Pennsylvania Jobs Project

A Guide to Creating Advanced Energy Jobs

MARCH 2016

AMERICAN JOBS PROJECT

A Letter from the American Jobs Project

It's 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.[1] Over the last few decades, the loss of middle-income jobs in America has been due largely to the global shift in manufacturing ("tradable jobs") to emerging economies.[2] Of the millions of jobs lost during the recession, most were good-paying, middle-class jobs.[3] Unfortunately, many of the jobs created during the recovery have been in low-skill, low-paying occupations.[4] 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 the 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 worry about terrorism. Hu Jintao's response was telling: what kept him up at night was, "creating 25 million new jobs a year" for his people.[5]

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 roadmap for 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 solutions. That demand—whether borne out of a need for diverse, reliable and clean power or to achieve energy independence from unstable regimes—creates "the mother of all markets" for local U.S. businesses to build and sell those solutions.[6] Strategically minded businesspeople looking at global growth projections in advanced energy demand are making major investments and reaping large revenues. In 2014, the private sector reported $1.3 trillion in global advanced energy revenues, the fastest-growing

year on record.[7] Advanced energy investments are now bigger than the global apparel sector and almost four times the size of the global semiconductor industry.[8] And jobs? Up to 16.7 million jobs are projected to be in the global advanced energy sector by 2030, almost tripling the 5.7 million people employed in the sector in 2012.[9] The question for the United States is: where will those new jobs be created?

The American Jobs Project is about finding ways to make our states the answer to this question. If countries across the globe, including the U.S., are seeking technical products and solutions for our 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 U.S. residents with the skills those businesses need to build their advanced energy products?

It is true that the U.S. will not likely be able to attract back the traditional manufacturing jobs of the past; those jobs are gone—either to low-wage countries or to automation—and we have to accept the fact that they are not coming back.[10] But our research shows that with innovative policies and a smart focus on industrial sectors, states can become hubs of innovation and job creation in specific advanced industries that soar with each state's strengths.

The American Jobs Project gives policymakers the tools to create good-paying jobs in their states. We propose innovative solutions built upon extensive research and tailored to each state. Many are best practices, some are new, and all are centered upon 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.

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

American Jobs Project

The American Jobs Project is a national, interdisciplinary, research-based initiative. Our team includes nearly 100 student researchers with a broad range of expertise, including law, business, engineering, and public policy. We have ongoing relationships with hundreds of on-the-ground stakeholders and are actively collaborating with university partners and industry allies.

Academic Partner - H. Scott Matthews, Carnegie Mellon University

Scott Matthews is a Professor in the Departments of Civil and Environmental Engineering (CEE) and Engineering & Public Policy (EPP) at Carnegie Mellon University. He is also the Associate Department Head of EPP.

Scott's work intends to facilitate infrastructure and environmental decision-making under uncertainty via large datasets, computation, and visualization methods. He has contributed to development of research and education tools for environmental and energy life-cycle assessment of products and processes (such as the EIO-LCA model), estimating and tracking environmental effects across global supply chains (such as carbon footprinting), and the sustainability of infrastructure systems.

At Carnegie Mellon, he has taught graduate and undergraduate courses in the Departments of Economics, Civil and Environmental Engineering, Engineering and Public Policy, and Computer Science.

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Employment in the Green Economy for their analysis on smart building and energy efficiency jobs.

We extend our sincere gratitude to the hundreds of individuals from businesses, government, nonprofits, utilities, and universities for meeting with us, exploring ideas, participating in working groups, collaborating on the report, and sharing their vision for the future.

Dozens of hands were involved in the process of researching, writing, and designing the report. Kate Ringness and Aravind Gayam were the lead writers and researchers. Jackie Kimble and Stephanie Smith were the lead editors, Hank Love was the lead analyst, and Amariah Baker was the graphic designer. Other researchers and writers include Rachel Young, Tiffany Wong, Alex Jang, Chucks Marcelo Okoli, Chris Martin Reilly, Laura Hobbs, Jacob Gill, and Andrew Herrmann.

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 sector—and to do so at the state, not the federal, level. Policymakers who leverage the unique strategic advantages of their state to grow localized sectors of interconnected companies and institutions are poised to create quality jobs.

Pennsylvania has a strong foundation in the advanced energy sector with approximately 57,000 full-time jobs in more than 4,000 clean energy businesses.[11] Extensive research and more than forty interviews with local stakeholders and experts in Pennsylvania have resulted in identifying two economic clusters showing particular promise: smart buildings and solar.

Tremendous growth opportunities exist in Pennsylvania's advanced energy economy, including the expansion of the smart building and solar sectors. To take full advantage of these opportunities, Pennsylvania policymakers can adopt strategic policies to help the commonwealth's businesses grow, innovate, and outcompete regional, national, and global competitors. Indeed, with the right policies, Pennsylvania's smart building and solar industries can support as many as 11,600 jobs per year through 2030.

This project serves as a research-based roadmap for state and local leaders who seek to develop smart policies that leverage Pennsylvania's resources to create skilled, good-paying jobs.

Summary of Policy Recommendations

The analysis presented in this report culminates in four thematic sets of recommendations for Pennsylvania's policymakers. Each set of recommendations identifies opportunities for barrier removal and future growth in the smart building and solar sectors. While the recommendations are intended to be complementary and would be powerful if adopted as a package, each can also be viewed as a stand-alone option. Taken together, these recommendations chart a course for Pennsylvania leaders to create and enhance jobs in the advanced energy sector.

Smart Building and Energy Efficiency

Implement State Energy Efficiency Benchmarking and Disclosure Policy: Establish city-level benchmarking programs throughout the commonwealth in order to monitor building energy performance, encourage smart building investments, and achieve environmental benefits.

Increase Compliance and Update Building Codes: Adopt the most recent residential and commercial building codes and establish a strong compliance plan in order to expand the market for energy-efficient structures.

Enable PACE Financing: Encourage energy efficiency upgrades and smart building projects by allowing Pennsylvania property owners to finance investments with a loan that is repaid through their property tax bill.

Use Competition to Encourage Small Businesses to Participate in Capacity Market Auctions: Incentivize small- and medium-sized businesses to jointly auction their future savings in PJM's capacity market by hosting a state or local competition.

Solar

Create an Online Crowdfunding Platform to Support Solar Projects: Support solar projects for schools, hospitals, and community centers by creating an online crowdfunding platform to pool public donations.

Establish a Statewide Model for Streamlined Permitting Processes: Reduce the soft costs of installing solar by simplifying permitting processes, lowering permit fees, and establishing consistent interconnection requirements throughout Pennsylvania.

Enable Local Communities to Develop Solar Projects: Allow customers to pool resources and invest in a single shared renewable energy system, especially in areas without adequate sunlight for individual solar systems and for customers based in multi-unit buildings.

Establish a Distributed Generation Carve-out: Mandate that a portion of electricity be procured from distributed generation projects to encourage in-state production of renewable energy and diversify Pennsylvania's fuel mix.

Innovation Ecosystem and Access to Capital

Create an Intrastate Securities Exemption for Equity Crowdfunding: Spur innovation, economic activity, and small business growth by creating an intrastate securities exemption for equity crowdfunding. The exemption will expand the pool of investors that could finance Pennsylvania startups.

