The Montana Jobs Project

A Guide to Photonics and Advanced Energy Job Creation

MARCH 2017

AMERICAN JOBS PROJECT

A Letter from the American Jobs Project

It is no secret that America's middle class is in crisis; indeed, "the hollowing out of the middle class" has become a well-worn phrase, causing politicians to rail, bloggers to rage, and citizens to reel. Polls consistently reveal that jobs and the economy are at or near the top of citizen concerns. Of the millions of jobs lost during the recession, most were good-paying, middle-class jobs. Unfortunately, many of the jobs created during the recovery have been in low-skill, low-paying occupations. These trends are not going to reverse themselves. Leadership is needed, but the gridlocked U.S. Congress has failed in recent years to adopt robust policies to stoke middle-class jobs in America.

In President George W. Bush's autobiography, *Decision Points*, the former president recounts a conversation he had with then-President of China, Hu Jintao. "What keeps you up at night?" President Bush asked President Hu as an icebreaker. As we can easily guess, what kept President Bush up at night was concern over terrorism. Hu Jintao's response was telling: what kept him up at night was "creating 25 million new jobs a year" for his people.

Is it possible to create good-paying American jobs in today's global economy? And what if the solutions did not involve Congress at all? What if there were creative middle-class job creation strategies being developed and tested in the laboratories of democracy—the states and cities? The American Jobs Project seeks to answer these questions and provide a research-based guide to action for state and local leaders who are kept up at night trying to figure out how to create jobs for the people they serve.

Our quest starts with identifying the biggest market opportunity of our era: the global demand for advanced energy and its enabling solutions. The world is at the brink of a historic energy transformation and the United States plays a crucial role in accelerating the energy transition. Whether borne out of a need for diverse, reliable, and clean power or to achieve energy independence from unstable regimes, the growing demand for advanced energy and its enabling technology creates "the mother of all markets" for local U.S. businesses to build and sell those solutions. Strategically minded businesspeople looking at global growth projections in advanced energy demand are

making major investments and reaping large revenues. In 2015, the private sector reported nearly $1.4 trillion in global advanced energy revenues. Advanced energy investments are now bigger than the global apparel sector and nearly twice the size of the global airline industry. And jobs? At least 9.4 million people were employed in the global advanced energy sector in 2015, and doubling the share of renewables could nearly triple employment. The question for the United States is: Where will those new jobs be created?

The American Jobs Project is focused on finding ways to make our states the answer to this question. If countries across the globe, including the United States, are seeking technical products and 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 to build their advanced energy products?

It is true that the United States will not likely be able to attract the traditional manufacturing jobs of the past; those jobs are gone—either to low-wage countries or to automation—and we must accept the fact that they are not coming back. But our research shows that with innovative policies and a smart focus on industrial sectors, states can become global hubs of innovation and job creation in specific advanced industries that capitalize on each state's strengths.

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. Many are best practices, some are new, and all are centered on a state's business ecosystem. 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 will empower state leaders to build prosperous and equitable advanced energy economies that will transform our nation's energy future. If these recommendations are adopted, the beneficiaries will be those hard-working Americans looking for the dignity of a good-paying job.

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About Us

The American Jobs Project

The American Jobs Project is a nationally focused, research-based project managed by the American Jobs Initiative, a nonprofit organization dedicated to U.S. economic growth through advanced industries. The organization is driven by six core team members and has received support from nearly one hundred student researchers with a broad range of expertise, including law, business, engineering, and public policy. The American Jobs Project brings best practice strategies and innovative ideas from around the globe to local and state governments and stakeholders, creating bottom-up strategies that create good-paying jobs in the advanced energy and advanced materials industries.

University of Montana, Bureau of Business and Economic Research

As Montana's premier center for economic analysis, the Bureau of Business and Economic Research (BBER) provides accessible and reliable information about Montana's business and economic climate. For nearly seventy years, BBER has provided unique information about Montana businesses, as well as state and local economies, to private- and public-sector decision-makers. Housed on the campus of the University of Montana, it is the research and public service branch of the School of Business Administration. On an ongoing basis the bureau:

- Analyzes local, state, and national economies.
- Provides wage, workforce, and employment forecasts.
- Conducts extensive research on the healthcare, manufacturing, energy, natural resources, and forest products industries.
- Designs, conducts, and reports on survey research.
- Presents annual economic outlook seminars in cities across Montana.
- Publishes the award-winning Montana Business Quarterly magazine.

BBER's manufacturing program assesses current conditions and trends in Montana's manufacturing industries via annual surveys. From cottage industries to nationally recognized corporations, BBER maintains a comprehensive database on the industry, following trends and publishing annual reports on the state of this sector.

Dozens of hands were involved in the process of researching, writing, designing, and reviewing the report. Sam Schabacker was the lead author and researcher. Kate Ringness served as the lead editor; Laura Hobbs was a supporting editor; Rob Purviance, Tiffany Wong, and Andrew Miller were supporting researchers; Henry Love was the lead analyst; and Amariah Baker was the graphic designer.

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The author and editors thank the following individuals for offering their insight and perspectives on this work. We are especially grateful to Paul Polzin of the Bureau of Business and Economic Research at the University of Montana for his guidance.

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Executive Summary

The American Jobs Project was borne of two tough problems: loss of middle-class jobs in America and congressional paralysis. It seeks to address these problems by taking advantage of one of the biggest market opportunities of our era—the advanced energy and enabling technology sectors—and to do so at the state, not the federal, level. State and local leaders who leverage the unique strategic advantages of their state to grow localized clusters of interconnected companies and institutions are poised to create quality jobs. This report serves as a strategic guide to support those efforts.

Extensive research and more than thirty interviews with stakeholders and experts in Montana have identified photonics as showing particular promise in the state. Photonics is a key enabling technology for many manufacturing industries and can provide a pathway for technological innovation, thereby creating middle-income jobs for Montanans and elevating Montana's companies in the marketplace.

Montana is well positioned to benefit from rising global demand for photonics given its existing cluster of over thirty companies, its leading research university with photonics expertise, its affordable cost of living, and its attractive quality of life. Opportunities to leverage this momentum to further serve growing regional, national, and global markets offer real benefits for the state economy and Montana residents. Montana could capitalize on its existing cluster and vast wind resources to create a competitive advantage over other clusters in the U.S. and Europe by promoting photonics solutions within advanced energy applications.

However, there are several barriers hindering Montana's photonics industry and preventing its existing companies from reaching their full potential. These barriers to growth range from lack of access to capital for the next generation of photonics researchers and entrepreneurs to the lack of technical training for business development. Montana must address these roadblocks in order to become a competitive hub for photonics.

To take full advantage of these opportunities, state leaders can pursue strategies to create a strong foundation for industry growth and to help Montana businesses grow, innovate, and outcompete regional, national, and global competitors. With forward-thinking policies, Montana's photonics industry can support over 6,300 direct, indirect, and induced jobs annually through 2030. These jobs will spark local job growth and economic

development as employees spend their earnings in the local economy.

Summary of Recommendations

The analysis presented in this report culminates in recommendations for Montana's leaders based on best practices in the United States and abroad. Each recommendation identifies opportunities for barrier removal and future growth in the photonics sector. 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.

Recruiting and Expanding Photonics Companies

Boost the Foreign Direct Investment Strategy: Taking advantage of Montana's high quality of life, ample space, and existing photonics infrastructure to attract international optics investment.

Provide Tax Incentives to Attract New Photonics Businesses and Fill Supply Chain Gaps: Creating incentives for large companies to locate in the state and recruit their supply chain companies to join them.

Institute a Business Equipment Tax Exemption for Photonics Companies: Spurring photonics companies to invest in the technologically sophisticated and expensive equipment necessary to manufacture optical products.

Access to Capital

Create an Online Crowdfunding Hub: Creating an online hub where potential investors can learn about and invest in Montana companies.

Use an Insurance Credit Auction to Fund the Montana Board of Research and Commercialization Technology: Strategically investing in the most promising Montana photonics startup companies to generate a positive return on investment, increase tax revenue, and create jobs.

Establish a Technology Investment Tax Credit: Creating an incentive for early-stage investments in photonics to grow companies.

Innovation Ecosystem

Leverage Philanthropic Funding Via a Foundation Liaison: Bolstering state resources by coordinating and leveraging private funds.

Provide Scholarships and Fellowship Grants to Attract and Retain Top Photonics Students: Backing the best and brightest photonics students to attract world-class talent to Montana State University's photonics program, where they can discover cutting-edge photonics technologies and applications.

Become an AIM Photonics Innovation Center: Joining the preeminent national photonics research, development, and commercialization organization to elevate Montana's profile and expand exposure to potential investors, entrepreneurs, and researchers.

Workforce Development

Introduce Lab Space and Equipment Sharing: Pooling lab resources and space for Montana's leading photonics research university and technical college to unleash cost savings and add capacity to train additional photonics engineers, lab technicians, and scientists.

Develop Online and Field Training Options: Offering remote learning methods to overcome the vast geographic expanses that separate hundreds of thousands of Montanans from where the photonics training programs are based.

Offer an Accelerated Optical Technician Training Program: Providing a one-year, intensive program to empower those Montanans changing careers to gain the technical skills and training necessary to enter the industry while minimizing their time out of the workforce.

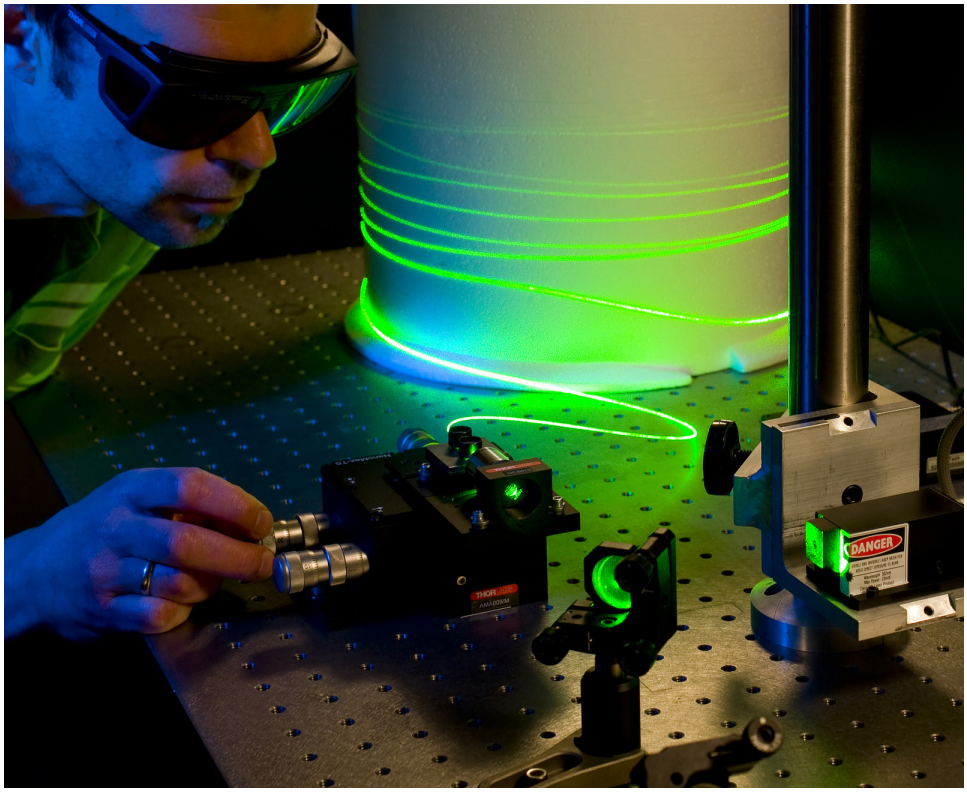
Create Demand for Advanced Energy Photonics Products

Increase Montana's Renewable Portfolio Standard: Including a wind carve-out in an updated RPS to stimulate Montana-based demand for photonics products with wind applications.

Introduction

The American Jobs Project aims to spur job creation in the advanced energy sector by identifying innovative and state-specific policies and non-legislative solutions. This national initiative takes advantage of the emerging global demand for advanced energy and related products. The American Jobs Project team analyzed the advanced energy economy in Montana and designed recommendations specifically tailored to the state's strengths. These recommendations are informed by extensive research and over thirty interviews with local stakeholders and experts.

This report identifies opportunities to stimulate growth in an advanced energy economic cluster that leverages the state's legacy industries, current investments, and entrepreneurial business development activities. State and local leaders who seek to capitalize on the state's resources to create skilled, good-paying jobs can use this report as a foundation for action.



Photonics has applications in advanced energy

Why Advanced Energy?

Demand for advanced energy has soared in recent years and is poised for continued growth. In 2015, investment in the advanced energy sector totaled $329 billion worldwide, more than five times the total in 2004. In the United States alone, over $323 billion was invested in advanced energy between 2010 and 2015. In nationwide polls, Americans increasingly support renewables over other forms of energy. Projections show that by 2030 renewables could account for 27 percent of the U.S. energy mix and roughly 50 percent in the power sector alone. These trends point to a clear market signal: demand for advanced energy will continue to grow substantially and create opportunities for investment and job growth.

