration across the value chain in areas such as knowledge sharing, asset growth, policy advocacy, and cluster development. Specifically, this public-private partnership could conduct a variety of inward- and outward-facing activities to support its participants and grow the industry. Inward-facing activities could pursue shared interests through internal coordination, such as:

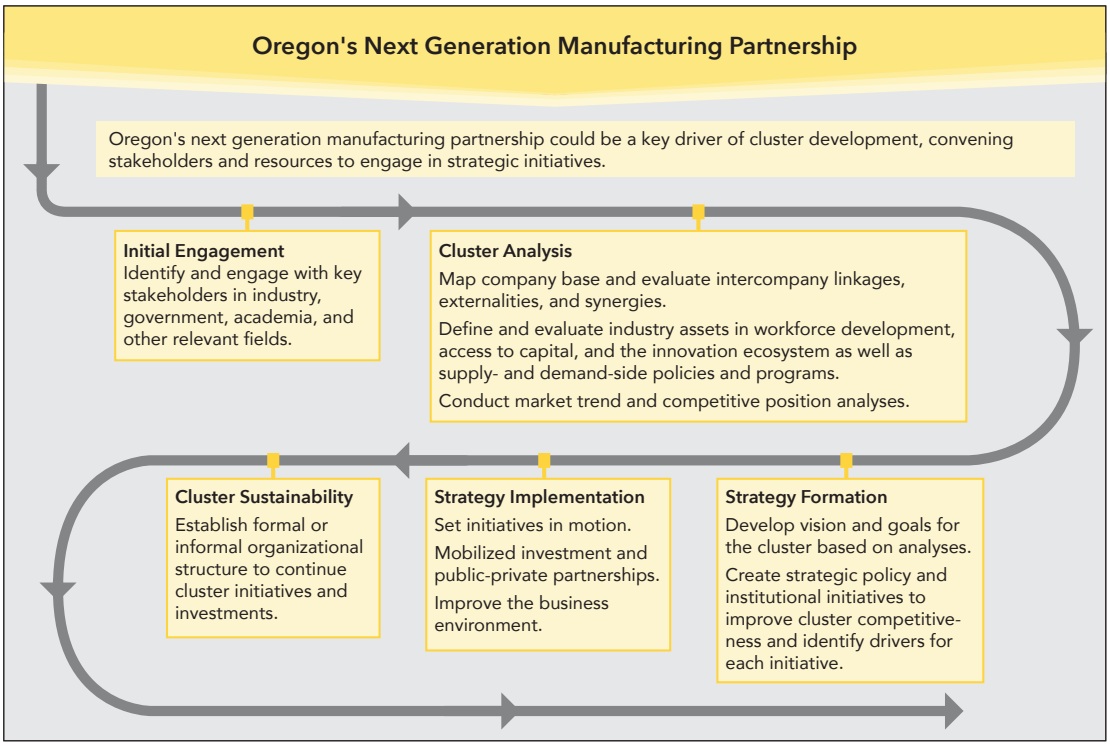
- Mapping the supply chain and broader value chain of the state's NGM industry to serve as a business resource, marketing asset, and recruitment tool, using Wisconsin's Supply Chain Marketplace as a model (*see case study*).
- Advocating for policies such as an incumbent worker training tax incentive (*see Policy 7*).
- Identifying skill areas employers most need to create incumbent worker training programs.
- Developing a shared research agenda that tackles industry challenges.
- Collaborating on large regional and federal contract opportunities.
- Supporting the development of STEM curricula and industry-specific training programs.

Outward-facing activities could help to communicate the industry's economic impacts and market opportunities by:

- Conducting a cohesive and high-impact outreach campaign to promote investment in NGM technology (*see Policy12*).
- Hosting knowledge-sharing events for policymakers and other stakeholders.
- Organizing research projects and hackathons to solve industry challenges.
- Supporting participation in trade shows and networking events.
- Leveraging relationships with aerospace, semiconductor, and other manufacturers to help startups develop an initial customer base.
- Facilitating out-of-state funding opportunities for startups (*see Arizona case study*).
- Advocating for policies that increase demand for NGM technologies and services and support business development.

The partnership could engage and draw on the existing resources, expertise, and networks of in-state industry associations that are working to advance the interests of NGM companies in the state. Oregon could look to North Carolina and Kansas as strong public-private partnership models for cluster development (*see case studies*).

Once the partnership has solidified a cluster growth plan, it could formalize and create a Next-Generation Manufacturing Center of Excellence to oversee ongoing initiatives. Centers of Excellence, when structured in tandem with industry, are an effective means to coordinate industry-wide growth efforts. Oregon could replicate successful models from South Carolina (*see case study*). An NGM Center of Excellence would signal Oregon's commitment to cultivating the cluster in the state and create the "buzz" that the state's industry needs to attract investment.



Key Players
Business Oregon, Companies, Universities, NGOs, Technology Association of Oregon, OMEP, Prosper Portland

Case Study: Wisconsin Supply Chain Marketplace
The Supply Chain Marketplace is a dynamic online platform for Wisconsin suppliers to engage new customers and facilitate buyer connections, supporting local business growth and providing access to new market opportunities. The Marketplace is open to all businesses free of charge, where suppliers can showcase their business capabilities; be readily searchable to potential buyers by targeted industry sectors, certifications, and ownership; and access requests for proposals and calls for innovation.[201] The Supply Chain Marketplace was initially launched by New North, the northeast Wisconsin economic development group, as a regional economic diversification asset,

with support from the U.S. Department of Defense's Office of Economic Adjustment.[202] In 2017, the state awarded $99,000 to New North to expand the platform statewide, and it now boasts over 1,000 local businesses.[203]