Establish an Early-Stage Capital Gains Tax Exemption: Increase the flow of venture capital and incentivize investors by establishing a capital gains tax exemption for investments in early-stage Pennsylvania companies.

Facilitate Partnerships within the Energy Innovation Ecosystem: Attract public and private research funds and venture capital to Pennsylvania by aligning advanced energy sector efforts and establishing collaborative partnerships among various stakeholders.

Workforce Development

Incentivize Businesses to Create More Apprenticeship Opportunities: Provide tax incentives and additional support to companies that hire and train apprentices. Increasing apprenticeship opportunities will help meet employer demand for trained workers and prepare Pennsylvanians for jobs in advanced energy sectors.

Develop Certificate and Degree Programs around High Performance Buildings: Collaborate with Pennsylvania universities and technical colleges to create certificate and degree programs that prepare students for jobs in the smart building and energy efficiency sector.

Provide Pathways for Adults to Return to College: Establish a program that enables adults to pursue higher education and supports companies that offer educational opportunities to their workers.

Chapter 1: Introduction

The American Jobs Project aims to spur job creation in the advanced energy sector by identifying innovative and state-specific policy and technology roadmaps. This national initiative takes advantage of the emerging global demand for advanced energy products and services. The American Jobs Project team analyzed the advanced energy economy in Pennsylvania and designed recommendations specifically tailored to the state's strengths. These recommendations were informed by extensive research and more than forty interviews with local stakeholders and experts.

This report identifies opportunities to boost growth in two advanced energy clusters that leverage the commonwealth's legacy industries and current investment activities. State and local leaders who seek to leverage the state's resources to create skilled, good-paying jobs can use this report as a foundation for action.

Market Opportunity

Demand for advanced energy has soared in recent years and is poised for continued growth. Since 2004, new investment in the advanced energy sector has totaled $2.3 trillion worldwide.[12] In the United States alone, over $386 billion was invested in advanced energy between 2007 and 2014; more than $51 billion was invested in 2014.[13] In nationwide polls, Americans increasingly support renewables over other forms of energy[14] and demand for renewable energy will continue to grow. By 2030, states will need to significantly reduce pollution from power plants, which will make an even stronger case for advanced energy technology, renewable energy resources, and increased energy efficiency.[15] Projections show that renewable energy will be responsible for the vast majority of new generation (69 percent to 74 percent) between now and 2030.[16] These trends point to a clear market signal: demand for advanced energy will continue to grow over the next fifteen years.[17]

Economic Clusters

> *"Clusters are geographic concentrations of interconnected companies and institutions in a particular field."*
>
> – Michael Porter, *Clusters and the New Economics of Competition*[18]

Economic clusters encompass a variety of linked industries and institutions—including suppliers of specialized services, machinery, and infrastructure—which form a supply chain.[19] Clusters also extend to manufacturers of complementary products and industries related in skills and technologies. By placing themselves in close proximity to industry allies, companies can benefit from each other's unique expertise and skilled workers.[20] Companies in a cluster enjoy closer access to specialized skills and information, which helps increase productivity and efficiency.[21]

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

Geographic proximity and repeated exchanges of information help foster an environment of coordination and cooperation among companies and institutions. Business clusters are shown to increase the productivity of participating companies, drive innovation in the field, and facilitate the commercialization of this innovation by increasing communication, logistical support, and overall interaction between cluster entities.[22] Clusters also help build a strong foundation for creating and retaining employment opportunities.

Pennsylvania's Energy Profile

Current Energy Portfolio

In 2013, Pennsylvania ranked third in the nation in total energy production.[23] Indeed, the commonwealth produces enough energy to meet the demand of local industry while also serving as a leading supplier to the entire country.[24] Pennsylvania is among the top five states producing coal, natural gas, and nuclear energy.[25] Approximately 36 percent of the commonwealth's total electricity production comes from nuclear energy, while natural gas and coal account for roughly 30 percent each.[26] Pennsylvania ranks in the top ten in the nation for total energy consumption; however, the state's per capita consumption ranks twenty-eighth in the country.[27] The industrial sector is responsible for 35 percent of energy use, while the residential and transportation sectors each account for about 24 percent of total use.[28]

Pennsylvania is heavily reliant on coal, natural gas, and nuclear power to meet energy needs.[29] Renewable sources ac-counted for only 4 percent of electricity generation in 2014.[30] Currently, wind, hydropower, and biomass are the primary renewable energy sources in the state.[31]

Renewable Energy Development

As a result of Pennsylvania's Alternative Energy Portfolio Standards (AEPS), the commonwealth is expected to see an increase in the amount of energy generated from renewable sources.[32] The AEPS Act of 2004 mandates that 18 percent of electricity sold must come from renewable and alternative energy sources by 2021, with at least 0.5 percent coming from solar power.[33] Currently, solar power accounts for less than 1 percent of the commonwealth's electricity generation.[34] Other alternative sources include byproducts of wood processing, methane from coal mines, and waste coal.[35] Since 2008, electric utilities have been mandated under Act 129 to pursue energy efficiency and conservation measures.[36] Utilities are also required to offer net metering to customers who connect their renewable energy systems to the grid.[37]

The commonwealth boasts multiple financial assistance programs that target renewable and alternative energy development. The Renewable Energy, Solar Energy, and Alternative and Clean Energy programs offer grants and loans for renewable energy component manufacturers and project developers based on job creation.[38] Additionally, the Pennsylvania Energy Development Authority (PEDA) recently dedicated $12.5 million for financing advanced energy projects and supporting businesses located in the commonwealth.[39] Since 2004, PEDA has invested $10 million annually in the advanced energy sector.[40]

Evolving Energy Needs

Although Pennsylvania is a major coal-producing and coal-supplying state, new EPA regulations and the discovery of the Marcellus Shale signal a transition away from coal.[41] The retirement of coal facilities provides Pennsylvania with an opportunity to increase investments in the advanced energy sector. Attracting new companies and growing existing renewable energy and energy efficiency companies located in Pennsylvania could ensure that money filtering out of the coal industry is spent within the commonwealth to boost the local economy and maintain jobs for Pennsylvanians. Boosting the commonwealth's solar capacity and promoting smart building technology offers distinct economic benefits and will create skilled, good-paying jobs.

Jobs Potential

Maximizing job creation in Pennsylvania is highly dependent on local action. An original equipment manufacturer (OEM) and its local suppliers employ workers from their community. Those employees spend much of their earnings at businesses in the local economy, such as grocery stores and restaurants. Local businesses also hire employees from within the community, who spend their earnings at other local establishments. This results in a multiplier effect, where a single dollar of spending in a community circulates through local businesses and their employees numerous times. Thus, recruiting advanced energy OEMs and their suppliers to a community can result in increases in local spending that are many times greater than the actual expenses of those companies. With the right policies, Pennsylvania's smart building and solar industries can support as many as 11,600 jobs per year through 2030. See the appendix for more information on the jobs modeling methodology.