Furthermore, the advanced energy sector fosters many good-paying, middle-class jobs. In 2016, nearly 3.3 million employees were engaged in the national advanced energy industry, including low-carbon emission generation (800,000), energy-efficient products and services (2.2 million), and alternative fuel vehicles (259,000). In particular, solar and wind employment grew by 25 percent and 32 percent in 2016 to reach 374,000 and 102,000 workers, respectively. Many advanced energy jobs are in the manufacturing sector, which offers higher wages for the U.S. workforce and stimulates local job growth. Manufacturing jobs average an hourly wage of $26, over three times the federal minimum wage. Thus, the average manufacturing worker can fall within the middle-class income range. For each U.S. job created in manufacturing, 1.6 new jobs in local goods and services are supported.

What is Advanced Energy?

Advanced energy diversifies energy sources, uses energy more productively, and reduces health and environmental costs. All sources, technologies, products, and services that help meet the need for affordable, secure, and clean energy are advanced energy. For example, advanced energy encompasses renewable energy sources, such as solar, wind, hydro, geothermal, and biofuels. Advanced energy also incorporates technologies and services that improve energy efficiency or make energy available when needed, such as photonics, smart buildings, energy storage, demand response, and smart grids. Other technologies and products that reduce energy consumption include electric vehicles, efficient industrial processes, and airplane bodies made of lightweight composites.

Why Economic Clusters?

> *"Clusters are geographically close groups of interconnected companies and associated institutions in a particular field, linked by common technologies and skills."*
>
> – Michael E. Porter, *Clusters of Innovation*

Economic clusters encompass a variety of linked industries and institutions—including suppliers of specialized services, machinery, and infrastructure—which form a supply chain. Clusters also extend to manufacturers of complementary products and to industries related in skills and technologies. By placing themselves near industry allies, companies can benefit from each other's unique expertise and a trained workforce. Companies in a cluster enjoy access to specialized assets, which helps increase productivity and efficiency.

Geographic proximity and repeated exchanges of information help foster an environment of coordination and cooperation among these companies and institutions. Business clusters are shown to increase the productivity of companies, drive innovation in the field, and facilitate the commercialization of this innovation by increasing communication, logistical support, and overall interaction between cluster entities. By having a close network of suppliers and partners, companies can reap the benefits of greater operational efficiency and reduce costs. Clusters also help build a strong foundation for creating employment opportunities and retaining jobs.

Key Cluster Elements

Economic clusters require strong foundations for growth. In today's competitive, globalized economy, businesses are more likely to thrive in cities and states that offer a rich innovation ecosystem, provide fertile grounds for capital investment, and boast a highly skilled workforce. A successful innovation ecosystem bridges the gap between the knowledge economy and the commercial economy, while access to capital programs provide the necessary funds to facilitate commercialization and expansion of businesses. Seamless connections between researchers, entrepreneurs, and investors are vital to the success of advanced energy technology businesses—bringing innovative ideas to the marketplace quickly and efficiently. Trained and skilled workers are also fundamental to the success of an economic cluster. A thoughtful, sector-based workforce development approach that engages the public sector, the private sector, and related nonprofits can ensure businesses are equipped to identify employment needs and schools prepare workers with the skills needed to fill available jobs.

Local Demand

Local demand is not essential for cluster development, but it can help to establish a geographic base. Local abundance of raw materials and natural resources can also help grow a local manufacturing cluster. For example, a state with a high solar energy potential or abundance of silicon can be a natural home for a thriving solar manufacturing cluster. However, if local adoption of solar technology is slow, the state can tap into larger regional, national, and global markets to drive cluster development.

Economic Cluster

Economic Clusters are created when industries and institutions become linked with suppliers of specialized services, machinery, and infrastructure that are within close proximity, forming a supply chain. Key elements to a successful cluster include Policy Certainty, Workforce Development, Innovation Ecosystem, and Access to Capital.

Policy Certainty

- Provides a clear market signal
- Reduces business risk
- Allows for long-term planning

Workforce Development

- Invests resources in people
- Bridges skills gap
- Develops training programs and industry partnerships

Innovation Ecosystem

- Promotes research and development
- Facilitates new technology to market
- Incubates early-stage businesses

Access to Capital

- Provides funding for new and growing businesses
- Connects investors with market opportunities
- Attracts entrepreneurs

Jobs Potential of Cluster Growth

Clusters can foster a large number of direct, indirect, and induced jobs by stimulating economic activity in a region, and maximizing job creation is highly dependent on local activity. Since manufacturing clusters primarily serve non-local markets, new manufacturing jobs create additional jobs in the trade and service sectors. Workers in manufacturing clusters earn income from sales made throughout the region or nation. These dollars are spent and re-spent in the local economy creating and maintaining additional jobs in grocery stores, restaurants, medical providers, and other sectors. The result is the multiplier effect where a dollar of earning in a cluster circulates throughout local businesses and their employees and creates an impact greater than the initial injection. Therefore, promoting an economic cluster by fostering the growth of existing cluster members as well as recruiting additional manufacturers and their suppliers will result in an economic impact many times greater than the initial investment.

Report Structure

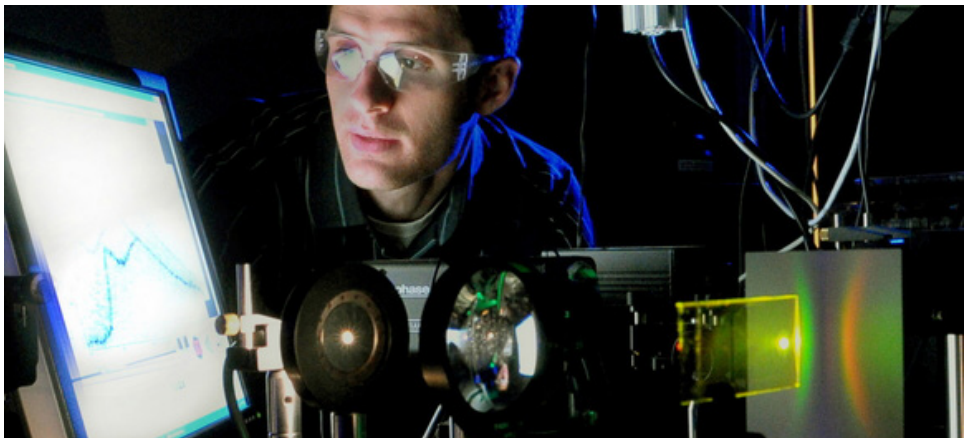
The Montana Jobs Project: A Guide to Photonics and Advanced Energy Job Creation begins by highlighting Montana's economic opportunity to build a globally competitive photonics cluster; evaluating the strengths, weaknesses, opportunities, and threats of the state and its photonics industry; and expanding on the global market opportunity of the technology. The report then details Montana's photonics cluster development assets. The next sections provide a snapshot of job opportunities in the sector and potential job growth from cluster development. The analysis culminates in policy recommendations to grow the cluster tailored to Montana. A fully cited version of this report is available on the American Jobs Project website at http://americanjobsproject.us/.

Montana's Economic Opportunity in Photonics

What is Photonics?

Photonics is the science of light. There are technical distinctions between optics and photonics, but for the purpose of this report, the terms will be used interchangeably. They comprise key enabling technologies for a multitude of medical, communication, art, and national security products and processes in our everyday life, including touch screens on smartphones and the internet. In the energy landscape, optical technology is poised to revolutionize our advanced energy and advanced manufacturing systems.

Cutting-edge photonics products, known as Light Detection and Ranging (LIDAR) systems, enhance the siting of wind turbines in order to measure and maximize utility-scale wind generation. Solar illuminators employ optical technology to replicate the sun's rays for designing and testing photovoltaic solar cells, giving scientists and manufacturers a critical tool to assess the quantity of energy being captured. Fiber optic cables meaningfully reduce the energy needed to transmit and store data. Remote sensing optical technologies can detect gas leaks from afar on pipelines, substantially reducing methane leaks and saving money. Lasers, —yet another example of photonics—are increasingly used in drilling, micromachining, welding, and other forms of precision manufacturing. In total, optical and photonic technologies possess far-reaching applications in numerous advanced energy and advanced manufacturing industries.



Examining a luminescent solar concentrator

Photonics: A Key Enabling Technology

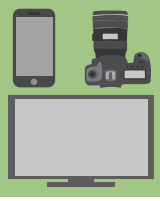
What is Photonics?

Photonics is the **generation, modification, and utilization** of light and other electromagnetic radiation via lasers, lenses, mirrors, optics, or fibers.

What can we do with photonics?

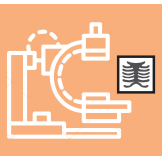
Sense, Monitor

Image capture, Display



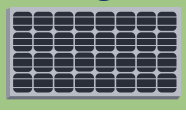
Compute, Process

Actuate



Store

Energize



Transport

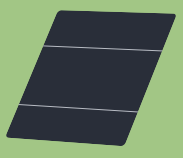
Advanced Energy and Advanced Manufacturing Applications

Optimize Wind Power Generation

Utilize Light Detection and Ranging (LIDAR) Systems to enhance the siting of wind turbines and consequently optimize utility-scale wind power generation.

Create Highly Productive Solar PV Cells

Solar simulators require optical technology that replicates solar radiation to test and perfect the next generation of photovoltaic (PV) solar cells.

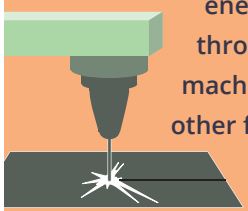


Prevent Costly Gas Leakages

Remote sensing optical technologies detect and visualize gas leaks underground and far away to speed up response time.

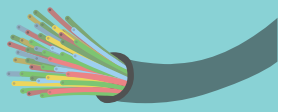
Streamline the Manufacturing Process

Precision laser manufacturing reduces energy use and waste through drilling, micromachining, welding, and other forms of precision manufacturing.



Store and Send Data More Efficiently

Fiber optic cables reduce the energy needed to transmit and store data.



Enable Energy Efficiency

LED lighting provides stable and long lasting energy efficient lighting sources.

State Wage Trends

Montana has struggled with some of the lowest wages in the country, but rapid wage growth over the past few years has helped to increase Montana's wages significantly. The state saw the average real wage gain 2.9 percent in 2015 alone, reaching $40,056. However, that wage is equivalent to only 76 percent of the U.S. average wage, which signifies a continued need to recruit and promote high-paying jobs like those found in manufacturing.

Landscape for Job Growth

Montana, as with most of the nation, has struggled to recover from the Great Recession. Throughout most of the recent recovery period, economic growth has not spread evenly across the state. Technological advances in drilling and recovery led to the Bakken oil boom in eastern Montana and western North Dakota; however, a recent decline in oil prices has partly dampened economic activity, and wages and employment have returned to within range of pre-boom levels. Agricultural prices are near decade lows, and coal and precious metal production are down. The City of Bozeman and Gallatin County stand out as consistent leaders in economic growth. While the City of Kalispell and Flathead County economies have recovered from significant declines, the Butte and Helena economies have been stagnant.

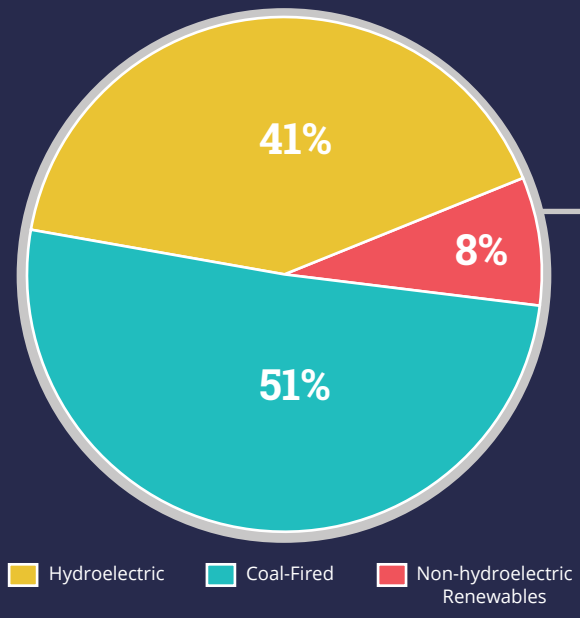
New manufacturing jobs are an ideal tool for economic development. In 2016, manufacturing accounted for 6.8 percent of Montana's total output and 4.1 percent of its workforce. Expanding the manufacturing sector in Montana is an opportunity to galvanize economic development—for each Montana job created in manufacturing, an average of 2.6 local service jobs are supported, well above the U.S. average of 1.6. With U.S. manufacturing workers earning an average of 24 percent more than other workers, Montana's skilled workforce could continue to benefit from traditionally higher manufacturing wages. In fact, the average annual wage of Montana's 23,000 manufacturing employees in 2014 was nearly $46,000, which is roughly 18 percent higher than what the average state employee earns. Unemployed and underemployed Montanans could benefit from the expansion of manufacturing jobs.

Energy and the Economy

Montana has been hit especially hard by the global downturn in coal and oil prices. In 2016, Montana's largest coal-fired power plant announced that it would close two of its four units starting in 2022. As a result of the oil and gas slump, workers are migrating out of eastern Montana's Bakken oil field, and local governments that previously enjoyed substantial revenue during the hydraulic fracturing boom are facing budget shortfalls. Against this backdrop, the Governor has embraced an all-of-the-above energy policy, including placing emphasis on cutting-edge technologies to take advantage of Montana's prodigious wind, solar, and geothermal resources. The state currently generates 665 MW of wind power, enough to power 180,000 homes. That wind development is responsible for approximately one hundred permanent jobs, 1,500 construction jobs, and $1.5 billion in new capital investment.