Case Study: Arizona's BioAccel

Based in Phoenix, Arizona, BioAccel is a nonprofit organization dedicated to providing funding and entrepreneurial expertise to life science companies.[204] A main goal of the organization is to foster an entrepreneurial ecosystem through education, outreach, training, and mentorship. Since over 95 percent of venture funding for bioscience comes from outside the state, bioscience companies relocate from Arizona to wherever capital is available. [205] BioAccel helps combat this trend by providing proof-of-concept and seed funding to bioscience startups, and facilitating later-stage financing from local venture funds when appropriate.[206] Since its inception in 2009, BioAccel has helped launch seventeen firms.[207]

Case Study: North Carolina's Cleantech Cluster

North Carolina's Research Triangle Regional Partnership—an association of economic development agencies in the state's Research Triangle region—founded the Research Triangle Cleantech Cluster (RTCC) as a way to strategically engage industry leaders in the regional development of the cleantech industry.[208] Notably, while RTCC's Advisory Council bridges the public-private divide by drawing from industry, academia, and government, the Board of Directors that steers the cluster is composed exclusively of business leaders.[209] This organizational structure positions industry players to contribute valuable insight and to substantially influence the industry's regional growth strategy. Among other technology areas, RTCC strategically targeted the smart grid industry for growth and engaged local anchor companies to spearhead efforts to build the state's cluster.[210]

Case Study: Kansas Aviation Research & Technology Growth Initiative

The Kansas Aviation Research & Technology Growth Initiative aims to fortify the state's robust aerospace industry by leveraging university expertise, industry leadership, and government funding. Based at Wichita State University's National Institute for Aviation Research (NIAR), the program uses $5 million from the Kansas Department of Commerce and requires matching funds from industry, university, and philanthropy partners to support industry-driven research projects and equipment/infrastructure upgrades at NIAR.[211] The executive committee is comprised of the state's anchor companies and identifies research projects based on industry needs and potential for improved competitiveness.[212]

Case Study: Clemson University International Center for Automotive Research (CU-ICAR)

CU-ICAR is an automotive center of excellence dedicated to quality education, industry-focused research, public outreach, and economic development.[213] The center anchors South Carolina's automotive cluster and grew out of early discussions with BMW on how to stimulate technology commercialization and build a local skilled workforce. The South Carolina Department of Commerce provided an initial investment of $40 million and other founding partners across government, academia, and industry—including BMW, Michelin, and Timken—have contributed follow-on funding.[214] CU-ICAR houses the only U.S. graduate program in automotive engineering and has seven strategic research areas derived from industry needs.[215] With over twenty campus partners, CU-ICAR actively engages them to locate and collaborate on commercial R&D projects,

support graduate student internships and capstones, lease office space, and leverage the center's commercial-scale equipment and testing services.[216] Since 2003, the center has attracted $250 million from public and private investments, supported 770 on-campus jobs and thousands more across partner companies, and channeled hundreds of graduates into automotive jobs, while keeping a quarter employed in the state.[217]

Policy 11: Reinstate and Improve the R&D Tax Credit

Opportunity
In 2017, Oregon allowed its decades-old R&D tax credit to expire.[218] The legislature found that the credit was not a significant driver of research investment and was mostly used by large companies with high net incomes.[219] However, a credit that is narrowly targeted at either small enterprises in strategic sectors or at projects that significantly increase R&D investment could provide critical support to startups in the NGM value chain while encouraging companies to place big bets on potentially breakthrough research that might otherwise be too risky. In the Legislative Assembly's assessment of the old tax credit's effectiveness, some of these features were mentioned as potential ways to improve the credit.[220] While keeping in mind its history with business tax credits, Oregon could craft an effective R&D tax credit that supports the growth of companies of all sizes in the NGM value chain while curtailing opportunities for abuse.

Solution
Due to the inherent risk of R&D investments and scarcity of capital, research has shown that tax credits have the greatest effect on increasing R&D investment among small enterprises.[221] Enabling small enterprises to benefit from the tax credit, even if they do not yet have tax liabilities, is critical for a credit to achieve its full potential for impact. An effective modification to Oregon's previous tax credit could be to make it refundable or otherwise more valuable for companies below a certain size (*see Maryland case study*). Startups in emerging fields, such as metal 3D printing materials, are an essential component of the NGM value chain. Giving these startups a tax incentive they can benefit from at a time when they most need support could help bolster the growth of Oregon's NGM industry from the bottom up.

Oregon's modified R&D credit could also reward one-off substantial increases in R&D investment. Under such a plan, a company would be entitled to more tax credits if their R&D investment increases by more than 50 percent in a given year, encouraging companies of all sizes to make big commitments to high-risk research areas with potentially high rewards for the public interest (*see Maine case study*). Finally, Oregon could also target the credit at industries or project types of strategic value to Oregon, such as NGM (*see Arkansas case study*). To protect the state from delivering windfalls to companies that do not need financial support to increase investment, Oregon could consider capping the credit's availability to businesses or projects that fall outside the credit's strategic target categories.