Report Structure

The analysis presented in this report is divided into four complementary chapters, each covering key elements of growing advanced energy economic clusters in smart building and solar. Chapters 2 and 3 conduct a supply chain analysis for Pennsylvania's emerging smart building and solar clusters. This analysis culminates in an assessment of Pennsylvania's potential for advanced energy jobs within each cluster and specific policy recommendations tailored to the state's needs. Chapter 4 analyzes Pennsylvania's innovation ecosystem and access to capital, both crucial elements of sector development, and provides recommendations for further developing the state's innovation pipeline. Chapter 5 provides recommendations for workforce development programs and policies to prepare Pennsylvanians for advanced energy jobs. The conclusion of the report summarizes key themes and the appendix details our jobs modeling methodology.

Chapter 2: Smart Building and Energy Efficiency Technology

This chapter provides a guide to the smart building sector in Pennsylvania through analysis of the existing supply chain, an overview of the commonwealth's potential for smart building jobs, and policy recommendations for further strengthening and developing the cluster. Pennsylvania's policymakers will play a decisive role in the future of energy efficiency and smart building technology in the commonwealth. Making strategic policy choices that support the smart building sector can create jobs, while helping Pennsylvania's residents and businesses save money on energy costs. By emphasizing growth and technological innovation in the smart building sector, Pennsylvania will be able to take advantage of opportunities in the strong in-state market, while also expanding participation on the national and global stage.

Home energy management system
Photo Credit. U.S. Department of Energy

Strengths, Weaknesses, Opportunities, and Threats for Smart and Efficient Building Technology in Pennsylvania

STRENGTHS	WEAKNESSES
• Utility-implemented energy efficiency programs for grid reliability (PA Act 129) • State incremental electricity savings targets and peak demand targets[1] • Local government energy efficiency leadership in Philadelphia and Pittsburgh • University and national lab research on smart energy systems and appliances • Strong presence of advanced materials manufacturing • Cluster of private companies, startups, and educational institutions that provide opportunity for continued innovation in efficiency and products	• Building owners lack awareness of energy efficiency incentives and potential cost savings • Regulatory barriers that prevent utilities from investing in energy efficiency
OPPORTUNITIES	**THREATS**
• Major utility companies are required to submit a smart meter technology procurement and installation plan[2] • Businesses, industries, and local governments are eligible to take advantage of loans under the Pennsylvania Green Energy Loan Fund (GELF)[3] • Smart product innovation at state universities gives Pennsylvania the opportunity to lead in manufacturing these items • Internet-enabled building products that provide potential for a growing energy-efficient ecosystem	• 2019 expiration of Act 129's Energy Efficiency and Conservation program, which requires utilities to formalize energy efficiency and conservation plans • Competition from states that have more developed energy efficiency clusters, including Illinois, North Carolina, and Colorado • All states must compete with emerging economies that are determined to attract international manufacturers

Local Leaders Stoke Demand for Energy Efficiency

The Philadelphia Energy Campaign, announced in February 2016, plans to invest $1 billion in energy efficiency projects for public schools, city-owned buildings, small businesses, and low-income housing. The funds will come from a combination of public and private sources. Over the ten-year project timeline, the energy efficiency retrofits will potentially save $200 million per year in energy costs, while also stimulating local demand for energy efficiency products and services.[6]

Energy efficiency is Pennsylvania's largest advanced energy sector, accounting for more than 65 percent of all clean energy jobs.[4]

The commonwealth is uniquely positioned to be a regional leader in the smart building sector. For example, Pennsylvania's existing advanced materials manufacturing industry could be leveraged to promote in-state production of energy-efficient products. Additionally, the commonwealth's higher education institutions, such as Carnegie Mellon University, University of Pennsylvania, Lehigh University, and Pennsylvania State University are leading innovators in smart appliances and energy management systems. Pennsylvania also houses the Consortium for Building Energy Innovation, which is a collaborative hub of research universities, global industrial firms, and national laboratories working on solutions for 50 percent energy reduction in existing buildings by 2030.[5]

Furthermore, Pennsylvania has demonstrated energy efficiency leadership through policy choices. Due in large part to state government initiatives, Pennsylvania ranked seventeenth in the ACEEE's *2015 State Energy Efficiency Scorecard.*[7] The commonwealth has a modest Energy Efficiency Resource Standard that covers utilities with more than 100,000 customers.[8] PA Act 129 requires the state's largest electric distribution companies to submit a smart meter technology procurement and installation plan,[9] which aligns with the Public Utility Commission's goal of providing all customers with smart meters by 2023.[10] Additionally, Philadelphia is participating in the U.S. Department of Energy's Better Buildings initiative, aiming to reduce energy intensity by 20 percent in local government buildings by 2023.[11]

Despite encouraging advancements, Pennsylvania has room to promote energy efficiency and reap the economic benefits of utilizing products manufactured in the commonwealth. The commonwealth would benefit from implementing broad policies that enhance the existing smart building sector and promote energy efficiency investment and innovation. Several existing state energy efficiency policies and incentives offer opportunities for expansion, such as city-level benchmarking and disclosure policies. Additionally, Pennsylvania's leaders could promote financing mechanisms that level the playing field for energy efficiency investments. Through smart policy leadership, the commonwealth can reduce barriers and capitalize on energy efficiency opportunities, boosting in-state businesses and creating good-paying jobs for Pennsylvanians.

Smart Building and Energy Efficiency Market Trends

Rising Demand

Buildings (commercial and residential) account for 41 percent of energy use in the United States.[12] Transforming how buildings are designed, built, and operated can reduce energy use and save money.

Demand for smart building and energy-efficient technology is growing nationally and globally. The global market for smart homes and buildings is expected to grow from $4.8 billion of revenue in 2012 to more than $35 billion by 2020.[13] This growth is attributed to government regulations, rising energy costs, and increasing environmental awareness.[14] Significantly, $12.4 billion of this market is expected to be in North America and the sector is expected to grow at more than 25 percent per year.[15] Furthermore, worldwide smart appliance sales will grow from $5 billion in 2015 to $34 billion by 2020.[16] This represents a considerable opportunity for Pennsylvania companies to position themselves on the cutting edge of smart building and energy efficiency technology, provided a position of strength can be identified for industry growth and export leverage.

Increasing Market Share for Smart Buildings 2015-2020 (in Billions)

Compound Annual Growth Rate: 29.5%

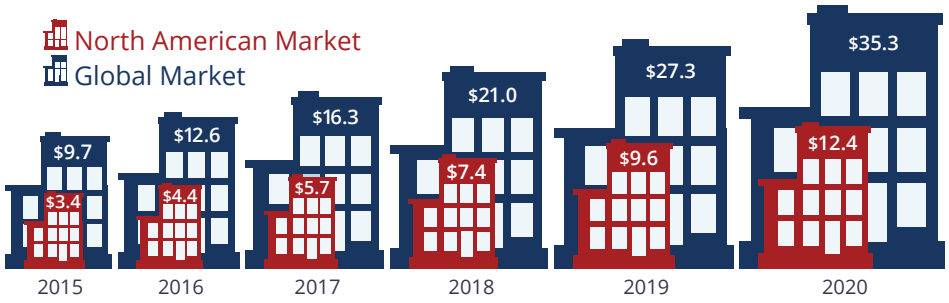


Figure 1. The North American market will account for about one-third of increasing market shares (Source: Allied Market Research, "Global Smart Homes," January 2014)