Montana's Energy Infrastructure

Net Electricity Generation by Source, November 2016

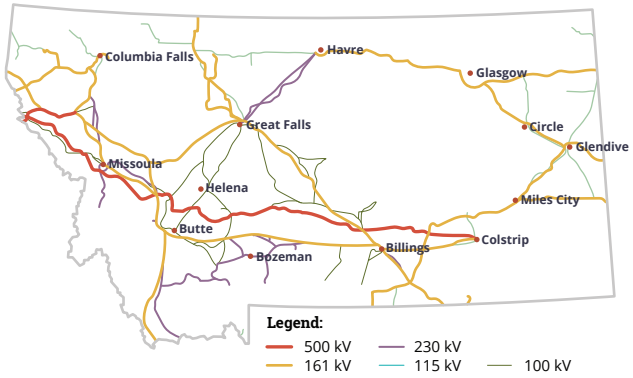


Current Wind Generation

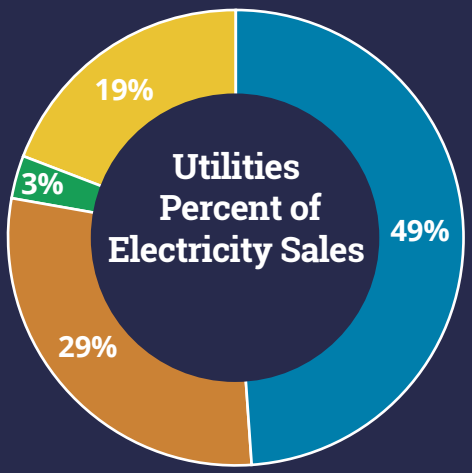
Wind energy supplied **7.53%** of the state's electricity generation between July 2015 and July 2016.

Montana consumes about **half** of the electricity it generates - exporting portions of the remainder to Washington and Oregon.

Electric Transmission Lines of Montana



NorthWestern Energy serves over **1/3** of Montana residents and is the state's largest utility



- Investor Owned Utilities
- Power Marketers
- Federal Agencies
- Cooperatives

Montana: The Treasure State

Montana possesses more than 1/4 of the estimated recoverable coal reserves in the U.S. and has substantial oil and gas deposits.

Montana's Energy Economy

Impact of the Manufacturing Industry

Manufacturing accounts for **6.8%** of Montana's GDP

Average annual wage of Montana's **23,400** manufacturing employees is **$45,754**

Coal Plant Shutdowns:
July 2016: MT's largest coal-fired power plant announced it would close two of its four units by 2022

High Tech Job Growth

High tech jobs and revenues are growing quickly

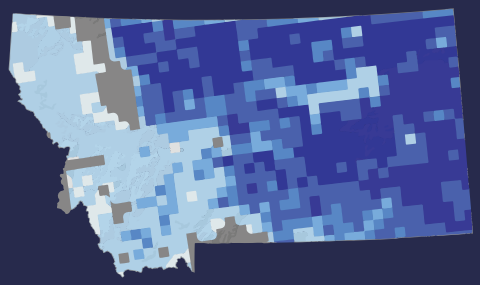
Projections show they will grow at rates up to **10%** higher than statewide growth

High tech jobs provide wages that are **double** the median wage in the state

Potential for Wind Development

#3 Wind Generation **Potential**

Wind Energy Potential
Montana ranks **3rd** in wind generation *potential* in the U.S. but ranks **21st** in wind energy *generated*.



Potential Wind Capacity at 110-Meters Hub Height

Area (sq km)

0	< 100	100 - 200
200 - 300	300 - 400	> 400

Land exclusions

KEY ACTIONS

2001

Alternative Energy Investment Tax Credit

State adopts 35% tax credit on alternative energy investments of $5,000 or more on new or used renewable facilities.

2005

Renewable Portfolio Standard

State passes the Renewable Power Production and Rural Economic Development Act requiring investor-owned utilities to obtain 15% of their energy from non-fossil sources by 2015. Goal attained in 2015, no increase of RES planned.

2013

Main Street Montana Project

State sponsors a public-private partnership to create a business plan for the state to improve workforce development, attract investment, and encourage innovation. One focus area is energy and utilities.

2016

Montana's Energy Future

Governor Bullock releases a state energy blueprint to build out renewable energy and encourage innovation in the energy sector.

Montana's Competitive Advantage in Photonics

As the state rises to the challenge of growing its economy and seeks to expand its energy generation and manufacturing base, there is enormous potential to create good-paying jobs in the photonics industry. Montana's photonics cluster has firmly established itself in the Gallatin Valley and has the innovative ingredients to be a world leader in manufacturing optical products for advanced energy and other advanced manufacturing applications. Over the past three decades, Montana's photonics cluster has benefited from strategic investing, forward-thinking policies, and visionary academic research. The growing photonics cluster is driven by a collaboration between multiple photonics companies, Montana State University, Gallatin Technical College, and Prospera Business Network.

Montana could grow its existing photonics cluster and create a competitive advantage over other photonics clusters by focusing on companies working in advanced energy applications for photonics. For example, companies in the cluster could manufacture and develop new technologies that service the wind, solar, and energy efficiency sectors. With an innovative, robust set of local and state policies to build upon the cluster's already strong foundation and impressive track record, Montana could become a national and global leader in manufacturing optics products for advanced energy applications.

Middle-Class Jobs

The advanced energy and photonics industries foster many good-paying, middle-class jobs, most of which are in the manufacturing sector. Manufacturing jobs average an hourly wage of $26, over three times the federal minimum wage. Thus, the average manufacturing worker can earn a middle-class income.

As the home of the only photonics cluster in the Northwest United States, the state is well positioned to serve key markets in Canada, Oregon, Washington, and the Rocky Mountain states. Montana's photonics companies also easily serve markets throughout North America and abroad. Finally, with a comparatively low cost of living and peerless outdoor amenities, the quality of life is high and a major attraction for top researchers and entrepreneurs.

Engineering and Physical Sciences Building - Montana State University

Montana's Strengths, Weaknesses, Opportunities, and Threats in the Photonics Industry

STRENGTHS	WEAKNESSES
• Preexisting cluster with defined organization through Montana Photonics Industry Alliance • Well-established and successful state commercialization grant program • Cutting-edge photonics labs and centers at Montana State University (MSU) • Workforce development program already in place at Gallatin College • Innovative, enabling technology with many advanced energy applications • Local business networks and incubators available to advise and grow the industry	• Limited space and funding for photonics lab equipment • Funding shortfall for key agency that supports development of photonics enterprises • No state-level tax credits for photonics companies • Limited private venture capital and private equity funding • Difficulty recruiting top-notch students to MSU programs • Limited capacity for budding photonics firms to conduct market analyses and strategically market new products • Lack of involvement in AIM Photonics by Montana-based entities
OPPORTUNITIES	**THREATS**
• Capacity to increase advanced energy focus of current cluster to meet growing national and global demand • Extensive, in-state wind resource to parlay the industry • Substantial job growth potential of photonics cluster • Foreign direct investment strategy to jumpstart expansion	• Multiple photonics clusters in U.S. competing in similar markets • Competition with foreign optics firms, specifically in Europe • Regulatory uncertainty at federal level

Market Opportunity

Rising Demand

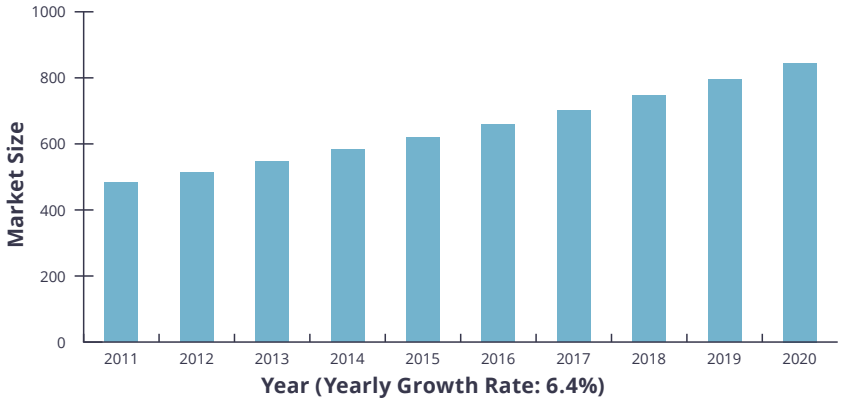
Photonics supports large, growing end-use markets, including energy, national security, health, and information and communication technology. The global photonics industry is projected to grow at 6.4 percent per year from 2011 to 2020 to a market size of roughly $650 billion. Industry experts predict photonics industry growth to be well balanced, as evidenced by estimated growth rates in all major segments, exceeding GDP growth. As of 2010, the most recent year with data available, there were nearly 7.5 million people working in the global photonics industry.

Overall growth in the photonics industry will be supported by robust growth in advanced energy applications. Photovoltaics are projected grow at a yearly rate of 6 percent to comprise 16 percent of the global photonics market by 2020, up from 4 percent in 2005. Growth in the LIDAR market is predicted to be even more robust at 18.5 percent from 2016 to 2022.

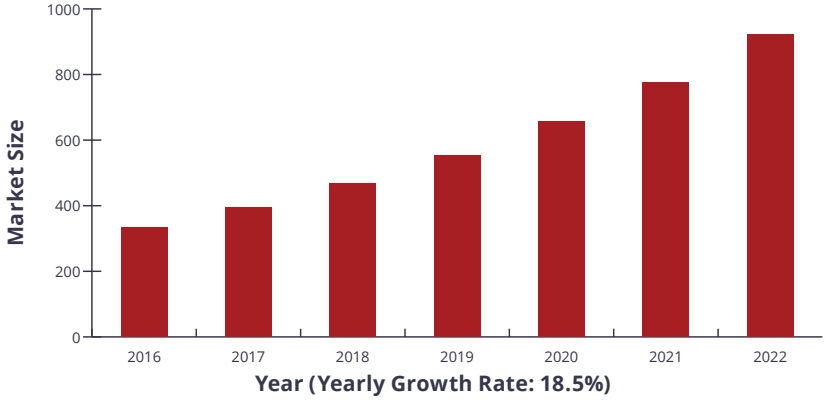
Photonics in the News

Photonics technology is ubiquitous in our modern society. In 2011, *Time* magazine ranked the top fifty inventions and twelve contained optical technologies. The United Nations General Assembly proclaimed 2015 as the "International Year of Light and Light Technologies." Understanding, harnessing, and deploying light is pivotal to nearly every aspect of our world. Over the past five years, the science of optics and associated photonics industry has developed by leaps-and-bounds.

Overall Photonics Industry Size (in $Billions)



Overall LIDAR Market Size (in $Millions)

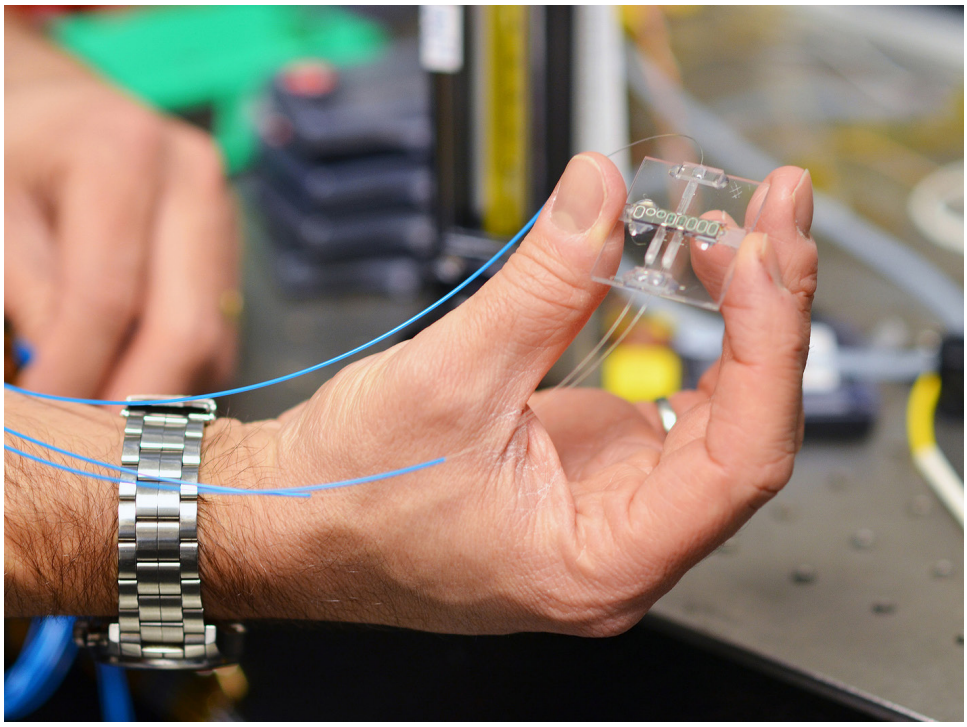


Optical Technicians

Within the United States, there were nearly 20,000 optical technicians employed in 2012, and their average salary was $41,000, not including benefits.