Key Players
Oregon Legislative Assembly

Case Study: Maryland's Incentives for Small Companies

Enacted in 2012, Maryland's R&D tax credit is particularly lucrative for small companies. While all companies can claim a reduction in their tax liability worth 10 percent of research expenses above the set base amount, Maryland's tax credit is refundable for companies with net book assets under $5 million to the extent that the company's available tax credit exceeds its tax liability.[222] This allows startups with little or no tax liability to benefit from the research incentive and it also contributes to Maryland's reputation as an innovation-friendly state. In 2017, a national analysis ranked Maryland as the most innovative state in the country, surpassed only by the District of Columbia.[223]

Case Study: Maine's Research and Development Super Credit
In 1997, Maine enacted a Research and Development Super Credit.[224] Designed to encourage dramatic rises in R&D, the credit is equal to all research expenses above 150 percent of the average amount spent on research in the three years preceding 1998.[225] In the four years after the credit's enactment, statewide R&D spending increased by 162 percent, compared with 30 percent over the four years preceding enactment.[226] By 2002, Maine ranked forty-third out of fifty states in total R&D spending, up from forty-seventh in 1998.[227]

Case Study: Arkansas' Strategic Value R&D Incentives
Arkansas' Strategic Value Research and Development incentives provide a 33 percent credit on income tax liability for qualified research expenses in a strategic area.[228] Strategic areas are fields with long-term economic or commercial value to the state and those which have been identified in the state's R&D plan approved by the Arkansas Science and Technology Authority.[229]

Policy 12: Broadcast Oregon's Business Assets

Opportunity
With abundant natural resources, low energy costs, and a low cost of living, Oregon is a fertile climate for NGM businesses. However, business leaders around the world are under-informed about Oregon's advantages; many overlook Oregon's opportunities due to its small population and its location just north of California. Meanwhile, Oregon's economic development marketing team has no staff devoted specifically to supporting business recruitment and retention and spends relatively little on marketing assets or paid media.[230] At the same time, the website for Oregon's economic and business development agency, Business Oregon, does little to draw in unaccustomed visitors. Modest investments in Oregon's brand, website, and media strategy can demonstrate its value to small- and medium-sized enterprises looking to relocate, bringing more NGM firms into its value chain.

Solution
The starting point for an improved marketing strategy could be a new Oregon brand that reflects the state's reputation for forward-thinking leadership and culture. Once complete, this brand could be placed front and center on a revamped, world-class economic development website. Research shows that a user-friendly website is the most important component of an effective economic development marketing strategy, and Oregon could improve its current online presence by simplifying its landing page while making information about incentives and site location easier to access.[231] Finally, Oregon could invest in a digital media campaign that precisely targets the small- and medium-sized business executives that comprise the state's best recruitment prospects. By

creating high-quality video content, hiring dedicated staff, and making modest investments in digital advertising, Oregon can get its brand in front of NGM decision makers. The experiences of Tennessee and South Carolina (*see case studies*) show how modest investments in digital strategy, built around a strong brand and aimed at small- and medium-sized business leaders, can bring jobs and investment to a state.

Key Players
Business Oregon, Oregon Legislative Assembly

Case Study: Mastered in Tennessee
In 2015, Tennessee launched its award-winning "Mastered in Tennessee" campaign.[232] The campaign used a state-of-the-art website, high-quality video content, and an active presence on all major social media channels to showcase the quality of Tennessee's artisanship.[233] To build these assets, Tennessee contracted with a local design firm.[234] Their website includes a visually stunning landing page, easily available site selection information, and navigable menus offering a variety of content depending on the site visitor's industry.[235] Tennessee supported these assets with an annual investment of $600,000 in highly targeted digital advertising.[236] The state's investment paid off; in 2016, Tennessee led the nation in small business job growth.[237] In a recent survey of economic development organization members, Tennessee was rated the third-highest of all fifty states in economic development marketing program success.[238]

Case Study: South Carolina is "Just Right"
South Carolina also has one of the best regarded economic development marketing programs in the country. It is not surprising: Their website is appealing and clear, with a wealth of relevant information that is easy to find for all kinds of businesses. South Carolina's program began with the creation of a statewide brand, "Just Right." With uniform messaging and a consistent look and feel across all assets and communications, South Carolina's marketing team has over-performed. In 2014, South Carolina's economic development team directly won 146 projects, representing $5 billion in investment and leading to the creation of over 19,000 jobs.[239]

Policy 13: Accelerate Foreign Direct Investment Efforts for Next-Generation Manufacturing

Opportunity
Working to attract foreign direct investment (FDI) is a common strategy to bring new jobs and capital into the state economy. FDI can be of particular value to Oregon's NGM industry, as many of the largest and most innovative companies in 3D printer manufacturing, the industrial IoT, and advanced materials are based outside of the United States. Despite a talented workforce and coastal geography, in 2015 Oregon ranked 41st out of 50 states in FDI jobs per capita and FDI supported 25 percent fewer local jobs than it should have, given Oregon's population size.[240] Furthermore, the state only has one office overseas, compared to nine overseas trade offices for Tennessee and thirteen for Florida.[241] To create new jobs and strengthen its NGM cluster, Oregon could prioritize FDI outreach. Through more strategic stakeholder engagement, targeted missions, and a program dedicated to helping foreign companies relocate, state leaders could fill key supply chain gaps and make Oregon an easy option for NGM firms looking to expand to the United States.

Solution
Organizations such as SelectUSA, the US Cluster Mapping Project, and the European Cluster Collaboration Platform serve as intermediaries for U.S. and international companies.[242] Oregon officials could engage with these networks more aggressively to highlight its cluster assets and attract NGM firms from overseas.

Oregon could further enhance its presence abroad by establishing more formal relationships with potential trade partners, particularly in Germany and France, where leading NGM firms are located. An alternative to establishing more overseas trade offices is to forge innovation partnerships in key countries. These innovation partnerships can begin as research collaborations and can grow into more robust trade relationships (*see case study*). Finally, state leaders can build relationships with international NGM clusters and industry organizations, such as the European Association of Machine Tool Industries (CECIMO), the European Powder Metallurgy Association, and the Industrie 4.0 initiative in Germany.[243] Oregon could leverage relationships with these organizations to highlight its NGM cluster assets and attract foreign firms.