Smart buildings are "smart" because they utilize integrated sensors and controls to provide two-way communication and automated control between lighting, appliances, plug-loads, heating, and cooling systems; distributed energy generation; and energy storage systems. Often, these smart components are connected through a home energy management system (HEM) for residential buildings or a building energy management system (BEM) for commercial and industrial buildings. These connections

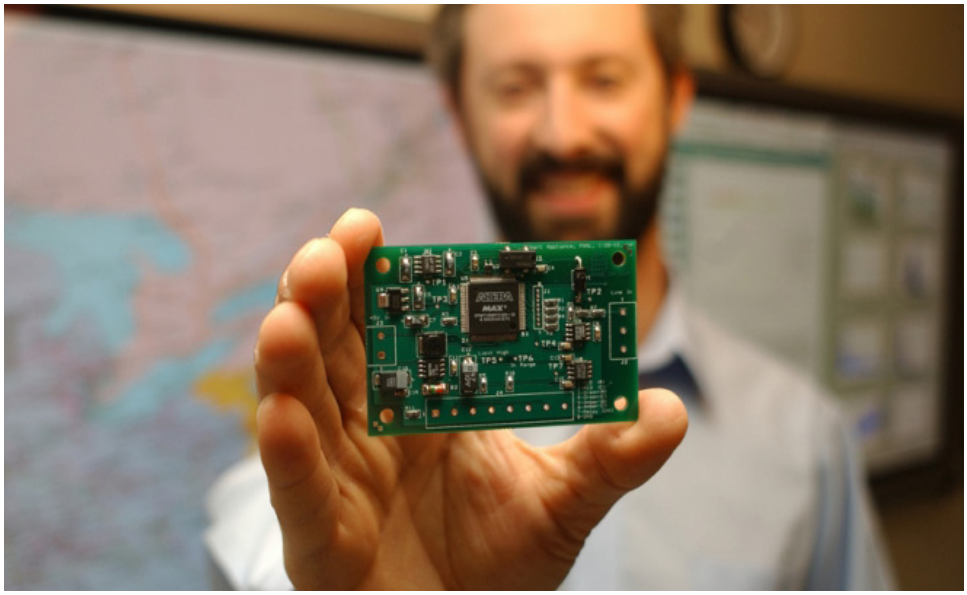
allow the building components to work together to maintain comfort while attaining maximum efficiency.

Typical energy management systems are comprised of components that underpin the foundation of a smart building, including sensors, controllers, actuators, and perhaps most importantly, management software. Nationally, new BEM market entrants have attracted $1.4 billion in venture capital investment since 2000, which represents 26 percent of all investment in building energy technology arenas.[17]

Falling Costs

The costs of sensors have dropped dramatically in recent years, making average return-on-investment payback periods on smart building upgrades very short—two years, in many cases.[18] Significantly, the average cost per square foot of smart lighting systems has dropped by half or more in the past few years.[19] The Department of Energy's Building Technologies Office (BTO) has set a goal of driving the cost of building sensors and controls down to between $1 and $10 per node installed.[20] The BTO estimates that by 2030, cost-effective technologies will be capable of reducing current building energy usage by 35 percent.[21]

Smart buildings allow constant commissioning of equipment, meaning building managers or owners can make proactive repairs as opposed to costly reactive emergency repairs. Innovations in automation and smart sensors can also drive efficiencies in water use, security systems, and emergency detection of fires and other dangerous situations.[22]



Integrated circuit to help make home appliances more responsive to the electric grid. Photo Credit. U.S. Department of Energy

Smart Building Technology

In order for Pennsylvania's leaders to craft forward-thinking policy that reflects the future of smart building technology, it is important to understand the different applications and advances in the space.

Pennsylvania's Smart Building and Energy Efficiency Supply Chain

The smart building supply chain is comprised of companies working across a variety of technology categories. For example, to achieve greater reliability and lower energy consumption, there must be a smart grid capable of communicating with the buildings. Additionally, smart meters are required to communicate between the grid and buildings. Energy management systems control the lighting, temperature, HVAC, air quality, security, and other energy consumption systems within the building. Smart appliances communicate with smart meters and mobile devices to optimize electricity consumption. Behind all these elements, sensors detect changes in the environment and are used to control the building.

Many businesses in Pennsylvania already design, research, and manufacture smart building products and services, including design and construction of new buildings, as well as installation, maintenance, and sale of building system components. Table 1 describes each of these technology categories and lists examples of in-state companies.

Table 1. Pennsylvania's Smart Building Companies

Category	Pennsylvania Companies	Description
Energy Management/ Building Automation	• American Auto-Matrix • Blue Conservation • StratIS	Manufacture components used in energy management, building automation, or building retrofits.
Construction/Retrofits	• EcoCraft Homes • DiMarco Construction Company • Envinity • Laser Scanning America	Design and construct new smart buildings or provide services for building retrofits such as energy audits and upgrades.
Smart Meters/Smart Grid Capabilities	• Energy Management Systems • Grid One Solutions • PECO • Sensus • Siemens • Viridity Energy	Create devices that would help buildings work in synergy with smart grid infrastructure.