Facilitating Growth

The national focus on improving manufacturing practices and decreasing costs could facilitate growth of the U.S. photonics market. In 2016, the Department of Defense established the American Institute for Manufacturing Integrated Photonics (AIM Photonics), a Manufacturing USA center dedicated to next-generation photonics technology. The $610 million effort includes over 120 partners located across twenty states. AIM's goal is to build out a national manufacturing consortium dedicated to catalyzing the discovery, manufacturing, and deployment of photonics, while reducing costs across the value chain. Among other services, AIM Photonics helps shape the direction of photonics research and commercialization across the country by partnering with industry, academic institutions, and federal agencies. The consortium has identified research and development tools for its members, such as a process design kit for silicon photonics, and collaborative efforts can continue to transform the industry.



Smart sensors will detect environmental pollution at the speed of light

State Assets to Support Photonics Cluster Development

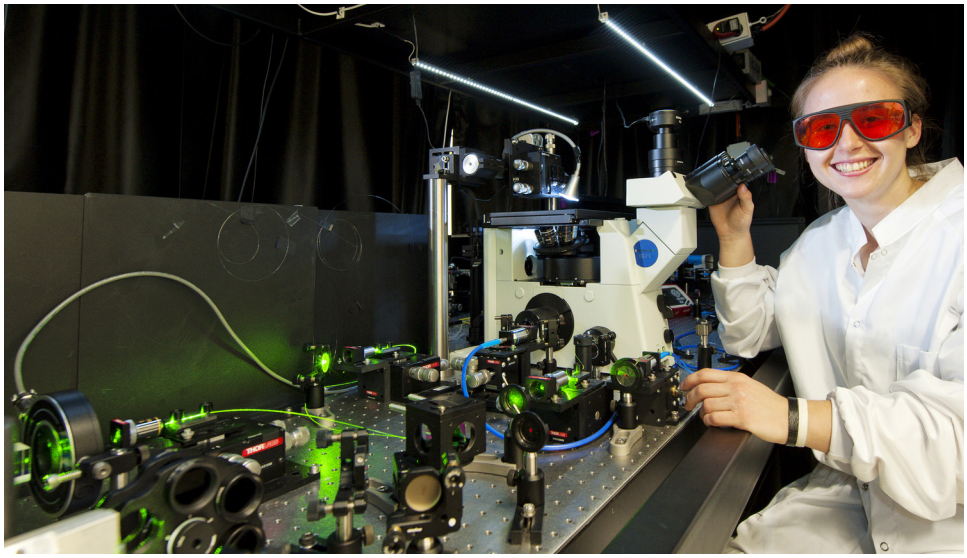
Having a strong economic foundation is essential to sustaining and growing clusters. Montana has a solid foundation upon which they could build a world-class photonics manufacturing cluster with advanced energy applications. Reinforcing its innovation ecosystem, access to capital, and workforce development could support the expansion of existing photonics companies and attract new businesses to the state.

Main Street Montana Project

The Main Street Montana Project was established in 2013 as a public-private partnership to create a business plan for the state's future. The completed plan—which incorporated input from more than 3,000 Montanans—was built upon five pillars: improving workforce development, creating a desirable business climate, building upon Montana's economic foundation, promoting Montana's natural and urban amenities, and encouraging innovation. Many of the recommendations in the plan could help support growth of the photonics cluster. Several recommendations have been implemented and are showing early signs of success.

Montana Photonics Industry Alliance

The Montana Photonics Industry Alliance (MPIA) was founded in October 2013. It is the coordinating body and driver of the photonics cluster, seeking to expand, recruit, and market the efforts of its members across the state, nation, and globe. It consists of thirty photonics enterprises, academic researchers, and key business leaders.



PhD student showcasing her optical biosensor

Innovation Ecosystem

In today's competitive, globalized economy, businesses are more likely to thrive in cities and states that offer a rich innovative environment. Innovation ecosystems promote research and development (R&D), bring new technologies to market, and incubate early-stage businesses. Innovation leads to high-skilled, local jobs, and the streamlined transfer of ideas from the lab to the marketplace accelerates further entrepreneurship and job creation. Robust innovation ecosystems offer efficient intellectual property protection mechanisms, mentoring for entrepreneurs, and active engagement of business and venture capital.

The Bozeman area leads the United States with one of the highest per-capita densities of photonics firms. Collectively, these firms currently employ about 460 Montanans. A strong university network and community resources support these companies, both at the R&D stage as well as in the growth stage. Many optical technologies discovered and developed at Montana State University (MSU) have been commercialized by graduates of its program and turned into successful business ventures.

Innovation Ecosystem

- Promotes research and development
- Facilitates movement of new technology to market
- Incubates early-stage businesses

Research Universities

MSU hosts two world-class R&D labs: the Optical Technology Center (OpTeC) and Spectrum Lab. Both OpTeC and Spectrum Lab work to provide MSU students with a nationally competitive optics and photonics education that emphasizes collaboration between departments as well as with local businesses. OpTeC draws upon the expertise of faculty and students from the departments of physics, chemistry and biochemistry, and electrical and computer engineering to conduct breakthrough photonics research, while Spectrum Lab acts as a bridge between MSU and Montana businesses. To ensure there is a steady flow of new researchers in the academic pipeline, MSU recently launched a new photonics curriculum and is now offering both a master's degree and a minor in optics and photonics science.

The Optical Technology Center

Established in 1995, OpTeC at MSU is a multidisciplinary center that supports and advances education and research in photonics and optics. It functions as a primary resource for knowledge-sharing and networking among faculty, students, and private industry to solve problems and collaborate on new technology applications.

MSU's Impact on the Growth of Local Photonics Companies

Many of the photonics companies located in the Bozeman area were started by MSU graduates, have licensed MSU technologies, or have collaborated with MSU. S2 Corporation, for example, works with MSU and Spectrum Lab to develop and deploy its innovative spatial-spectral holography technology. Scientific Materials Corporation uses their proximity to the university to develop and grow the highest-quality single-crystal laser materials in the world. Many local photonics companies continue to collaborate with the university and its students outside of their research. A 2015 seminar series by Spectrum Lab brought local companies—S2 and Scientific Materials included—into the classroom to teach students about their technologies and the science behind them.

Spectrum Lab

Spectrum Lab helps move optic and photonic technologies developed at MSU out of the labs and into private-sector applications. Since 1999, the Lab has acted as a bridge between MSU and the private sector, maintaining university-corporate partnerships to promote streamlined technology transfers while providing enhanced educational and employment opportunities for MSU students.

While MSU is unique in Montana for its dedication to photonics specifically, other universities in Montana are strong in physics, optics, and energy-related research. The University of Montana's (UM) scanning photo-ionization microscopy lab, housed in the physics and astronomy department, draws researchers from across the state to study nanomaterial characterization through the use of multiple lasers and a high-vacuum science chamber surrounded with a range of sensors. In particular, UM researchers explore biomedical applications and renewable energy technologies. The Montana Tech Nanotech Laboratory works with advanced materials and optics-related technologies.

Resources for Innovation and Expansion

The Prospera Business Network is a county-wide organization that offers consulting, lending, and expansion services to all photonics firms in the Gallatin Valley. Its Executive Director is also an active MPIA board member and offers critical advice and strategic guidance to individual firms and the overall cluster.

Innovate Montana connects Montana's entrepreneurs with a network of organizations to encourage business development. As part of Governor Steve Bullock's Main Street Montana plan, the program is designed to foster a strong entrepreneurial climate. Available resources include events to connect innovators, partner organizations, and startup resources, including workforce training and marketing support.

Blackstone Launchpad is a national entrepreneurship development program available to more than 630,000 undergraduates and graduate students at universities across the country. UM and MSU students have access to one-on-one coaching designed to foster entrepreneurship as a viable career path. The Blackstone Charitable Foundation funds the UM and MSU programs via a three-year grant of $2 million.

The Bozeman Technology Incubator encourages the creation of high-wage jobs in the technology and manufacturing industries through support for aspiring entrepreneurs. The incubator sponsors the Summit Circle, a high-intensity growth accelerator for high-tech firms. Participants in the accelerator program gain

access to coaching and strategy planning from startup experts, recruiting assistance, and introductions to potential sources of capital.

The Jake Jabs Center for Entrepreneurship at MSU offers a minor program in Entrepreneurship and Small Business Management that is open to all undergraduate students. The program provides entrepreneurial training to encourage the commercialization of university-based innovations. The center connects company leaders with student teams that help solve a specific business problem at no charge.

MSU's Technology Transfer Office (TTO) assists with commercializing discoveries emanating from researchers' scholarship. The TTO digs into the viability of various optical discoveries. For the most promising options, the TTO will file provisional patents and market the technology to external partners, often negotiating licensing agreements to bring the technology to market.

The Montana Manufacturing Extension Center (MMEC) is also housed at MSU and serves as a technical resource to photonics companies. MMEC provides guidance to firms needing expertise in lean manufacturing, business management, marketing, innovation, and worker training. MMEC serves over 1,000 clients across the state.

Access to Capital

Access to affordable capital is essential for entrepreneurs to develop new products, grow their businesses, bring products to market, and create new jobs. Having access to investors and non-dilutive capital can be the difference between success and failure. Capital pricing can make the bottom-line difference in product affordability and market viability, yet many businesses are unable to secure the necessary capital to survive the commercialization phase. In 2014, 75 percent of venture capital funding went to companies in California, New York, and Massachusetts; businesses in the other forty-seven states had to compete over the remaining 25 percent, stifling innovation across the country and highlighting the importance of state policies for new venture capital investments. Unfortunately, Montana has one of the lowest rates of venture capital investments per capita in the country. To ensure the success of as many new and small businesses as possible, Montana's lawmakers should consider creating policies to attract more diverse capital investments in the state. Many of Montana's photonics companies are not able to qualify for traditional venture capital, creating a need to attract more angel investors to the state.

Access to Capital

- Provides funding for new and growing businesses
- Connects investors with market opportunities
- Attracts entrepreneurs

Dilutive and Non-Dilutive Capital

Dilutive capital, such as venture capital, reduces shares of ownership in a company. Non-dilutive capital, such as grants and loans, do not reduce firm ownership.

Programs and Resources for Montana's Entrepreneurs

Since its founding in 1999, the Montana Board of Research and Commercialization Technology (MBRCT) has been exceptionally successful in identifying, fostering, and funding nascent commercial technology ventures. As of 2014, in-state companies backed by MBRCT have created 459 annual jobs, paying $22.5 million to employees each year and generating $4.7 million in annual tax revenue. MBRCT achieved these results by awarding grants averaging about $2.6 million per year from 2001 through 2016.

The Montana Board of Investments provides locally owned businesses with access to loans from participating financial institutions. These in-state loan programs, including the Business Loan Participation Program and Value-Added Business Loan Program, leverage funds from the Permanent Coal Tax Trust for interest rate enhancements and increased loan sizes for eligible businesses. The Board encourages lending by drawing from the roughly $800 million trust to participate in as much as 80 percent of the funding and risk of approved loans.

Technology companies in Montana can apply to the state-run SBIR/STTR Matching Funds Program if they have been awarded Small Business Innovation Research Program or Small Business Technology Transfer Program grants from the federal government. Those receiving a Phase I award can apply for up to $30,000 in matching funds from the state and an additional $30,000 if the company continues the same project via a Phase II award.

In the private sector, a venture fund launched in 2015 called Next Frontier Capital announced in June 2016 that it raised over $21 million to invest in Montana-grown technology companies. Next Frontier Capital is located in Bozeman, directly in the center of the photonics cluster.

The Angel Investment Network, a national organization connecting entrepreneurs with angel capital, is present in the state. A network of Montana angel investors also founded a local fund called the Frontier Angel Fund. The fund's primary goal is to provide Montana-based businesses with early-stage capital. The first fund closed in December 2006 with $1.75 million in commitments and went on to invest in fifteen companies. The second fund expanded to $2.75 million and has invested in ten companies since 2015.

Workforce Development

Trained and skilled workers are fundamental to the success of an industrial cluster. Sector-based workforce development goes hand-in-hand with cluster development. If firms in the same cluster are able to coordinate with the government, schools, and related nonprofits on policies and programs to train workers, they will be better equipped to identify employment needs and find qualified workers with the necessary skills to fill available jobs.

In 2013, just over 144,000 students attended Montana's 824 elementary, middle, and high schools. On average, Montana's schools have a student-teacher ratio of 14:1 compared to 16:1 nationally. Nearly 50,000 students enrolled in postsecondary institutions in Fall 2015, with 16 percent of all full-time equivalent undergraduate enrollment being in public two-year institutions.

Montana students are highly educated and highly engaged. Just under 92 percent of Montana's population over twenty-five years old obtained a high school diploma or higher by 2016, making Montana the second-highest ranking state for such an achievement. However, there are still educational challenges that the state can address. With some of the lowest average wages in the country, training a workforce for high-wage positions is more important than ever.

Best Practices

A thoughtful sector-based workforce development approach should include industry best practices for recruiting, hiring, training, promotion, and compensation; education and training infrastructure (including community colleges, project-based learning experiences, and apprenticeship programs); and public policy, specifically rules, regulations, and funding streams related to workforce and education.