Oregon could also establish a program focused on helping foreign firms overcome the logistical hurdles that complicate international expansion. This program could help companies with investment business plans, economic impact studies, and general advice to help them navigate the complex immigration, legal, and business landscape of opening an office in a new country (*see case study*). Through this process, Oregon could proactively identify and engage with target firms in the NGM industry. Local universities and lead generation consultants, such as WAVTEQ and OCO Global, could help assess potential FDI opportunities. Once fully focused and engaged, Oregon's strong network of partners could help bring leading NGM firms to Oregon, creating jobs and fortifying the state's value chain.

Key Players
Business Oregon, Universities, NGM Center of Excellence (*see Policy 10*)

Case Study: Massachusetts-Israel Innovation Partnership
The Massachusetts-Israel Innovation Partnership offers an innovative model for facilitating global connections. Launched in 2011 after the governor's mission to Israel, the partnership grew from an industry research collaborative to a joint FDI partnership. Major Israeli companies have expanded operations into Massachusetts, and domestic firms have invested in Israeli intellectual property and R&D.[244] As of 2015, more than 200 Israeli-founded companies have made a home in Massachusetts; altogether, these firms accounted for $9 billion in direct revenue, $18 billion in total economic impact, and 4 percent of the state's GDP, as well as 9,000 direct jobs and 27,000 indirect and induced jobs.[245]

Case Study: The Texas International Business Accelerator
The Texas International Business Accelerator (TIBA) provides critical assistance to foreign firms looking to invest in the Lone Star State. While the United States is known globally for its friendly business environment, investing in a new country is always a legal, logistical, and cultural challenge. TIBA eases that transition by providing technical assistance and practical local market knowledge to help clients establish operations and set up investment projects.[246] Many of TIBA's

clients are small- and medium-sized enterprises that get overlooked by consulting firms.[247] Since its inception in 2011, TIBA has brought over $136 million in FDI to Texas.[248]

START CALL-OUT BOX

Best Practices for FDI and Exporting Programs

The U.S. Department of Commerce commissioned an extensive study of the most successful FDI and exporting programs around the country and found that state leaders of these programs share several key practices.[249] The report found that they:

- Engage universities in making international connections and economic development.
- Foster strong relationships with economic development resources engaged in FDI.
- Collect good data about companies in the cluster.
- Develop contact points at companies overseas.
- Embrace and adapt to cultural differences, e.g., language-specific business cards and marketing materials.
- Commit to long-term involvement in FDI efforts.

END CALL-OUT BOX

Local Market

Policy 14: Create a Next-Generation Manufacturing Showcase Program

Barrier

Networked equipment and precision machinery remain rare in many industries, despite their efficiency and productivity benefits. Attracting the interest of manufacturers who have more pressing concerns is a considerable obstacle to NGM technology deployment. Without clear validation from peers in their industries, many manufacturers will not take the time to investigate the efficiency advantages NGM technology can offer.

Solution

Installing new and relatively unknown technologies carries inherent risk. Awareness of a new technology and validation of its usefulness typically spreads through behavior of one's peers within a distinct group (*see case study*).[250] Oregon could increase awareness and interest in NGM technologies among manufacturers in industries with low technology penetration by funding showcase projects with firms in those industries. The state could identify target manufacturers in partnership with Energy Trust of Oregon, the Bonneville Power Administration, Portland General Electric, and Oregon BEST. Oregon's legislature could provide a subsidy covering all project costs for projects that use locally-built solutions, minimizing risk to manufacturers. Finally, Business Oregon, in collaboration with Oregon BEST, could promote showcase projects around the state and the country. These showcases could provide critical peer validation for NGM technologies that are unfamiliar to some manufacturers, proving that they are worth the upfront cost and that the benefits are tangible. This could help establish new local markets for NGM startups, driving inbound investments and enhancing cluster growth.

Key Players
Oregon Legislative Assembly, Energy Trust of Oregon, Bonneville Power Administration, Portland General Electric, Business Oregon, Oregon BEST

Case Study: Residential Solar Panels in California
A 2012 research study demonstrates how peer behavior influences the adoption of energy-related equipment. By examining patterns of solar panel installation by California residents across a range of zip codes, researchers from New York University and Yale University found that each new solar panel installation increased the probability of a future installation on the same street by 15 percentage points.[251] Simply seeing a peer install a solar panel significantly increased the likelihood of a homeowner doing the same. This effect led to accelerating concentrations of solar equipment in zip codes where panels were already installed, independent of population density.[252] The report's authors conclude that "increasing the visibility of adoptions would be expected to increase the rate of adoption."[253] An NGM showcase program could recreate this "neighborhood peer effect" within industries, facilitating higher levels of NGM adoption.

Policy 15: Allocate Funding for Embedded Energy Efficiency Experts

Opportunity
Increasing energy efficiency requires manufacturers to understand where gains can be made, identify the right solution, supervise implementation, and ensure efficient energy practices on an ongoing basis. These processes take a lot of time, but staff resources are in high demand just to maintain existing operations and meet production quotas. Many manufacturers would like to install NGM equipment and use less energy, but simply do not have the time or personnel to do it. While the Energy Trust of Oregon provides strategic energy management expert consultations and the Bonneville Power Administration partially funds energy project managers at its industrial customers, Oregon lacks a fully-funded, full-time expert program to ensure more manufacturers have the staff resources they need to reduce their energy consumption.[254]

Solution
Oregon could provide funding for energy efficiency project managers to be embedded at manufacturers with large energy savings potential. These experts could be their respective facilities' point person for identifying and capitalizing on opportunities to boost energy efficiency through the use of NGM technologies and systems.