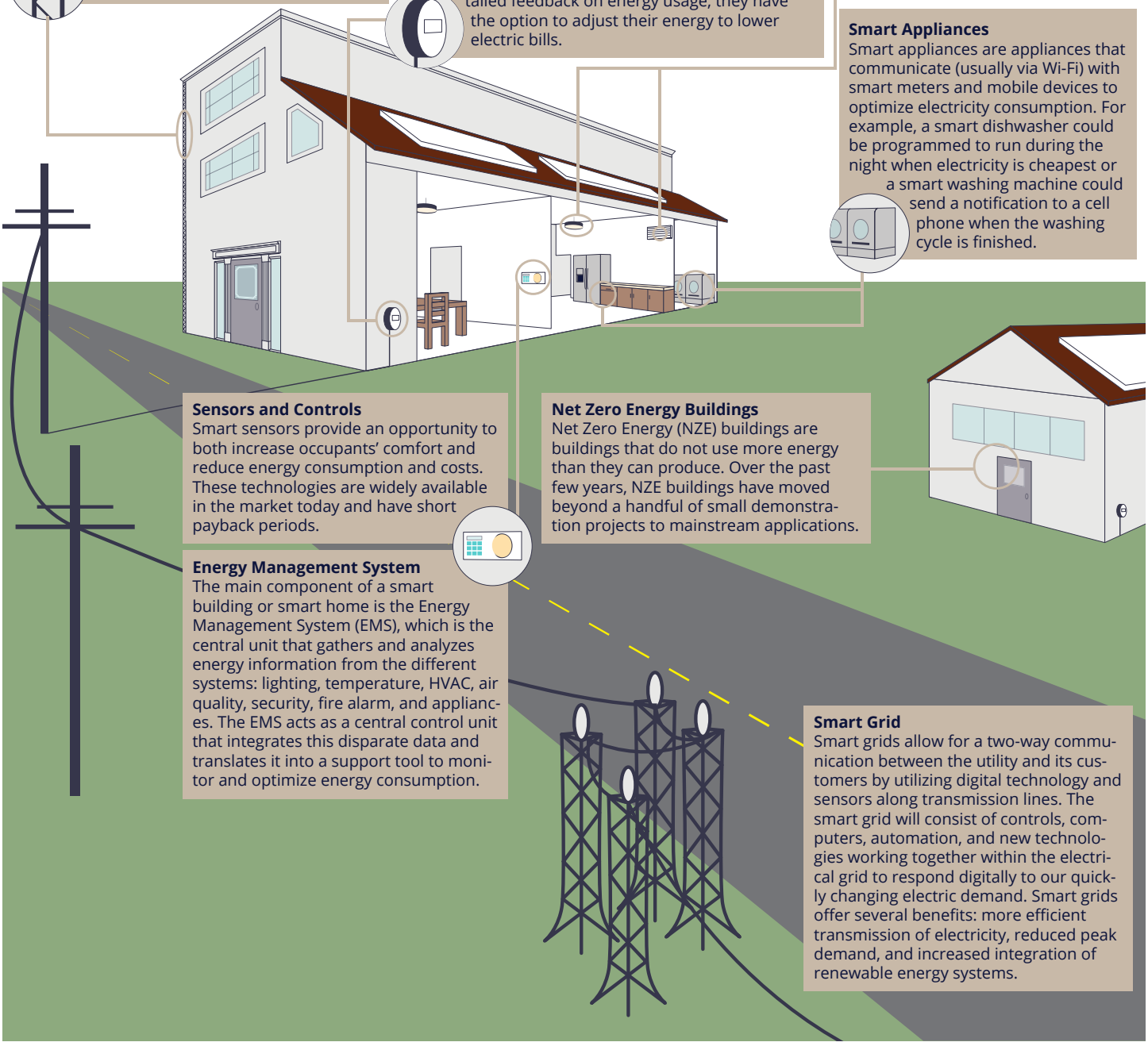
Smart Building Technology

Building Envelope
Envelopes include walls, windows, insulation, and roofing. A well-insulated structure without air leakages will prevent heat loss during cold weather and keep heat out during hot weather, greatly reducing heating and cooling demands. Similarly, insulated windows with low-emissivity coating and automated exterior shading contribute to energy savings. Reflective rooftops and walls can reflect UV, visible, and infrared radiation, reducing air conditioning needs.

Smart Meters
Smart meters are a tool to obtain information from the two-way communication system existing in a smart grid. Smart meters help the energy providers manage the demand on the grid and increase service and reliability. This allows the electric companies to monitor the electric system more quickly and make a more informed decision about which power resources to use at a given time to maximize efficiencies. On the consumer side, smart meters help the user see how and when their home or business is consuming energy. By offering the customer more detailed feedback on energy usage, they have the option to adjust their energy to lower electric bills.

Lighting and Equipment
Lighting, air conditioning, ventilation, and heat pumps are the main uses of energy in a building. Upgrading to the most efficient HVAC systems, Energy Star appliances, and lighting have proven to reduce energy bills. In particular, solid-state lighting upgrades can reduce lighting energy use by nearly one-half.

Smart Appliances
Smart appliances are appliances that communicate (usually via Wi-Fi) with smart meters and mobile devices to optimize electricity consumption. For example, a smart dishwasher could be programmed to run during the night when electricity is cheapest or a smart washing machine could send a notification to a cell phone when the washing cycle is finished.



Sensors and Controls
Smart sensors provide an opportunity to both increase occupants' comfort and reduce energy consumption and costs. These technologies are widely available in the market today and have short payback periods.

Net Zero Energy Buildings
Net Zero Energy (NZE) buildings are buildings that do not use more energy than they can produce. Over the past few years, NZE buildings have moved beyond a handful of small demonstration projects to mainstream applications.

Energy Management System
The main component of a smart building or smart home is the Energy Management System (EMS), which is the central unit that gathers and analyzes energy information from the different systems: lighting, temperature, HVAC, air quality, security, fire alarm, and appliances. The EMS acts as a central control unit that integrates this disparate data and translates it into a support tool to monitor and optimize energy consumption.

Smart Grid
Smart grids allow for a two-way communication between the utility and its customers by utilizing digital technology and sensors along transmission lines. The smart grid will consist of controls, computers, automation, and new technologies working together within the electrical grid to respond digitally to our quickly changing electric demand. Smart grids offer several benefits: more efficient transmission of electricity, reduced peak demand, and increased integration of renewable energy systems.

Advanced manufacturing in Pennsylvania remains relatively strong compared to other areas in the country. The commonwealth's advanced manufacturing sector includes production of chemicals; rubber and plastics; electronics; metals; and vehicles and vehicle parts.[23] By tapping into existing companies, industries, and expertise in the state, Pennsylvania can bolster advanced manufacturing economic clusters and capitalize on local demand for energy-efficient products and smart meters. There are also opportunities for Pennsylvania to strengthen its workforce by training skilled building construction workers to focus on smart building technologies.

Pennsylvania's Potential for Smart Building and Energy Efficiency Jobs

As demand for smart buildings and energy efficiency improvements skyrocket, Pennsylvania has the opportunity to expand the economy, increase in-state spending, and employ an average of over 5,900 Pennsylvanians annually over the next fifteen years. If optimistic projections prove to be correct and Pennsylvania's smart building and energy efficiency companies are able to fill most of their supply chain needs with in-state purchases, over 88,000 direct, indirect, and induced job-years would be supported. While over 29,000 of those would be direct job-years in the state's smart building and energy efficiency industry, 59,000 indirect and induced job-years could be supported if those companies were able to procure supplies from in-state businesses.

These projections for job-years potential in Pennsylvania's smart building and energy efficiency industry are based on tools and analysis by the U.C. Berkeley Don Vial Center on Employment in the Green Economy and the Energy Information Administration (EIA). We utilized the Jobs from Energy Efficiency (JEE-1) model to estimate direct job-years based on projections of energy efficiency savings and generally accepted economic multipliers.

To highlight why clustering supply chain businesses in Pennsylvania is so important, we have estimated the number of direct, indirect, and induced jobs based on future efficiency within the state. Figure 2 shows how the number of energy efficiency and smart building job-years vary as the percentage of supply chain purchases made within Pennsylvania changes. The figures show the number of indirect and induced jobs based on multiplier effects of 2.0, 2.5, and 3.0. Since projections often vary, we analyzed how those supply chain differences affect three reputable estimates of future demand: the EIA's Annual Energy Outlook 2015 for the Clean Power Plan's High Energy Efficiency Compliance forecast as a high-demand scenario, the EIA's Base Policy forecast as a moderate-demand scenario, and the EIA's No

What is a Job-Year?

A job-year is one full-time equivalent job for one year (i.e., forty hours per week for fifty-two weeks, which is 2,080 hours per year). If two people each work a part-time job for twenty hours per week for fifty-two weeks, this is counted as one full-time equivalent job for one year, or one job-year. If one person works forty hours per week for ten years, this is counted as ten job-years.

Direct, Indirect, and Induced Job-Years

In order to estimate the potential economic impact of Pennsylvania's smart building and energy efficiency supply chain, direct, indirect, and induced job-years are measured.