Technical Education Programs

RevUp Montana—a partnership led by Great Falls College, the Montana Department of Labor and Industry, and several two-year colleges—unites funding and support services to prepare students for high-wage and high-skill jobs in Montana's manufacturing and energy sectors. Since 2014, RevUp Montana has trained over 2,000 students in a wide range of skills.

Established through the Main Street Montana Project, the Montana Registered Apprenticeship Program emphasizes skill development by helping employers create effective apprenticeship training programs to ensure workers can succeed in their occupational trade or craft. By May 2016, the program had already enlisted 700 business sponsors that were training nearly 1,400 registered Montanan apprentices in more than fifty occupations across the state.

Employee Engagement

In 2013 and 2014, Montana had the highest level of employee engagement in the United States.

In 2016, MSU and Gallatin College unveiled a two-year Photonics and Laser Technology training program to fill a critical gap in the workforce needs for local optics companies. This two-year technical associate's degree will train students to specialize in lasers and optical technology. Nine students enrolled in its first year, and the program hopes to ramp up to sixteen members to fill out the cohort.

Wind Energy Jobs

Wind turbine service technician is projected to be the fastest-growing (in percentage terms) occupation in the United States between 2014 and 2024, with employment set to increase by 108 percent and hit 4,800 new jobs.

Creating New Opportunities for Growth in Photonics: Wind Development

By enacting smart, forward-looking policies that encourage in-state demand, Montana can send a market signal to the photonics industry and attract companies from around the globe. Having robust local demand near industry headquarters can create synergies that drive innovation and retain talent in the state. Additionally, stimulating in-state demand can make local companies competing for capital more attractive to out-of-state investors.

Wind energy is a promising advanced energy application to increase demand for optics products manufactured in Montana. There are multiple wind applications for optics, including Light Detection and Ranging (LIDAR) systems. LIDAR enhances the siting of wind turbines in order to measure and maximize utility-scale wind generation. Additionally, fiber optics can be used to monitor wind turbines; these sensitive devices detect maintenance problems before they occur, preventing catastrophic equipment failures and thus reducing operation costs and delays.

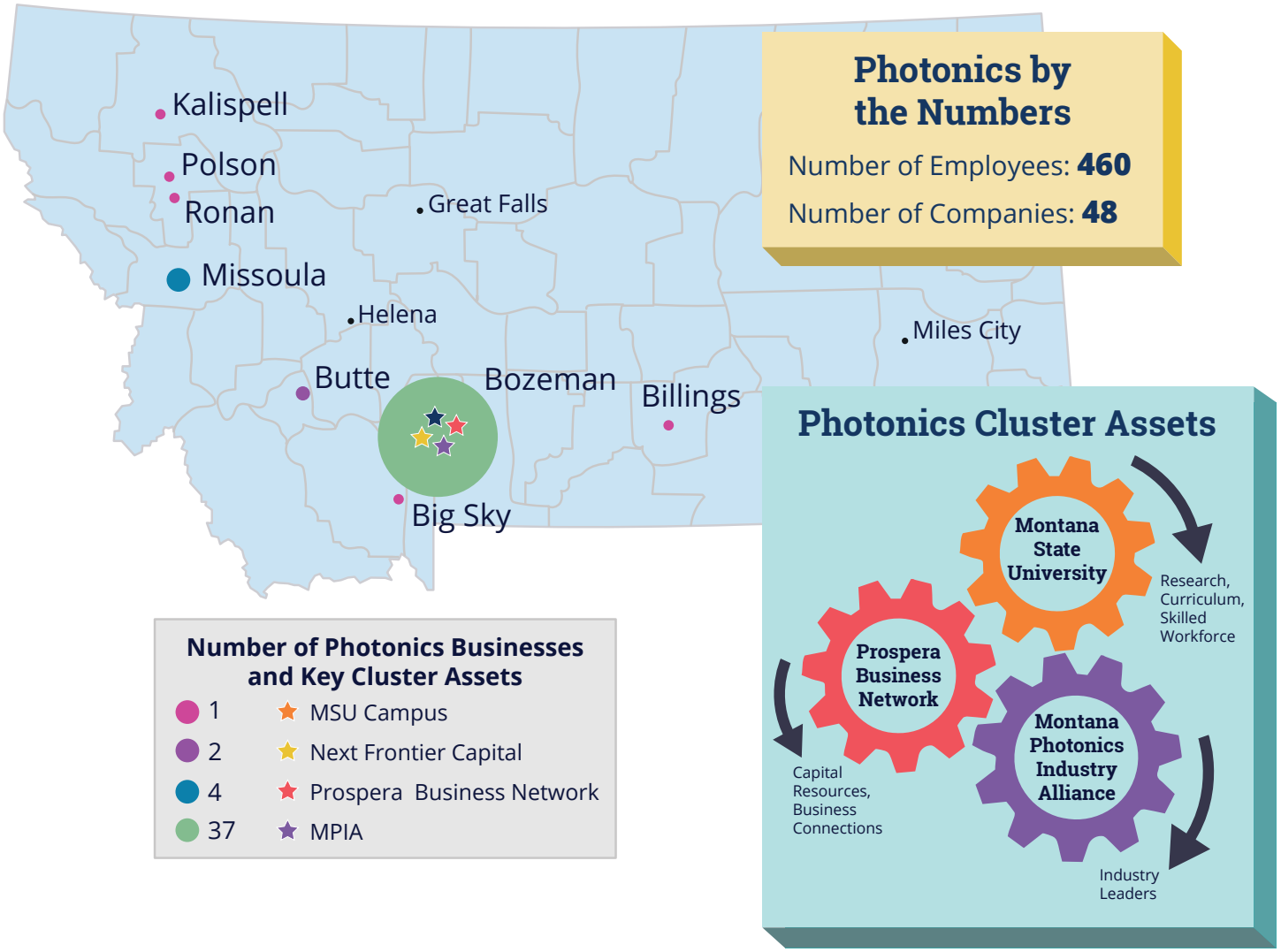
Montana enjoys a prodigious supply of wind and possesses some of the best wind generation potential in the country. Despite this abundant, renewable, natural resource, wind energy only supplied 6.5 percent of Montana's electricity generation in 2014. There are major opportunities to increase wind generation in the state, and, in turn, spur demand for photonics products that measure, harness, and test this resource. Furthermore, increased wind deployment will distribute new installation and maintenance jobs throughout the state, beyond Gallatin County where photonics jobs are most concentrated.

LIDAR systems

The Impact of Montana's Photonic Cluster

Montana can leverage its existing assets to further cultivate the photonics industry and lay the groundwork for catalyzing job growth and economic opportunity for thousands of Montanans.

Snapshot of Montana's Photonics Cluster



Snapshot: Montana's Photonics Companies

The existing photonics cluster has successfully recruited, trained, commercialized, and jumpstarted several innovative technologies and companies in the state. Two are profiled here to demonstrate the vast power of this cluster's structure and the enormous potential to foster more home-grown photonics companies in the Big Sky state.

Bridger Photonics: 18 employees

- Founded in 2006 by three MSU laser physicists
- World leader in high-resolution distance measurement, advanced imaging, and optical remote sensing with applications in the defense and oil and gas industries
- Developed a mapping tool that provides 3D images with gas concentration overlays, allowing for the detection, localization, and quantification of methane leaks
- Recipient of MBRCT and ARPA-E grants
- Employs engineers, scientists, optical technicians, and assemblers
- Two-thirds of employees graduated from MSU

ILX Lightwave: Est. 50 employees

- Founded in 1986 based on its groundbreaking precision laser diode current source
- Designs and manufactures laser diode instrumentation and test systems, optical power and wavelength meters, solar light simulators, and photovoltaic cell evaluation systems
- Acquired by Newport Corporation in 2012
- Generated revenue of $8 million at the time of acquisition in 2012
- Works closely with MSU through a collaborative research program
- Sees growth opportunity for Bozeman location

Job Opportunities in Photonics

Manufacturing photonics products requires a variety of professions, including skilled engineers, technicians, assemblers, operations, logisticians, research, and sales representatives. As a result, holistic workforce development and education programs are required to ensure all positions—from manufacturers to maintenance—are filled. These are good-paying jobs that require anything from a high-school diploma to an advanced degree. The following tables give a snapshot of the type of jobs available in the photonics industry, with a closer look at three job opportunities.

Position	**Photonics Technicians**
Description	Assist head photonics engineers with design, production, and testing
Median Hourly Wage in Montana	$30.25
Training	Associate's degree

Position	**Electrical Engineers**
Description	Design and develop electrical equipment
Average Hourly Wage in Montana	$35.83
Training Needed	Bachelor's degree

Position	**Sales Representatives**
Description	Sell products for wholesalers or manufacturers
Average Hourly Wage in Montana	$40.13
Training Needed	Ranges from high school diploma to bachelor's degree

	Job Description
Photonics Engineers	Design and test photonics systems or components
Photonics Technicians	Assist head photonics engineers with design, production, and testing
Physicists	Study how matter and energy interact
Materials Engineers	Develop and analyze materials used to create products
Electrical Engineers	Design and develop electrical equipment
Mechanical Engineers	Design and develop mechanical tools, engines, and machines
Mechanical Engineering Technicians	Assist head mechanical engineers with design, production, and testing
Software Developers	Develop underlying software systems or applications
Metal & Plastic Machine Workers	Prepare and operate machines that process metals and plastics
Assemblers & Fabricators	Assemble manufactured components to create finished products
Industrial Production Managers	Oversee daily operations of manufacturing
Logisticians	Manage an organization's supply chain
Buyers & Purchasing Agents	Source products and services to use or resell and negotiate with suppliers
Sales Representatives	Sell products for wholesalers or manufacturers

Potential Job Growth from Photonics Cluster Development

To estimate the potential job growth of Montana's photonics industry, we combine existing tools, analyses, and projections from several reputable sources. Rather than provide a specific estimate, we examine multiple industry growth scenarios that show the average number of jobs that the in-state industry could support annually from 2017 through 2030, a fourteen-year timeframe. To generate these estimates, the photonics analysis utilized IMPLAN, a highly respected regional economic analysis model maintained by the Minnesota IMPLAN Group. IMPLAN models inter-industry interactions and the resulting regional economic impacts, including employment. We present scenarios across two dimensions: supply chain concentration and national market penetration. The appendix provides a more detailed description of our modeling approach and resources used.

As global demand for photonics increases, Montana's photonics cluster could grow to serve a larger portion of national demand than it does currently. By fostering industry growth, Montana could reasonably support over 6,300 direct, indirect, and induced jobs from 2017 through 2030.

Our projections for job growth in the photonics industry come from global estimates of future demand, current employment in Montana's photonics cluster, and industry benchmarks for wages and profits. We utilized these inputs to create a variety of scenarios based on two industry growth factors. For one growth factor, we estimated the number of jobs supported based on varying levels of Montana's market penetration. For the second growth factor, we estimated the number of jobs supported by varying levels of supply chain concentration.

Market Penetration: Market penetration refers to the amount of sales of a product as a percentage of the total sales volume for that product. Montana's current estimate of market penetration for photonics products in the United States is 6 percent. We created job estimates based on this current scenario of a 6 percent U.S. market penetration. We then created two additional scenarios in which the market penetration is increased to 7.5 percent and 9 percent.

Supply Chain Concentration: Supply chain concentration refers to the level at which Montana is able to fill its supply chain needs from in-state companies and attract new companies to its current photonics supply chain. The "Current" scenario is based on the existing Montana supply chain. The "Median" scenario represents

Direct, Indirect, and Induced Jobs

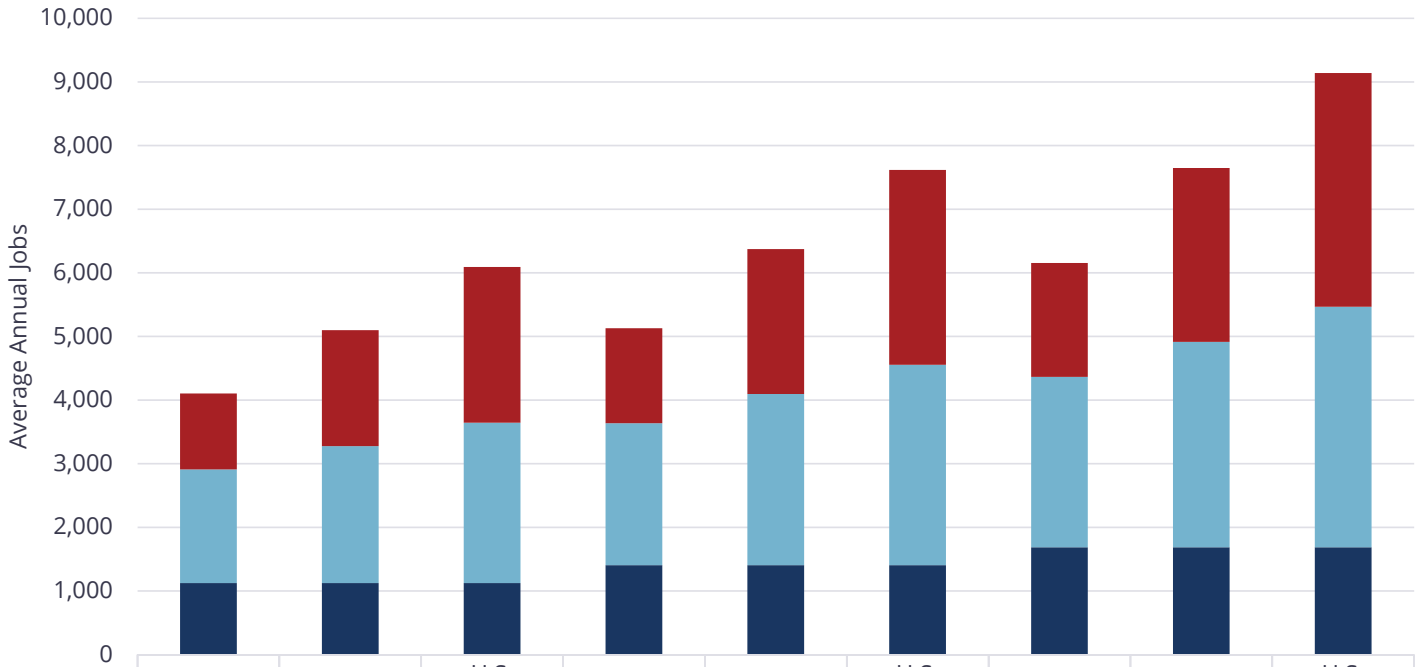
To estimate the potential economic impact of Montana's photonics supply chain, we distinguish direct, indirect, and induced jobs.