To identify participating manufacturers and administer the program, Oregon could rely on the expertise and local knowledge of the Energy Trust of Oregon and the Bonneville Power Administration (BPA) in their respective territories. The project managers could be full-time or part-time, depending on the needs of the manufacturer. With dedicated onsite experts focusing on energy efficiency projects, busy manufacturers would be able to capitalize on valuable savings opportunities by adopting NGM technology. Oregon could expand on the successful program model employed by the Bonneville Power Administration (*see case study*) while taking other key lessons from New York's On-Site Energy Manager Program (*see case study*).

START CALL-OUT BOX

Leveraging Retired Experts

Many retired scientists and engineers are willing to engage in new projects on a limited basis. Retired energy efficiency managers and production engineers could be ideal candidates to serve in an embedded expert program. Energy Trust of Oregon and the Bonneville Power Administration could leverage groups such as the American Association for the Advancement of Science to provide expertise for Oregon's manufacturers.

END CALL-OUT BOX

Key Players

Oregon Legislative Assembly, Energy Trust of Oregon, Bonneville Power Administration

Case Study: Bonneville Power Administration's Energy Project Manager Program

The BPA Energy Project Manager Program helps industrial customers with ongoing energy efficiency efforts by embedding a project manager in customer facilities.[255] Each project manager, whose salary is co-funded by BPA, typically remains embedded at their designated facility for a year or more.[256] During that time, project managers oversee machinery retrofits, strategic energy management, and measures of per-unit efficiency gains. Together with other components of BPA's Energy Smart Industrial initiative, the energy project manager program has helped 473 industrial customers save 647 million kilowatt-hours of electricity.[257]

Case Study: New York's On-Site Energy Manager Program

In 2016, New York launched multiple initiatives to promote industrial energy efficiency, including the On-Site Energy Manager program.[258] This initiative provided $7 million in funding for large- and medium-sized industrial facilities to hire a full-time, on-site energy manager.[259] Through a competitive application process, the New York State Energy Research and Development Authority selected thirty facilities to receive state support to put a staff member into the energy manager role for one year, helping these facilities increase productivity and energy efficiency on an ongoing basis.[260] Comparable initiatives undertaken by New York manufacturers have reduced consumption by almost 5 percent, which represent significant cost savings.[261]

Policy 16: Enact an Energy Efficiency Property Tax Incentive

Opportunity

When manufacturers evaluate the costs and benefits of installing NGM equipment, they consider the potential increase to their tax burden. Oregon's property tax exemption for alternative energy systems allows manufacturers to install renewable generation capacity to their facilities without increasing their property tax liability. However, eligible projects exclude installation of equipment that increase energy efficiency.[262] Thus, manufacturers could see their property taxes increase as a result of installing NGM technologies to their facilities. NGM technologies can create energy savings up and down the supply chain, but are not specifically encouraged by the tax code.[263] Given Oregon's low energy costs, a tax incentive could be especially important to driving adoption of NGM technologies.

Solution
Oregon's legislature could amend the existing property tax exemption to include building upgrades or equipment that increases onsite or upstream energy efficiency. Such an incentive could provide a helpful supplement to the rebates already offered by the Energy Trust of Oregon, which alone may not be enough to motivate manufacturers to invest in NGM technology. To assess onsite energy efficiency, Oregon could rely on the Energy Trust's eligibility requirements, which allow projects that reduce energy intensity, or energy used per unit of production, at a facility.[264] Alternatively, the exemption could specify technologies known to reduce lifecycle energy consumption, such as additive manufacturing, as eligible for the exemption. By exempting projects that increase onsite and upstream energy efficiency from property taxation, Oregon could improve the financial viability of NGM installations and retrofits, promote further energy savings, and build a local market for Oregon's emerging NGM cluster.

Key Players
Oregon Legislative Assembly

Case Study: Ohio's Air Quality Improvement Tax Incentives
First enacted in 2002, Ohio's Air Quality Improvement Tax Incentives exempt qualified technologies and businesses from the property tax, corporate franchise tax, and sales and use tax.[265] These incentives encourage the use of technologies to reduce harmful pollutants before they are emitted into the atmosphere. Eligible projects include any device, property, or equipment that contributes to more efficient electricity utilization.[266] Between 2002 and 2015, Ohio's statewide energy intensity declined by 13 percent, a larger decrease over the same time period than that of neighboring states of the industrial midwest.[267]

Case Study: Arizona's Energy Equipment Property Tax Exemption
In 2009, Arizona's legislature expanded its solar energy property tax exemption to include energy-efficient building components.[268] Under this provision, qualifying renewable energy systems and energy efficiency upgrades are considered to add no value to a property's assessed value, allowing manufacturers to install energy-efficient technology without worrying about an increased tax burden.[269] In the six years following enactment, Arizona's energy consumption per unit of output declined by five percent, and between 2009 and 2017, Arizona rose from twenty-ninth to seventeenth in the American Council for an Energy Efficient Economy's state energy efficiency rankings.[270]

Call to Action

Oregon's emerging NGM cluster is a solid foundation upon which the state can grow its economy, support over 65,000 jobs, and become a leader in the production and deployment of advanced energy technology. The policies recommended in this report are complementary and intended to help Oregon manufacture products within the state, foster entrepreneurship for technological advances, fund innovation with accessible capital, equip workers with needed skills, and grow demand for NGM technology.

START QUOTE BOX

Oregon has the opportunity to support an average of over 65,000 direct, indirect, and induced jobs annually in the next-generation manufacturing industry from 2018 through 2030. This cluster is well positioned to serve a significant portion of national demand, especially considering its skyrocketing global demand, promising cluster assets, complementary industries, and the unique expertise of its workforce.