- Direct job-years: reflect jobs created in the smart building and energy efficiency industry to meet demand
- Indirect job-years: reflect jobs created at supply chain companies resulting from increased transactions as supplying industries respond to increased demand from Pennsylvania's smart building and energy efficiency industry
- Induced job-years: reflect jobs created throughout the local economy as a result of increased spending by workers and firms in Pennsylvania's smart building and energy efficiency industry and in supply chain industries

Why Use Job-Years?

By using job-years, our analysis can take into account the length of a job. In energy projects, many construction and installation jobs are short-term, while manufacturing and maintenance jobs may be long-term. Using job-years allows us to accurately count both types of jobs. For example, if ten full-time electricians are expected to each spend 208 hours installing LED lighting in a new smart building, this is measured as one job-year. Alternatively, if one full-time engineer is expected to spend fifteen years operating that smart building, this is measured as fifteen job-years. In our analysis of Pennsylvania's supply chain, job-years are aggregated over the 2016–2030 period.

Multipliers

Multipliers are used to capture the secondary effects of increases in direct job-years. A multiplier of 1.0 signifies that no indirect or induced job-years will be created. A multiplier of 2.0 signifies that, for every one direct job-year, the number of indirect and induced job-years created in the local economy will add up to one full-time equivalent job-year. For example, if rising demand for energy-efficient upgrades creates ten new HVAC installation job-years and the local multiplier is 2.5, then fifteen new indirect and induced job-years will be created in the local economy.

Energy Efficiency Compliance forecast as a low-demand scenario.

In all three demand scenarios, increasing the percentage of local spending by Pennsylvania's smart building and energy efficiency companies creates thousands of job-years. For example, in the high-demand scenario, an increase of in-state supply chain purchases that raises the multiplier from 2.0 to 2.5 would generate 14,750 indirect and induced job-years. Even in the low-demand scenario, that increase in in-state supply chain purchases would create over 10,800 indirect and induced job-years.

If a concerted effort were made by the state to fill in the supply chain and strengthen the smart building and energy efficiency cluster, Pennsylvania companies could meet the expected demand from the residential, commercial, and industrial sectors, supporting up to 59,000 job-years. Increasing the number of supply chain businesses can create thousands of good-paying, skilled jobs and make Pennsylvania a leader in the smart building and energy efficiency industries.

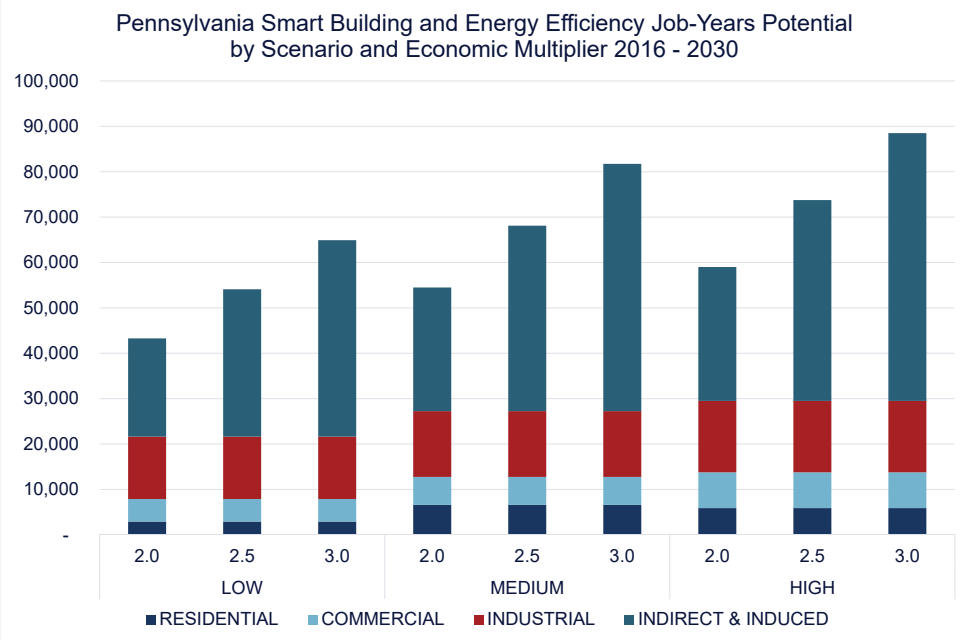


Figure 2. Pennsylvania has the opportunity to create at least 88,000 job-years by stimulating the smart building and energy efficiency sector.

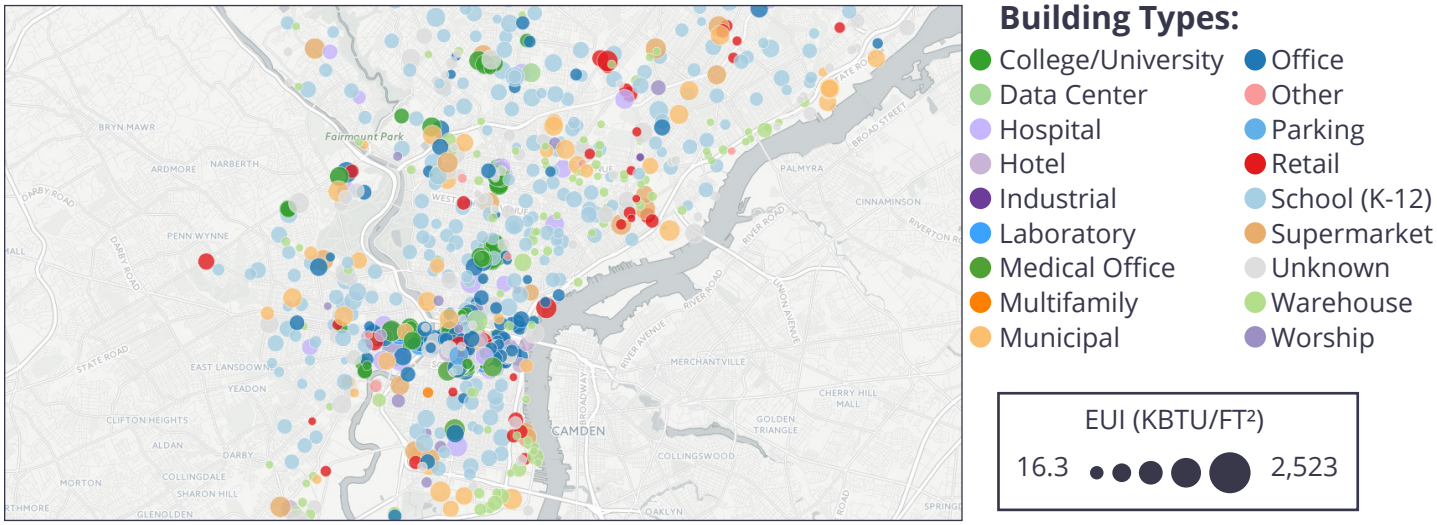
Policy Recommendations

Pennsylvania policymakers can bolster the state's smart building and energy efficiency cluster by (1) removing financial and regulatory barriers to spur investment in energy efficiency and (2) exploring new and existing policies that stimulate demand within the commonwealth. Creating a robust in-state market will attract private investment, strengthen the state's economy, and create good-paying jobs for residents.