- **Direct jobs:** reflect jobs resulting from initial changes in demand in Montana's photonics industry.
- **Indirect jobs:** reflect jobs resulting from changes in transactions between industries as supplying industries respond to increased demand from Montana's photonics industry.
- **Induced jobs:** reflect jobs resulting from changes in local spending as a result of increased demand in Montana's photonics and indirect industries.

the mid-point between the "Current" and "U.S. Equivalent" scenarios. The "U.S. Equivalent" scenario is based on the supply chain concentration that is equivalent to what is currently available in the U.S. economy per IMPLAN's model.

The following graph shows the jobs potential of Montana's photonics industry under the different scenarios.

Montana Photonics Annual Average Jobs Potential by Percent of National Market Penetration and Supply Chain Concentration 2017-2030



	6% Market Penetration			7.5% Market Penetration			9% Market Penetration		
	Current	Median	U.S. Equivalent	Current	Median	U.S. Equivalent	Current	Median	U.S. Equivalent
Induced	1,194	1,821	2,448	1,492	2,276	3,061	1,790	2,732	3,673
Indirect	1,786	2,153	2,520	2,232	2,691	3,150	2,679	3,230	3,781
Direct	1,123	1,123	1,123	1,404	1,404	1,404	1,685	1,685	1,685

Market Penetration Percentage and Supply Chain Concentration

We suggest that the 7.5 percent market penetration and the median supply chain concentrations are conservative goals for Montana. If Montana is able to grow its market share to 7.5 percent and expand its supply chain to match half of what is available nationally, the industry could support an annual average of over 6,300 direct, indirect, and induced jobs from 2017 through 2030. Thus, Montana's photonics industry could serve as a major vehicle for future state economic growth, while creating quality jobs for Montanans.

Policy Recommendations

Montana has tremendous potential to expand the photonics cluster and position itself as a national and global leader in manufacturing photonics products with advanced energy and advanced manufacturing applications. The state can focus on innovative strategies that remove barriers to growth and increase demand. State leaders can fortify the photonics industry by improving workforce training, increasing access to technical and financial resources for supply chain businesses, and bolstering in-state demand for photonics products. Whether taken as a whole or as piecemeal solutions, the following policy recommendations can attract private investment, stimulate the state's economy, and create good-paying jobs for Montanans.

Recruiting and Expanding Photonics Companies

Strengthen and Expand the State's Foreign Direct Investment and Exporting Strategy

Montana boasts numerous amenities to attract business, yet the state's foreign trade missions have tended to focus on export opportunities. This narrow focus can cause the state to miss out on a key element of foreign investment: international businesses locating manufacturing operations in Montana. This strategy, called foreign direct investment (FDI), is commonly used by governments to fill business gaps and inject jobs and capital into the state economy. Through more strategic stakeholder engagement, state and local leaders could attract investment from foreign companies, in addition to building a global customer base. Montana could look to national best practices and useful resources to enhance its FDI and exporting initiatives.

What is Foreign Direct Investment?

Foreign direct investment (FDI) occurs when a company based in another country makes an investment in the United States by establishing operations or acquiring business assets. FDI increases capital in the economy, encourages transfer of technology and expertise, creates job opportunities for the local workforce, and fills gaps in the local supply chain. Strategies for state leaders include conducting FDI missions in foreign countries, inviting industry leaders to in-state conferences and tours, and providing business incentives.

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. The report found that they:

- engage universities in making international connections and economic development;
- establish strong relationships with economic development agencies and organizations that are active 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; and
- commit to long-term involvement in FDI efforts.

The report cites the following programs, among others, as successful models that states such as Montana could emulate: Automation Alley (Michigan), Bothell Biomedical Manufacturing Innovation Partnership Zone (Washington), Nebraska Reverse Trade Mission, The Right Place (Michigan), State University of New York at Albany Nanotech Complex, Idaho Market Enhancement Strategy, and International Soft Landings Center at TechTown (Michigan).

Connect with Economic Development Resources to Put Montana Photonics on the Map

There are many platforms that serve as gateways for connecting U.S. and international companies, and Montana could leverage these resources to highlight its growing photonics cluster and advanced energy focus and attract foreign businesses and customers. Some of these resources are detailed below:

SelectUSA offers advocacy, marketing assistance, and information to help state economic developers compete for global investment. Many companies looking to invest in the United States approach SelectUSA as a first step. SelectUSA often turns to Manufacturing USA centers like AIM Photonics when looking to connect foreign companies with U.S. locations.

The U.S. Cluster Mapping Project offers information about clusters across the United States, and is directed by the Harvard Business School in partnership with the U.S. Economic Development Administration.

The European Cluster Collaboration Platform serves as a platform to facilitate cluster-based networking and collaboration, including identifying European partnerships.

The European Photonics Industry Consortium represents startups, multinational corporations, and research organizations focused on LED lighting, solar photovoltaics, fiber optics, and other photonics-related technologies, and is deeply networked with many of the forty photonics-related organizations in Europe.

Identify Target Companies to Enhance State-Driven FDI and Exporting Efforts

To enhance its international initiatives, Montana could also actively identify and engage with companies that may be interested in locating operations in the state or purchasing locally manufactured goods. In addition to the economic development resources mentioned above, Montana could seek assistance from lead generation consultants like OCO Global and WAVTEQ, other photonics consortiums, and local universities. This strong network of partners could help drive Montana's international initiatives. Successful programs in Massachusetts and Virginia offer innovative ideas on how to facilitate these relationships.

Launched in 2011 following the Governor's trade mission to Israel, the Massachusetts-Israel Innovation Partnership (MIIP) grew from an industry research collaborative to a joint FDI partnership. Major Israeli companies have expanded operations to the state and Massachusetts companies have invested in Israeli intellectual property and R&D operations. As of 2015, more than 200 Israeli-founded companies have made a home in Massachusetts. These businesses accounted for $9 billion in direct revenue, $18 billion in total economic impact, and 4 percent of the state GDP, as well as 9,000 direct jobs and 27,000 indirect and induced jobs.

Established in 2013, Virginia's Going Global Defense Initiative sends defense contractors overseas to pitch their knowledge and expertise to potential customers. The initiative is sponsored by the Virginia Economic Development Partnership, which employs a team of researchers to assist Virginia businesses with identifying potential partners, evaluating market opportunities, and navigating export regulations. This campaign has resulted in new customers for over 230 Virginia-based firms in countries such as Australia and Brazil.

Montana could specifically target photonics companies focused on advanced energy to elevate its position in the marketplace. The following table provides a snapshot of these potential FDI companies.

Company	Country	Description
TE Connectivity	Switzerland	Designs and manufactures sensors and sensor-based systems for numerous industries, including wind.
ASML Holding	Netherlands	Manufactures photolithography systems for logic chips used in advanced energy applications.
ficonTEC	Germany	Focuses on the combined use of electronics and light and can be used to test photonics vital to solar and wind applications.
IQE	United Kingdom	Manufactures advanced semiconductor wafers used in concentrated photovoltaic cells.
Lumerical	Canada	Offers design tools to accurately simulate the performance of photonic components, circuits, and systems. For example, researchers use Lumerical 3D simulation tools to assess how light interacts with solar cells to better understand how cell efficiency can be improved.

Multinational Photonics Company Seeking U.S. Home

Foxconn, a Taiwanese electronics manufacturer, is looking to invest $7 billion in a new U.S. manufacturing facility. The digital display assembly plant could create as many as 50,000 local jobs. Montana could be an ideal location for the plant given its photonics resources, availability of land, low energy costs, and proximity to west coast markets and Foxconn's partner, Apple. Foxconn's Chairman, Terry Gou, said that Pennsylvania is being very proactive in discussions and encourages other states to "hurry up" lest they miss out on the opportunity to compete for the plant.

By promoting Montana's growing photonics cluster and business-friendly environment in FDI and exporting initiatives, the Governor, mayors, business leaders, and universities could strengthen the photonics industry and support local jobs for Montanans.

Provide Tax Incentives to Attract New Photonics Businesses and Fill Supply Chain Gaps

Montana has the potential to significantly mark its leadership in the photonics industry by expanding its industry scope. Small businesses currently drive the state's economy, and companies with more than 500 employees are scarce. Attracting larger companies to Montana could bring new expertise to the in-state industry, inject more capital into local communities, and create numerous job opportunities for Montanans, especially in areas of the state where the economic recovery has not been as robust. Montana could leverage strategic tax incentives to attract new businesses by (1) developing a uniform, tiered tax incentive package and (2) offering an anchor company tax credit that leverages support from in-state businesses.

Montana could create a uniform, tiered tax incentive package for photonics companies interested in expanding or locating operations in the state. This tax incentive package could include tax exemptions, deductions, or credits as well as job training and infrastructure investments. To be eligible for this incentive, Montana could require that an interested company commit to creating a minimum of new jobs in the state. As a company's total investment and number of new employees increases, the length and percentage of certain tax incentives could improve. The Nebraska Advantage Package offers an example of this incentive structure. Nebraska's program provides six tiers of benefits to interested businesses based on their expected investment and employment. Potential provisions include sales tax refunds, investment credits, wage credits, and personal property tax exemptions. Between 2006 and 2015, seventy-eight companies received a benefit under this program, with only nine having relocated to the state. While creating tax incentive packages on a case-by-case basis may work well with large companies negotiating among several states, a uniform and tiered incentive

State resources can enable business development and planning for growth

for photonics companies could attract businesses of all sizes and signal Montana's commitment to the industry.

Montana could also encourage in-state photonics companies to fill supply chain gaps by offering an anchor company tax credit. Montana could look to Rhode Island as a model for this type of incentive. In 2015, Rhode Island created an Anchor Institution Tax Credit to bolster its in-state industry. Under this policy, an existing, in-state company receives a tax credit if it is responsible for a job-creating supplier locating in Rhode Island. For example, if a Rhode Island-based wind developer lures a tower manufacturer into the state, the wind developer would receive a tax credit. To effectively leverage its strong photonics company base, Montana could establish a tax incentive similar to Rhode Island's to leverage its strong photonics company base.

Montana could consider at least one of these strategic tax incentives. By supporting supply chain growth, Montana could fortify its competitive advantage in the photonics industry and ensure quality jobs for Montanans.

Institute a Business Equipment Tax Exemption for Photonics Companies

Montana could strategically leverage tax exemptions to attract out-of-state photonics companies and recruit in-state companies to expand. A principal example is the Montana business equipment tax exemption, which is currently capped at $100,000. Optics equipment is technologically sophisticated and quite expensive, often exceeding this threshold. The high level of capital required for companies to invest in optics equipment is a barrier to growth in the industry. The state could provide a special exemption for Montana-based photonics companies by raising the cap substantially or eliminating it entirely.

In Massachusetts, the City of Lowell successfully attracted new photonics business to the area by providing a thirteen-year Tax Increment Financing and Personal Property Tax Exemption Agreement. The tax exemption applied, in part, to the purchase of machinery and equipment needed to manufacture photonics products. The president of Metrigraphics, LLC, the relocating photonics company, cited the tax break as "the most important factor" in the company's move to Lowell, along with the proximity to the university. The new facility will bring and retain nearly 100 jobs in the region.

Montana has already passed an industry-specific tax exemption in 2015 with the Montana Ammunition Availability Act. A similar carve-out for photonics companies is a sensible approach to the unique, capital-intensive nature of optics product manufacturing and would entice more photonics companies to the state.

Crowdfunding Hub in Wisconsin

Rather than waiting for the private sector to act, several states have taken the initiative to set up a crowdfunding hub. Wisconsin, for example, offers a licensed crowdfunding hub called CraftFund where Wisconsin investors can browse specialized companies seeking investors.