END QUOTE BOX

To fully realize Oregon's potential in the NGM industry and position the state for continued growth, policymakers will need to make a concerted effort to seize the opportunity presented by increasing global demand. Strong leadership plays an important role in promoting Oregon's competitive advantage in the industry and creating quality jobs. State and local economic development depend on the collective work of many partners across government, universities, industry, and other stakeholders. This report recommends actions that each group can take to support the NGM technology cluster. As effective first actions, Oregon's leaders could establish an NGM cluster partnership to chart a path moving forward; establish a center of excellence to catalyze innovation and entrepreneurship in NGM technology; enable statewide entrepreneur resource coordination; increase access to long-term capital; expand training programs for incumbent workers; and establish an NGM technology showcase program. Continued collaboration is necessary to address barriers to cluster growth and demonstrate that the state is ripe for investment.

Oregon's leaders can draw from dozens of innovative strategies that city, county, and state governments across the country and abroad have implemented to create job opportunities in the advanced energy industry. Examples of these best practices and a fully cited version of this report can be found on the American Jobs Project website at http://americanjobsproject.us/. Furthermore, the American Jobs Project can continue to serve as a partner to Oregon by organizing working groups and conducting deeper analyses, such as identifying value chain gaps, exploring policy strategies, and evaluating the state's comparative advantage in other advanced industries.

When a state succeeds in building an economic cluster, the benefits are felt throughout the state: a more resilient state economy, a skilled twenty-first century workforce that is trained for the jobs of tomorrow, a firm base of young people optimistic about job opportunities close to home, and a rich hub for innovation and collaboration.

START CALL-OUT BOX

Growing the Next-Generation Manufacturing Cluster, Growing Jobs

- Enable Statewide Entrepreneur Resource Coordination
- Support Product Testing Resources for Technology Commercialization
- Foster the Commercialization Culture at Universities
- Increase Access to Long-Term Capital
- Create a Capital Gains Tax Exemption
- Establish Oregon's Capital Locator Tool
- Expand Training Programs and Opportunities for Incumbent Workers
- Create An NGM Industry Council to Coordinate Workforce Training
- Increase Work-Based Opportunities for High School Students
- Build a Comprehensive Next-Generation Manufacturing Cluster Partnership
- Reinstate and Improve the R&D Tax Credit
- Broadcast Oregon's Business Assets
- Accelerate Foreign Direct Investment Efforts for Next-Generation Manufacturing
- Create a Next-Generation Manufacturing Showcase Program
- Allocate Funding for Embedded Energy Efficiency Experts
- Enact an Energy Efficiency Property Tax Incentive

END CALL-OUT BOX

Appendix 1: Other Technologies That Show Promise for Oregon

The American Jobs Project chooses an advanced energy technology for each state report by examining existing manufacturing capacity, resource availability, political feasibility, level of state investment, jobs and economic outlook, capacity for decarbonizing the economy, and level of commercial readiness, and other criteria. Based on Oregon's competitive advantages, we identified NGM as the best opportunity for the state to strengthen its manufacturing base and support good-paying jobs. Given that demand for all advanced energy technologies is growing, we will briefly outline other technologies that have strong potential in the state, as well as reasons why they were not chosen as the focus technology of the report.

Cross-Laminated Timber (CLT)

- When used in tall building construction, CLT can provide significant energy efficiency improvements over traditional materials without sacrificing strength, stability, or fire resistance.[271]
- Oregon has a long history of timber production with a significant pre-existing forest products workforce and plentiful natural timber resources.[272]
- Policies promoting timber innovation can earn bipartisan support.[273]
- In addition to timber manufacturing, there is potential for growth in complementary industries, such as adhesives.[274]
- The market for CLT is limited compared to other technology categories, and needs time to mature beyond existing niches.[275]

Grid Modernization

- Oregon has a robust network of supportive NGOs and industry groups, including SmartGrid Northwest and Power Oregon.[276]
- Significant testing of grid modernization technologies is already underway in Oregon.[277]
- Oregon's renewable portfolio standard of 50 percent by 2040 will require deployment of non-hydro renewables, and grid modernization technology could be essential to bringing these new energy sources online.[278]
- Neighboring Washington is already a hub of smart grid technology manufacturing.[279]

Wave Energy / Hydrokinetic Energy

- There has been consistent investment in wave energy in Oregon, including a $40 million grant from the U.S. Department of Energy in December 2016.[280]
- Oregon universities have been at the forefront of research in making wave energy a reliable and cost-effective energy resource.[281]
- Strong partnerships exist between the Oregon Wave Energy Trust and research institutions.[282]
- The technology is years away from market viability, with no existing manufacturers of the technology in Oregon.[283]

Appendix 2: Oregon Companies in the Next-Generation Manufacturing Value Chain

Networked Industrial Process Equipment

Mentor Graphics Corporation
Huntair, Inc.
Dwfritz Automation, Inc.
Veris Industries
Concept Systems, Inc.
Inseego North America, LLC
Cascade Energy, Inc.
Printonia, LLC
INOVEC Inc
Powin International, LLC
BasX, LLC
Lucidyne Technologies, Inc.
Corrigo Incorporated
Engineering Design Team, Inc.
Northwest Analytics, Inc.
Wagner Electronic Products, Inc.
Fabtrol Systems, Inc.
Info Sys Management, Inc.
Technical Marine Service, Inc.
DENT Instruments
Rigado Inc.
Stevens Water Monitoring Systems Inc
Electronic Controls Design, Inc.
Johnston Automation LLC
Jama Software, Inc.
Holjeron Corporation
Lewis Controls, Inc.
Trillium Engineering LLC
National Energy and Conservation, Inc.
Cascade Hydro-Air of Oregon, LLC
Scada International Inc.
Dry Canyon Communications, LLC
Flomatcher Inc.
Botermans, Inc.
Ventacity Systems Inc.
Cyber-Tech, Inc.
Beta Control Systems, Incorporated
OMS Motion, Inc.
NeoFocal Systems Inc
Microridge Systems, Inc.
M/D Control Systems, Inc.
Fuller Enterprises Inc
G & D Chillers Inc
Performance Automation, Inc.
Airscape, Inc
Global Cache, Inc.
Celstream Technologies Private Limited
Sweetsense, Inc.
Aem Technologies LLC
Clouston Hydraulics, Inc
InSpec Group
ImaginEnergy
PECI
Energy350
RHT Energy Solutions
Jamco Engineering Inc