Policy 1: Implement State Energy Efficiency Benchmarking and Disclosure Policy

Philadelphia and Pittsburgh have demonstrated leadership in the energy efficiency space by launching energy benchmarking initiatives. Since 2011, Philadelphia has been evaluating energy use in municipal facilities over 10,000 square feet.[24] Philadelphia's 2012 Building Energy Benchmarking Ordinance extended the requirement to commercial buildings larger than 50,000 feet and added water usage.[25] In 2015, the Philadelphia City Council amended the ordinance to include multi-family properties over 50,000 square feet.[26] Benchmarking is conducted through Portfolio Manger, a free tool from the U.S. Environmental Protection Agency (EPA) that normalizes energy data by building size and use.[27] The city's ordinance requires public disclosure of benchmarking data.[28]

As part of the program implementation, the Mayor's Office of Sustainability has created a mapping tool to share citywide building performance data. The results of this initiative can be seen in the image below. The map shows buildings in Philadelphia that have reported usage data and enables the user to filter by building type, square footage, and year built.[29]



Building-level energy performance data shown via Philadelphia's mapping tool. (Source: The City of Philadelphia, Mayor's Office of Sustainability)

Benchmarking Energy Performance

Benchmarking building energy performance is an important tool for realizing energy savings. Benchmarking, or the practice of analyzing and comparing energy performance, informs businesses and building owners about how they use energy, where they use it, and what drives their energy use. With this information, businesses can increase profitability by lowering energy costs, a reference point for gauging the effectiveness of energy management practices. Additionally, governments can use benchmarking information to establish building codes and standards for the future. Consistent benchmarking translates into tangible energy savings: buildings that benchmark their energy use over three years save an average of 2.4 percent per year.[30]

Pittsburgh also utilizes the EPA's Portfolio Manager to benchmark 47 percent of the city's municipal building square footage.[31] Additionally, Pittsburgh's municipal code calls for energy audits every ten years and improvements to city-owned buildings larger than 5,000 square feet.[32]

Other cities in Pennsylvania could follow the Philadelphia and Pittsburgh lead in benchmarking, and use these cities as a blueprint for establishing their own performance monitoring and reporting standards. Benchmarking could support Pennsylvania's energy efficiency and smart building sector, while also helping cities achieve significant environmental and economic benefits. The commonwealth could play a critical role in this process by incentivizing and encouraging local governments to design effective programs. State leaders could spur benchmarking and disclosure through a "Governor's Cup" challenge among local governments that rewards the adoption of performance monitoring and reporting policies. As a reward, the commonwealth may offer access to capital assistance to help cities finance the upfront costs of local efficiency installations. Pennsylvania leaders could also implement statewide benchmarking and disclosure policies to complement city-level standards and encourage energy use documentation throughout the commonwealth.

Installing energy-efficient windows
Photo Credit. U.S. Department of Energy

Policy 2: Increase Compliance And Update Building Codes

Pennsylvania currently uses building codes that predate the rapid expansion of energy efficiency. Similar to other states spurred by American Recovery and Reinvestment Act funding, Pennsylvania has adopted the outdated 2009 IECC version of the building code.[33] The commonwealth could adopt the 2015 IECC building code to create a greater market for efficiency products. The additional costs associated with implementing the 2015 code varies from building to building, but research shows that each subsequent IECC has resulted in considerable savings in energy costs.[34]

Residential and Commercial Building Conservation Codes

The International Energy Conservation Code (IECC) is a residential building code created by the International Code Council to establish minimum design and construction requirements for energy efficiency. The International Code Council produces the most widely adopted codes for buildings in the United States and many other global markets.[35] The IECC provides prescriptive and performance requirements for design and construction of new residential buildings. Commercial building codes are largely based on the ASHRAE 90.1 standards developed by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) and the Illuminating Engineering Society of North America (IESNA).

To support a competitive market for energy efficiency, Pennsylvania could implement the most recent building codes and couple this with a strong compliance plan. A variety of methods exist to increase code compliance, and many organizations currently use successful enforcement strategies that states could adopt. For example, the Building Codes Assistance Project facilitates the Compliance Planning Assistance program, which helps states achieve energy code compliance.[37] The Department of Energy also provides states with technical assistance for compliance efforts through its Building Energy Codes Program.[38]

Improvements in the 2015 IECC Building Code

Changes in the 2015 IECC that have a beneficial impact on residential energy include:[36]

- Increased insulation requirements for return ducts in attics.
- New requirements for heated water circulation systems and heat trace systems that are expected to reduce heat loss from pipes and energy use by circulation pumps.
- New insulation requirements for three-quarter-inch pipes, a common size in typical residential buildings.
- New demand control requirements for specific recirculating systems that are expected to reduce energy consumption.
- New requirement for historic buildings to comply with code unless there is "compromise to the historic nature and function of the building." Previously, historic buildings were code-exempt.
- New requirement for outdoor reset control for hot water boilers that are expected to result in more efficient heating.

Financing Energy Efficiency Upgrades

Property Assessed Clean Energy (PACE) financing is a tool that helps property owners implement energy efficiency upgrades and renewable energy projects that increase the value and improve the performance of their buildings. PACE provides long-term, low-interest rate loans from private financiers. In some municipalities with PACE legislation, local governments offer a bond to investors and loan the money to consumers and businesses to put towards energy retrofits. The loans are repaid over time through property tax bills. PACE financing is now available in more than 800 U.S. municipalities and over 80 percent of the country's population lives in states that provide PACE financing.[39]

Policy 3: Enable Property Assessed Clean Energy (PACE) Financing

Property Assessed Clean Energy (PACE) financing is an attractive option for Pennsylvania because it addresses the largest barrier to increased efficiency and smart building projects for building owners: access to capital.[40] PACE helps put energy efficiency on a level playing field for small businesses and homeowners.

The Commonwealth of Pennsylvania does not currently have PACE financing.[41] PACE legislation could provide Pennsylvania with a viable model for overcoming barriers related to the high upfront costs associated with energy efficiency investments. The availability of PACE financing would also help alleviate concerns related to changes in building ownership that can often discourage longer-term investments.

> The Texas Legislature passed the PACE Act in June 2013.[42] Keeping PACE in Texas, a nonprofit that united over 100 stakeholders, spurred municipal support for the legislation and encouraged city participation throughout the state. The organization also developed "PACE in a Box," which is a toolkit that contains the necessary resources for any city in Texas to implement PACE. The toolkit standardizes the implementation of PACE across the state, while drawing on best practices from other examples across the country.[43] PACE in a Box was seeded with $200,000 from the Texas State Energy Conservation Office and $800,000 from foundations and PACE stakeholders.[44] As a result of that investment, Texas now has a uniform, scalable, turnkey program that facilitates the creation of consistent PACE programs throughout the state.[45]

To empower local governments to quickly and efficiently launch PACE programs, Pennsylvania could create a standardized design and implementation plan. The Texas toolkit is available online, which should enable Pennsylvania to write its own high-quality toolkit for a fraction of the cost. Ensuring that PACE financing is broadly available for installing smart, efficient building equipment is likely to create more customers throughout the commonwealth.