Access to Capital

Create an Online Crowdfunding Hub

Montana has one of the lowest rates of venture capital investments per capita in the country. Thirteen venture capital deals occurred in the state from 2009 to 2014, compared to the forty-seven that occurred in Delaware and eighty-three in Rhode Island, two states most comparable in population; the national average for that time-period is 445 deals. Ranking in the bottom quarter of states in terms of total venture capital funding, Montana needs innovative ways to attract investments to its promising new photonics companies. Montana has already passed legislation exempting intrastate crowdfunding from registration and compliance obligations required of large public companies, enabling local companies to use this effective funding tool. Simply put, through equity crowdfunding, small investors can buy shares in Montana startups to provide them with much-needed capital. However, small companies still experience difficulty taking advantage of crowdfunding opportunities due to their inability to reach a broad network of investors.

Online equity crowdfunding hubs allow entrepreneurs to advertise their business ideas and gather small investments from many investors via a website. By creating a single location for investors to fund new businesses, equity crowdfunding hubs can dramatically improve access to capital.

Montana's leaders could create an equity crowdfunding hub to showcase Montana companies looking for startup capital. The online portal could be hosted on the Innovate Montana website to leverage existing web traffic and improve its visibility. Montana's leaders could also provide a matching grant specifically to photonics companies to help offset the costs they expend preparing to crowdfund. By creating its own equity crowdfunding hub, Montana could attract funding to spur startup growth and job creation.

Use an Insurance Credit Auction to Fund the Montana Board of Research and Commercialization Technology

Montana's nascent photonics companies have limited options when searching for startup capital. However, MBRCT offers one the state's most successful grant programs for jumpstarting promising, home-grown ventures, with some photonics companies taking advantage of this funding to flourish. From 2001 through 2016, MBRCT awarded an annual average of about $2.6 million in grants. These grants resulted in 459 annual jobs created, $22.5

million additional annual dollars earned by Montana households, and $4.7 million annual tax dollars generated. Despite MBRCT's impressive track record of identifying, fostering, and funding nascent commercial technology ventures, budgetary restraints in recent years resulted in cuts to MBRCT's funding by nearly two-thirds. Given its outsized economic impacts, the state legislature could consider restoring MBRCT to full funding levels. Creative mechanisms could replenish program funds while minimizing the burden on the current budget. In particular, Montana could consider selling premium insurance tax credits, encouraging insurers to support MBRCT in exchange for a credit against future tax liability.

While this type of mechanism has been used in many states, it has seen recent success in Maryland and Pennsylvania, where deferred tax credits were auctioned off to insurers and then distributed to designated investment partners. Established in 2011, the InvestMaryland program is jointly managed by the Department of Business and Economic Development and the Maryland Venture Fund Authority, a nine-member group of business and investment experts. Maryland employs a hybrid model in which two-thirds of the funds go to selected private venture firms, about one-third filters into the state-run Maryland Venture Fund, and a small portion is directed to the Maryland Small Business Development Financing Authority. Invest-Maryland raised $84 million in the auction, exceeding its goal of $70 million. These funds were distributed to about seven venture capital firms and have since supported three InvestMaryland Challenges, an international business competition. Although attributable to multiple factors, the state experienced a 33 percent growth in venture capital from $470 million (fifty-seven deals) in 2012 to $623 million (sixty-two deals) in 2013, over the time of InvestMaryland's initial funding.

Similar to Maryland, Pennsylvania created the Innovate in PA program in 2013 and auctioned $100 million in deferred insurance tax credits. Innovate in PA is projected to create at least 1,850 technology jobs, about 3,500 indirect jobs, and a return of $2.37 for every dollar invested.

Montana could replicate these auctions to generate funds for MBRCT. State leaders could also broaden MBRCT's scope by channeling some of the proceeds into a state-run venture fund or private venture firms that commit to investing in Montana. By leveraging this innovative funding model, the state government could re-energize investment activity and enable positive economic impacts in Montana.

Establish a Technology Investment Tax Credit

Montana's high-tech industry is projected to grow nearly seven times faster than statewide growth, serving as a key source of high-paying jobs. To stay competitive and spur job creation, Montana could encourage investments in high-tech early-stage and startup businesses by offering a tax credit for these investors. The state could look to successful and innovative models in other states.

In 1996, Ohio pioneered a Technology Investment Tax Credit, a temporary tax credit with a $45 million aggregate cap. Ohio's program provided Ohio taxpayers who invested in early-stage, pre-approved, in-state technology companies to claim a credit worth 25 percent of the investment up to a maximum of $250,000 per company. Over the credit's life of six years, 3,500 Ohioans invested approximately $180 million into more than 665 companies through the program. The program was so popular that venture capitalists are calling for its return after the cap was hit in 2013.

In 2014, Kentucky followed Ohio's lead and established a similar credit but increased the tax credit to 40 percent of the investment in qualified small businesses. Kentucky also limits the amount claimed in any year to 50 percent of an individual's total credits and allows a carry-over for fifteen years. Kentucky's credit increases to 50 percent for investments in businesses in "enhanced incentive counties," or counties that have been deemed by the state to have exceptionally high unemployment rates or to be among the most distressed counties in the state.

A properly designed tax credit can influence investment decisions and boost demand for investments in early-stage and startup companies. By creating a significant incentive, Montana can help to funnel desperately needed capital into its high-tech industry that will innovate and at least partially recoup lost revenue resulting from the credit through increased revenue from new jobs and economic activity. Montana could also consider providing an increased incentive for qualified businesses, as Kentucky does. For example, the state could provide a 10 percent higher tax credit for investments in photonics companies to support the cluster. Montana's technology investment tax credit would help spur investment in growing companies and create good-paying jobs for Montanans.

Innovation Ecosystem

Leverage Philanthropic Funding Via a Foundation Liaison

Montana is in the midst of a severe budget shortfall, due to shrinking oil, gas, and coal revenue and a slow increase in tax collections. The state must continue to invest in programs that educate its workforce and foster a strong innovation ecosystem, but it is a challenge to make noncritical public investments when the budget is tight. Montana is home to many charitable organizations that can join together to help sustain underfunded programs. Montana's foundations share the goals of engaging citizens, supporting youth education, and serving the needs of communities. In 2014, 281 Montana-based foundations—about seventy-five of which are community foundations—with $1.5 billion in assets gave a total of $60 million in grants. The state government could appoint a Foundation Liaison to connect with and broker support from these foundations.

Montana could look to Michigan as a model for this initiative. In Michigan, the Governor's Office of Foundation Liaison (OFL) is the first of its kind in the nation. OFL builds funding partnerships and strategic collaborations between the state government and the philanthropic community to support programs that improve education and health for all Michigan residents. Foundations are actively engaged throughout OFL activities; the Foundation Liaison and OFL staff come to the state on loan from participating foundations, while contributing funders and nonprofits help make up the OFL Advisory Committee. Since 2003, OFL has brokered investments from seventeen foundations, totaling more than $150 million.

The Governor's Office of Community Service could reach out to the leading foundations in the state and enlist their help in appointing a Foundation Liaison and paying for a portion of the liaison's salary. Key priorities for the Foundation Liaison could be recruiting students, funding world-class educational facilities, and training workers. To maximize the impact on the state, the Foundation Liaison could also engage national foundations with potential interests in Montana, such as those wanting to support displaced coal workers. Via a Foundation Liaison, Montana and the foundation community could leverage one another's investments and efforts, working together to promote business, innovation, and jobs.

Provide Scholarships and Fellowship Grants to Attract and Retain Top Photonics Students

Both MSU and UM are active hubs for physics and photonics research, with MSU housing two cutting-edge photonics R&D labs: OpTeC and Spectrum Lab. Together, the universities lead the charge to identify innovative optics technologies and start these discoveries on the path to commercialization. However, they both face a perennial problem of recruiting top U.S. and international students due to a lack of dedicated funding sources to support fellowship opportunities. Much of the current research funding is project-specific, subject to cyclical flows that do not always correspond with the academic calendar. As such, once the project funding runs out, so too does a major incentive necessary to retain the next generation of photonics researchers. This impact of this barrier spills into the energy workforce where Montana businesses are unable to get an adequate labor pool to meet demand. To address this hurdle, Montana could leverage photonics industry partners to expand the number of scholarships and fellowship grants available for exceptional students in the field.

Both MSU and UM could partner with MPIA to identify and attract potential sources of funding from private companies or foundations within the existing cluster and outside of the state. The Foundation Liaison recommended in this report could be a good source of these funds. The universities could develop scholarship and grant programs that companies can provide matching funds in exchange for access to future graduates, influence over research projects, and role in curriculum development. The universities could also engage with professional and trade associations—such as SPIE, the Optical Society, and the IEEE Photonics Society—to promote available funding programs for students and use them as a model for state-specific opportunities. In 2016, SPIE awarded $392,000 to 153 students across the country to pursue an optics education. Given the state's impressive optical track record, there could be cross-promotional and matching opportunities to attract Montana students to enroll. By establishing sustainable funding to support top photonics students, Montana is investing in the future entrepreneurs, inventors, and operators who will grow the state's photonics industry.

Become an AIM Photonics Innovation Center

In 2016, the U.S. photonics industry received an enormous boost: the Department of Defense invested over $100 million in AIM Photonics to build out a national manufacturing consortium dedicated to growing the photonics industry. Among other services, AIM Photonics helps drive and shape the nature and direction of photonics research and commercialization across

the country. One of the main tools it uses to accomplish this mission is partnering with universities, state governments, and private industry to designate innovation centers that specialize in critical photonics applications and research. Although the Montana photonics cluster is one of six photonics clusters across the country, it is not currently a member of AIM Photonics. As such, it cannot benefit from the coordinated research, testing, commercialization, and marketing decisions that AIM spearheads. Furthermore, the Montana cluster misses out on opportunities to host visiting researchers, access AIM funding, and showcase its leadership in utilizing photonics for remote sensing, which has numerous advanced energy applications.

Membership in AIM Photonics elevates Montana's profile as a potential location for foreign photonics companies. SelectUSA looks to Manufacturing USA centers when foreign companies inquire regarding appropriate sites for their new U.S. operations.

As such, MSU and MPIA could become members of AIM Photonics. This approach will foster increased collaboration between MSU and photonics researchers across the country. Additionally, it will provide a priceless marketing opportunity. As businesses and researchers travel to test their products at the MSU lab space, they will enjoy the state's exceptional amenities and learn about the tax incentives, sources of funding, and other services available to photonics companies. It will enable Montana to position itself as the leader in photonics advanced energy applications, giving it a competitive advantage over other photonics clusters. This type of exposure is a pivotal recruitment strategy that will grow the cluster and put Montana squarely on the national map and on the leading edge of the photonics industry.

AIM Photonics Membership

There are different tiers of membership in AIM Photonics, with associated requirements and benefits. MSU could join as a Tier 2 academic member with no up-front fees. MSU then becomes eligible to apply for research projects sponsored by AIM. If chosen to participate in a project, the university would have to contribute a portion of the project costs, which can take the form of an in-kind contribution such as lab space and faculty time dedicated to the project.

Getting Montana on the Map

Op-Tec is a national consortium for optics and photonics education. While Op-Tec considers Gallatin College a partner, the website does not mention Montana's photonics cluster among the highlighted five other clusters. MPIA could establish a formal relationship with Op-Tec to ensure that the Montana cluster is featured along with other states on the Op-Tec website. Op-Tec is not a fee-based membership organization.

Workforce Development

Introduce Lab Space and Equipment Sharing

One of the major hurdles in accelerating workforce development and education programs is the cost of the training equipment. For example, a typical workstation shared by two or three students in the Gallatin College program costs approximately $50,000. Gallatin College students only use this equipment at night, leaving this expensive resource unused during the day. By pooling resources and space, MSU and Gallatin College could benefit from economies of scale to increase lab capacity and optical measuring equipment.

The University of Colorado, Boulder instituted a cutting-edge equipment-sharing program available to researchers throughout

the university. Any scientist on campus can rent space within an Ultra-Low Temperature freezer at a set rate per square inch. This program sought to consolidate the 150 freezer units spread out around the campus, saving energy, reducing infrastructure costs, and freeing up space. As a result, the leaders of this pilot program estimate up to $17,000 will be saved over a ten-year period.

By coordinating the use of photonics equipment and lab space, MSU and Gallatin College could replicate the UCB model to realize substantial cost, time, infrastructure, and energy savings. This would enable the institutions to train more photonics technicians, engineers, and scientists through their leading optical programs. Any additional, available time on the equipment could also be rented to private companies for their own R&D, generating revenue to support the photonics programs. Finally, making this space available to parties outside the university or college system could also give out-of-state researchers and entrepreneurs the opportunity to visit the Bozeman area in order to test their products, increasing the revenue generated by the facility and elevating the status of both institutions.

Develop Online and Field Training Options

Montana is geographically vast; it ranks fourth in the country behind Alaska, Texas, and California for total area. With only one million residents, Montanans are dispersed far and wide across the Big Sky State's fifty-six counties. But the Montana photonics cluster is predominately located within one area, Gallatin County in the southwest corner of the state, making it difficult for Montanans who do not live nearby to access educational, training, and employment opportunities in the cluster.

Online and field training components would empower those Montanans who do not live immediately in the Gallatin Valley to begin their education in optics. The University of Central Florida's Continuing Education program offers a Photonics Certification Program that includes a mix of online and hands-on training, requiring twenty-four hours of online study and twelve hours of hands-on lab and field application. This online option enables students to access two-thirds of the material at the time and location of their choosing.