Precision Manufacturing Machinery

Precision Machine and Manufacturing
Plural Additive Manufacturing
3D Systems (acquisition of Xerox's chemical group)
Korvis
ATI Metals
MTI Albany
i3DMFG
RapidMade
HP Open Materials Development Lab
Oregon Swiss Precision
Northwest Rapid Manufacturing
GoProto
ToPa 3D
Ultimate 3D
ESPI Metals
Treske Precision Manufacturing
Katon Precision Machining LLC
Cascade Steel Works LLC (ArcLight CNC)
Climax Portable
Rickard Engineering and Design
Usher Precision Manufacturing

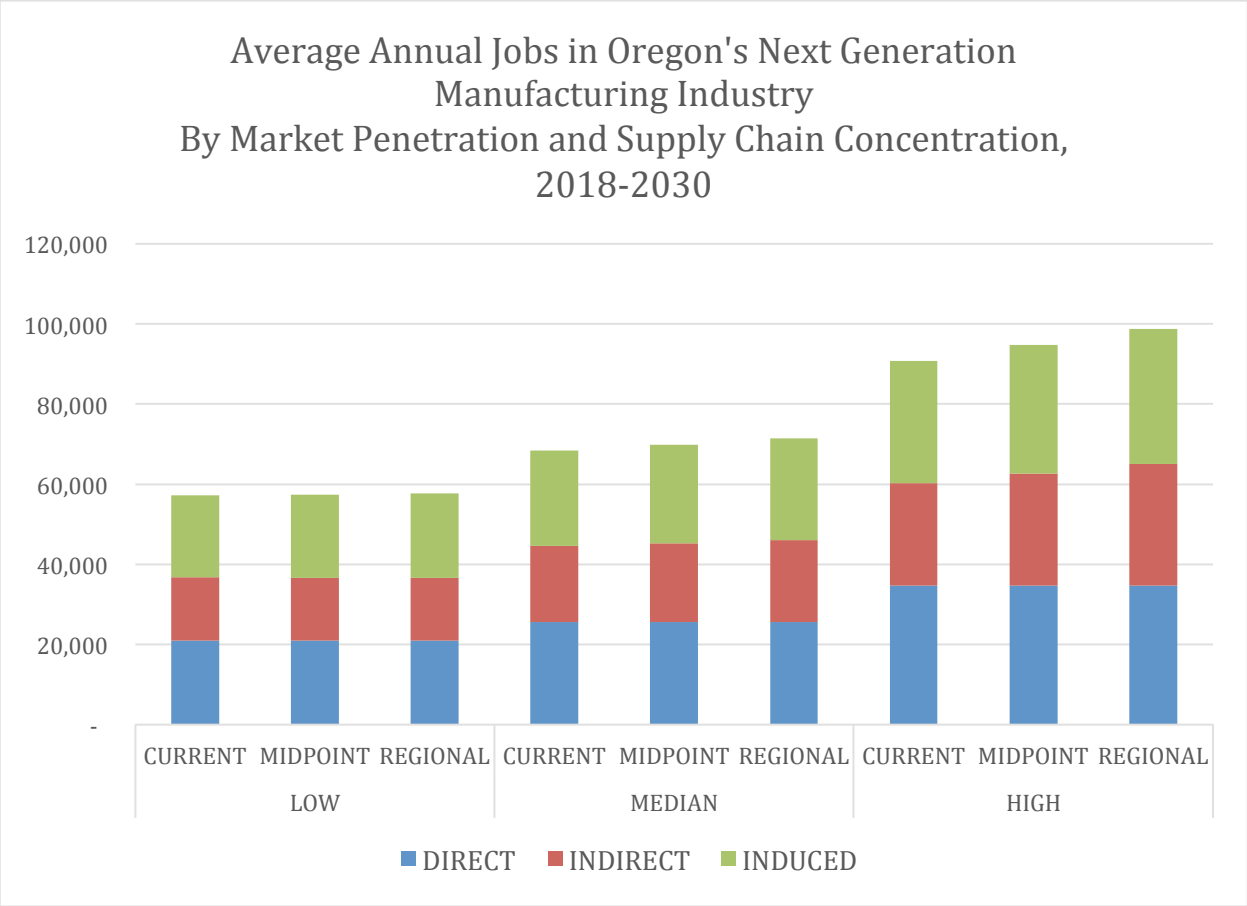
Appendix 3: Economic Impacts, Jobs Estimates, and Modeling Methodology

From 2018 through 2030, Oregon's next-generation manufacturing industry could support an annual average of over 65,000 direct jobs from manufacturing and software development, indirect jobs from suppliers, and induced jobs from spending in the local economy.

The American Jobs Project believes the key to job creation lies in local action. Our jobs estimates are intended to start a conversation about how state and local leaders can work together to set their goals and utilize the same tools and data that we have used to estimate potential impacts.