Given the vast size of Montana, online and field options would allow tribal members, rural residents, and those unable to travel far distances to take advantage of the training programs. Online courses also provide a cost-efficient way for low-income or unemployed prospective optics students to access the education and training to enter into the industry.

Offer an Accelerated Optical Technician Training Program

Compounding the geographic challenge, the current optical technician training program at Gallatin College is only offered at night and typically takes two years to complete for an Associate of Applied Science degree. For those Montanans willing to move to the area and enroll in the program, the two-year curriculum increases the costs for those hoping to enter the profession quickly. The length of the program is especially inhibitory for mid-career professionals who are between jobs.

There are opportunities to furnish classes and training that will shorten this timeline to one year by offering an accelerated, daytime program. For example, the University of Central Florida's Continuing Education photonics program enables students to customize their education based on their schedules and previous educational experience.

Furthermore, by using the photonics lab equipment during the day for the accelerated program, more students would be trained on the existing workstations. This would make it possible for the program to expand without needing to purchase additional equipment or identify new space.

Continuous training programs ensure a skilled manufacturing workforce

Creating New Opportunities for Growth in Photonics: Wind Development

Increase Montana's Renewable Portfolio Standard

A renewable portfolio standard (RPS) is an indispensable tool that a state can use to stimulate local demand for advanced energy. Although the exact structure can vary by state, an RPS stipulate that a certain percentage of energy purchased by utilities to satisfy consumer demand must come from a variety of advanced and renewable energy sources. Across the United States, twenty-nine states and the District of Columbia, including Montana, employ RPS programs, and over 55 percent of retail electricity sales are affected by RPS programs. Over half of the growth in renewable electricity generation and capacity since 2000 has been associated with state RPS requirements. RPS programs drive demand and provide critical market signals to investors, renewable energy developers, workforce development managers, and local chambers of commerce.

Montana's previous RPS increased the amount of energy coming from renewable sources to 15 percent of the state's energy needs by 2015. The state met that goal and elected not to raise the standard. Expanding the RPS target, and including a carve-out for wind, would send a clear market signal and spark in-state demand for the prolific wind resource in Montana.

An RPS carve-out sets specific goals for electricity generation from chosen renewable sources, such as solar or wind energy. A carve-out can promote industry growth, as it incentivizes energy producers to invest in the chosen technology. In fact, thanks to an RPS carve-out for solar, Massachusetts reached its goal of 250 MW of solar generation four years early and altered its target to an ambitious 1600 MW by 2020. Several states, including New Mexico and Illinois, have specific carve-outs to incentivize wind generation.

Were Montana to implement a similar carve-out for wind generation, there would be positive and cascading impacts for in-state demand of wind-applicable photonics products. For example, increasing wind generation could require additional utility-scale wind development and an accompanying need to use LIDAR technology to properly site, manage, and monitor turbines, blades, and transmission components. Increasing Montana's RPS and including a wind carve-out would drive beneficial spillover effects that would amplify photonics manufacturing within the state.

Additional Barriers to Wind Energy Deployment

Montana currently exports approximately half of the energy generated in the state, mostly to Washington and Oregon. Montana can capitalize on the wind demand from its out-of-state customers, as neighboring states increase their RPS targets. However, a major hurdle for supplying these markets is the management of its intrastate and interstate transmission lines. Montana could pursue three strategies to tackle this issue:

1. Direct the Montana Department of Environmental Quality to update and streamline transmission-siting guidelines based on best practices and public input.
2. Encourage the Bonneville Power Administration to eliminate the additional rate for the Montana segment of the Eastern Intertie and roll it into the standard network rate.
3. Coordinate statewide or regional balancing authorities to establish an Energy Imbalance Market that efficiently matches generation with load.

These strategies have been identified by the Governor's energy blueprint and could be supported by further coordination and collaboration across stakeholders. By addressing these barriers, Montana could promote wind deployment, expand its export potential, and create demand for advanced energy photonics products.

Wind turbines in Montana

North Carolina's Solar Carve-Out

In 2008, North Carolina included a solar carve-out or "set aside" of 0.2 percent by 2018 in its RPS, which requires all investor-owned utilities to supply 12.5 percent of retail electricity sales from eligible resources by 2021. Since 2008, North Carolina's solar industry has skyrocketed—growing from 0.4 MW of installed solar in 2008 to 2,295 MW by mid-2016 and ranking it second in the nation for installed solar capacity. This growing industry supported 5,439 solar jobs and created nearly $1.5 billion in revenue in 2015.

Call to Action

Growing the Photonics Cluster, Growing Jobs

- Boost the Foreign Direct Investment Strategy
- Provide Tax Incentives to Attract New Photonics Businesses and Fill Supply Chain Gaps
- Institute a Business Equipment Tax Exemption for Photonics Companies
- Create an Online Crowdfunding Hub
- Use an Insurance Credit Auction to Fund the Montana Board of Research and Commercialization Technology
- Establish a Technology Investment Tax Credit
- Leverage Philanthropic Funding Via a Foundation Liaison
- Provide Scholarships and Fellowship Grants to Attract and Retain Top Photonics Students
- Become an AIM Photonics Innovation Center
- Introduce Lab Space and Equipment Sharing
- Develop Online and Field Training Options
- Offer an Accelerated Optical Technician Training Program
- Increase Montana's Renewable Portfolio Standard

Montana's existing photonics cluster is a solid foundation upon which the state can grow its economy, create jobs for the state's residents, 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 Montana manufacture products within the state, enable entrepreneurship for technological advances, fund innovation with accessible capital, equip workers with the skills required for the state's future economy, and grow demand for photonics technology.

Montana has the opportunity to support over 6,300 direct, indirect, and induced jobs in the photonics industry from 2017 through 2030. The photonics cluster could grow to supply a meaningful portion of the global demand for photonics products in advanced energy, advanced manufacturing, and other applications.

To fully realize Montana's potential in the photonics 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 Montana's competitive advantage in the industry and creating quality jobs for Montanans. State and local economic development depends on the collective work of many partners across government, universities, businesses, and other stakeholders. This report recommends actions that each group can take to support the photonics industry. Continued collaboration is necessary to address barriers to cluster growth and demonstrate that the state is ripe for investment.

Montana's leaders can draw from among dozens of innovative strategies that city, county, and state governments across the country and abroad have implemented to create more job opportunities in the advanced energy sector. Examples of these best practices 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 Montana by organizing working groups and conducting deeper analyses, such as identifying supply 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.

A fully cited version of this report is available on our website at http://americanjobsproject.us/.

Appendix: Economic Impact Methodology

Modeling Approach

The American Jobs Project combines existing tools, analyses, and projections from several reputable sources to estimate jobs potential. Rather than providing a specific estimate, we show jobs potential across a range of possible outcomes. All jobs are shown as the average annual jobs that could exist during the analysis timeline (2017–2030). 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 believe the key to job creation lies in local action. Our estimates are intended to start a conversation about how local stakeholders can work together to set their goals and utilize the same tools and data that we have used to estimate potential impacts.

Specifically, the photonics analysis utilized IMPLAN, a proprietary model maintained by the Minnesota IMPLAN Group. Industry growth estimates and benchmarks from IBISWorld and BCC Research also were used to generate impacts across different levels of U.S. market penetration. Photonics is an industry of industries, with a broad range of technologies and markets, and does not have a specific designation in the North American Industry Classification System, the basis for most macroeconomic analysis and reporting. To estimate economic impacts for photonics, the American Jobs Project used a similar "analog" industry to model the spending patterns of businesses. For this photonics analysis, the semiconductor and related device manufacturing industry was the appropriate analog industry. Many photonics technologies fall into this industry, such as light-emitting diodes, lasers, photovoltaics, integrated circuits, photosensors, and optoelectronics.

The American Jobs Project presents several supply chain scenarios to identify the impacts of growing the Montana supply chain. The lowest scenario uses the current Montana economy as the model to represent the impacts of targeting direct photonics jobs and not developing the photonics supply chain. The highest scenario uses the entire U.S. economy as the model to represent the impacts of Montana having a photonics supply chain as complete as that of the entire United States. A "median" scenario gives the median between the upper and lower bounds presented by the other scenarios and is used as Montana's target jobs potential in

this report.

It is important to note that we do not include any impacts associated with the construction of new facilities that may result from an increased number of photonics firms locating in the Montana economy during the analysis timeline.

Introduction to IMPLAN

IMPLAN is a proprietary regional economic analysis model, maintained by the Minnesota IMPLAN Group. It 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. A region is defined by the user, and can be as small as a county or as large as the entire U.S. economy. For this analysis, both the state of Montana and the entire United States were used.

When a change of spending occurs in an economy, such as increased income for the photonics industry, spending also increases for supplying industries and the workforce. This cascading spending, or multiplier effect, can generate an economic impact that is often larger than the initial spending. This multiplier effect is created through multiple rounds of spending by industries paying their suppliers and employees. The supplier industries and employees, in turn, spend their money on other products or services in the economy. As the rounds of spending continue, money "leaks" out of the economy for purchasing products and services that are not available in the region. These leakages are determined by local purchasing coefficients, which are built in to IMPLAN's models. For example, an industry that relies heavily on imported commodity products or foreign labor will have a lower impact on the economy than an industry that can purchase nearly all of its supplies in the regional economy.

The resulting impacts from the spending, including tax revenues, are summed and presented across three impact categories:

- **Direct** – Increased payments to the target industry that support employees of that industry and generate the expenditures that begin to cascade through the economy.
- **Indirect** – Impacts created by industry-to-industry spending, such as supply chain purchases, that are first created by direct spending from the target industry and then through increased spending by suppliers to their supply chain.
- **Induced** – Employees of the target industry and their suppliers consume products and services, as a result of being

supported by direct and indirect spending (e.g., workers buy homes, cars, haircuts, and lattes). In turn, the consumer-facing industries can support their employees and those employees spend more of their income on products and services in the economy.

We used the most recent version of IMPLAN for this analysis, which includes 2013 data and improved modeling for regional imports and exports. The IMPLAN model utilizes input-output data from U.S. National Income and Product Accounts at the Bureau of Economic Analysis. The model includes 526 economic sectors that are tied to the North American Industry Classification System codes. Region-specific multipliers follow the flow of spending from where it originates, as it cascades throughout supplier industries and employee spending, and eventually "leaks" out of the regional economy. The sum of the direct and multiple rounds of secondary spending show the total impacts, including jobs created or sustained, tax revenues, proprietor income, and economic output.

Limitations of IMPLAN

It is important to note the limitations of these modeling methods. As mentioned, the estimates shown are only average annual jobs created or sustained and we base this off of the total job-years, or one job sustained for one year, that exist within the timeframe of our analysis. This does not mean that every year will have the same number of jobs over the timeline. Any given year could be above or below the average we present. Job losses in industries that compete with those in our analysis are also not evaluated. Models do not perfectly predict behavior, so indirect and induced job estimates could vary greatly based on the reality of what is actually purchased locally. Also, foreign and domestic competition can play a significant role in limiting the potential for job creation. The estimates presented in this report are highly dependent on sustained local action towards developing and maintaining these industries.

Model Inputs

The first step to conducting the economic impact modeling was to identify how to characterize the photonics industry. As previously mentioned, the semiconductors industry was used as an "analog" to the photonics industry, as a significant portion of photonics technologies fall under the semiconductor industry.

Second, a model for estimating the future demand for photonics technologies was needed. Estimates of market demand for photonics technologies through 2021 were taken from BCC Research reports for a variety of photonics technologies.

Current market demand for the United States was derived from estimating North American demand for specific technologies and applying the percentage of U.S. total demand in relation to other North American markets (i.e., Mexico and Canada). Annual demand through 2030 was derived from the current market demand estimate, by applying the individual compound annual growth rates for each technology type to its weighted portion of total demand. We assume, for this analysis, that the rates stay constant past 2021 through 2030.

Third, a model for estimating wages and owner income was needed. Estimates of average wages were taken from the semiconductor industry report from IBISWorld and cross-referenced with photonics-specific wages on O*Net Online. Owner income was derived from IBISWorld's semiconductor industry report.

Finally, the current market penetration of Montana's photonics industry was estimated as a function of current employment in the industry. Scenarios were developed by exploring modest increases in the estimated market share. Impacts from improving supply chain concentration utilized both the current Montana economy, an equivalent to the current U.S. economy, and a median between these two extremes. Using Montana's current economy for the first supply chain scenario would indicate that Montana attracts no new businesses to supply their photonics industry. Using the U.S. economy as an "U.S. Equivalent" scenario would indicate that Montana attracts suppliers that could meet the same demand as the current U.S. economy. The "Current" scenario is a lower bound and the "U.S Equivalent" scenario is an upper bound. A "Median" scenario is used to identify a reasonable target number of jobs for Montana.

Model Outputs

Once the data was prepared for input into IMPLAN, we ran the model for each scenario and generated the outputs. Outputs were reported for direct, indirect, and induced impacts under each scenario in terms of employment, labor income, GDP, total economic output, and state/local and federal tax revenue. Only employment is presented in the report, and we represent this output as the average annual employment during the analysis period. The additional output data is available by request.

Credits

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