To estimate jobs potential for the NGM industry in Oregon, we utilize several reputable tools, analyses, and projections to determine global and national estimates of future demand, the current estimated state market penetration for NGM businesses, and industry benchmarks for wages and profits. We use these inputs to generate multiple industry growth scenarios based on varying levels of market penetration and supply chain concentration. Each scenario shows the average number of jobs that the in-state manufacturing and software industries could support annually from 2018 through 2030. The actual number of jobs in any given year could vary significantly from the average, and the annual average is intended to be a target over the analysis timeline.

We suggest that the Median market penetration and the Midpoint supply chain concentration are realistic goals for Oregon. If Oregon can grow its market share and build a supply chain to these levels, the industry could support an annual average of over 65,000 direct, indirect, and induced jobs from 2018 through 2030. Thus, the NGM industry could serve as a major vehicle for future state economic growth while creating quality jobs for Oregonians.



START CALL-OUT BOX

Definitions

Market Penetration
Amount of sales of a product as a percentage of the total sales volume for that product in a defined market.

Supply Chain Concentration
Level at which target industries could meet supply chain needs from in-state companies.

Direct Jobs
Jobs created or sustained due to direct increases in sales to companies in the target state industry.

Indirect Jobs
Jobs created or sustained due to higher demand for equipment, materials, and services from supplying industries that support the target state industry.

Induced Jobs

Jobs created or sustained due to increased local spending by employees of the target state industry and its supplying industries.

Multiplier Effect
Refers to when the economic impact generated is larger than the initial investment due to cascading spending from target state industry to its supplying industries and workforce to products and services in the local economy.

END CALL-OUT BOX

Modeling Approach

We utilize IMPLAN, a proprietary model maintained by the Minnesota IMPLAN Group, and its 2013 data package to conduct our regional economic analysis. IMPLAN uses average expenditure data to estimate how industry spending cascades throughout the economy to suppliers and consumer-facing industries. IMPLAN tracks multiple rounds of indirect and induced spending impacts until that spending "leaks" out of the selected regional economy, as determined by local purchasing coefficients built into the model.

Drawing from reputable sources, we develop multiple scenarios in which Oregon could grow its NGM industry. Each scenario represents varying levels of market penetration and supply chain concentration, which generate different inputs for the IMPLAN model.

Market penetration is shown at three levels (Low, Median, High), with the lower bound being Oregon's current estimated market share and the upper bound being a 4X increase in market share for NGM.[1] Another level represents the median between both bounds. We use Bureau of Labor Statistics' (BLS) Quarterly Census of Employment and Wages (QCEW) and IBISWorld data to estimate market share as a function of establishments, wages, and revenue.

Three supply chain concentration levels (Current, Midpoint, Regional) are presented to identify the impacts of growing Oregon's supply chain. The lower bound uses the current state economy, demonstrating the effect of merely maintaining the present level of supply chain concentration. The upper bound uses the Western Region (WA, OR, CA and NV) as the model to represent the impacts of Oregon having as complete of an NGM supply chain as is available in the selected states. Another level gives the midpoint between both bounds.

It is important to note that we do not include any financial impacts associated with the construction of new facilities that may result from an increased number of NGM firms locating in the Oregon economy during the analysis timeline, nor do we include installation, operations, maintenance, consulting or platform management jobs associated with NGM technology, as these estimates would be purely speculative.

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[1] Estimates for "Smart Manufacturing Application Development" Market Share were held constant at the "Low" level, as the high growth in this sector showed an outsized and unrealistic economic impact compared to current employment in this sector.

Model Inputs

We define NGM as the combination of hardware, software, and advanced manufacturing technology utilized in the manufacturing industry, that is focused on computer assisted machining, additive manufacturing, and enabling hardware and software for networked industrial process equipment. Our analysis utilizes North American Industry Classification System (NAICS) codes, the basis for most macroeconomic analysis and reporting. To estimate the economic impacts of NGM, we look at several associated technologies:

- 3D Printer Manufacturing
- 3D Printing and Rapid Prototyping Services
- Machine Tools
- Networked Industrial Process Equipment
    - Gateways and Connective Devices
    - Applications and Platforms
    - Connected Devices

Estimates of market demand for NGM technologies are taken from BCC Research, Grand View Research, and IBISWorld reports. Annual demand for our analysis timeline is derived from the current estimates and compound annual growth rates through 2030. We assume that the rates stay constant through 2030 since they do not project further into the future.

Estimates of average wages are taken from IBISWorld, IMPLAN, and BLS QCEW. Owner income is also derived from IBISWorld and IMPLAN wherever possible.

The current market penetration of Oregon's NGM industry is estimated as a function of current estimated employment and firms. IBISWorld's ratio for employment per unit of revenue and the current concentration of firms in Oregon, as well as QCEW employment and firms data, are applied to BIS Research, Grand View Research, and BCC's market demand totals to estimate current employment and revenues.

Model Outputs

Once the data is prepared for input into IMPLAN, we run the model for each scenario and generate the following direct, indirect, and induced estimates for Oregon's NGM industry: employment, labor income, GDP, total economic output, state/local tax revenue, and federal tax revenue. Only employment outcomes are given in this report. Additional output estimates are available by request.

We present employment as an average of annual jobs sustained. These outcomes are based on the total job-years, or one full-time equivalent job sustained for one year, that exist within the timeframe of our analysis. Jobs in any given year can vary greatly within the timeframe. Additionally, job losses in industries that compete with those in our analysis are not evaluated. Models do not perfectly predict behavior, so job estimates could vary based on the reality of what is purchased locally and the impact of foreign and domestic competition. The estimates presented

in this report are highly dependent on sustained local action towards developing and maintaining the target state industry.

Appendix 4: References for Infographics

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