Policy 4: Use Competition to Encourage Small Businesses to Participate in Capacity Market Auctions

When a business is deciding how to invest in their company's energy efficiency upgrades might not be the most immediately attractive option. However, these businesses often do not realize they can make money on their upgrades by auctioning their future savings in PJM's capacity market. Due to their size, small- and medium-sized businesses are rarely able to capitalize on this opportunity. However, businesses and building owners can aggregate their savings with other building owners and sell their savings to utilities. Aggregating energy savings not only provides access to the capacity market for small- and medium-sized businesses, but it ensures Pennsylvania meets its utility energy efficiency goals.

To help small- and medium-sized businesses jointly participate in capacity markets and make building owners aware of this opportunity, Pennsylvania policymakers could use competition to encourage statewide participation.

Local, State, and Federal Governments Use Competition to Drive Change

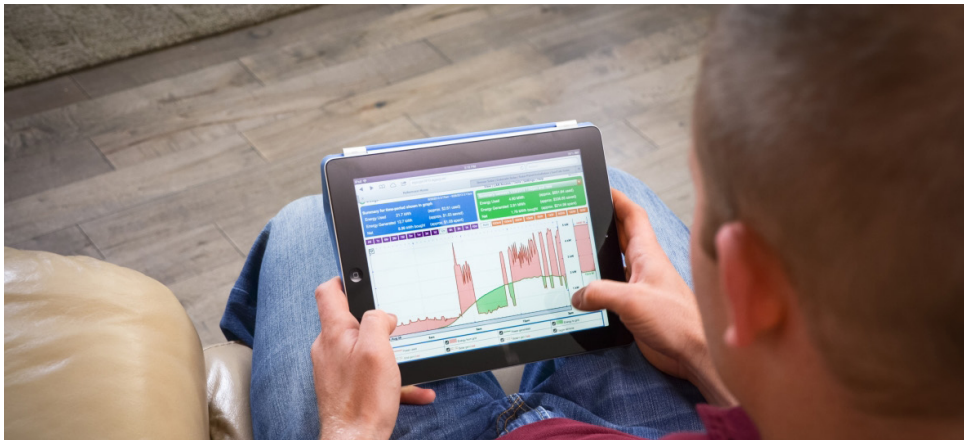
Local, state, and federal governments have promoted or participated in competitions to achieve a variety of policy goals. Mid-sized cities competed with each other to win the Georgetown University Energy Prize, which awarded $5 million to the city with the best plans to reduce per capita energy consumption.[50] New York State's regional competition to stoke economic development pitted seven regions against each other to vie for three $500 million awards to fund revitalization projects.[51] On a federal level, the Department of Education encouraged states to reform their education systems through competition: $4.35 billion in grant funds were available to states across the nation with the best plans to close achievement gaps and prepare students for college.[52]

PJM's Capacity Market Auctions

PJM is responsible for managing the electric grid and wholesale power market for a large part of the Mid-Atlantic United States, with a footprint that includes all or parts of Pennsylvania, New Jersey, Maryland, Delaware, Illinois, Indiana, Kentucky, Michigan, North Carolina, Ohio, Tennessee, Virginia, West Virginia, and the District of Columbia.[46] Among other responsibilities, PJM oversees a capacity auction market where utilities can bid for their power supply resources. Utilities can purchase energy efficiency as one of their energy resources, committing them to reducing energy demand three years into the future.[47] Building owners who claim energy savings from implementing efficiency measures can auction off those savings as "energy efficiency resources" to help utilities meet expected market demand.[48]

The Role of Capacity Market Aggregators

When a building owner completes an energy efficiency project, the energy saved from that project has economic value. Aggregators are third parties that combine the savings from multiple building owners and auction those aggregated savings in the capacity market. Aggregator firms, such as Electric Market Connection, facilitate the auction process for building owners, and then compensate building owners based on auction results.[49] Thus, building owners can receive compensation for their energy efficiency upgrades.



Smart meters make tracking electricity usage easier.
Photo Credit. U.S. Department of Energy

Pennsylvania state or local policymakers could use similar principles of competition to create an energy efficiency contest. Small- and medium-sized businesses that participate in capacity markets could elect to compete in city- or district-based teams against other cities or districts in the PJM capacity market. Teams could be organized annually based on planned savings, and the winning teams could be determined by factors like the most energy saved, the largest percent reduction in energy use, or the level of participation in the capacity market. Additionally, the governor could offer a prize to the winning cities or districts. By encouraging small- and medium-sized businesses to aggregate and auction energy savings, demand for smart building products and services will increase, resulting in more good-paying jobs for Pennsylvanians.

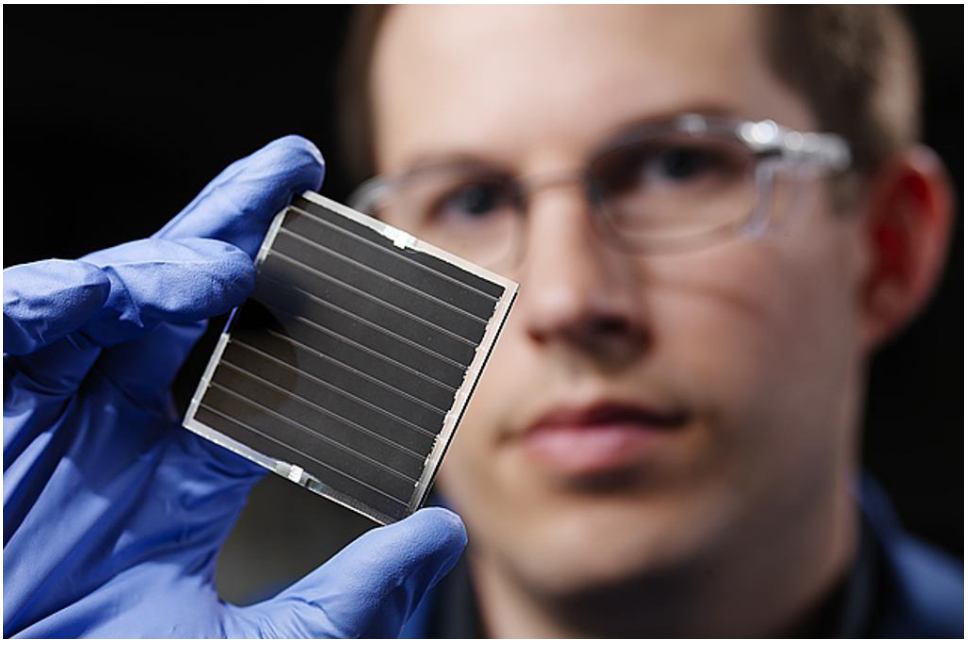
Chapter Summary

Smart, strategic policy can help leverage Pennsylvania's unique strengths and base of legacy companies to create a thriving smart building and energy efficiency sector. Pennsylvania can spur growth in the sector by adopting stronger building energy codes, enabling innovative financing models and markets to remove barriers to energy efficiency investments, and tracking energy use at the city and state levels. Strategic policies and strong leadership could expand the energy efficiency sector, increase consumer choice, and make Pennsylvania a more efficient and economically competitive state.

Chapter 3: Solar Technology

Pennsylvania's policymakers will play a decisive role in the future of solar energy in the state. Over the last decade, solar energy deployment has grown rapidly in the United States due to falling photovoltaic (PV) prices, technological advancements, favorable government policies, increased available financing, and growing consumer demand for clean and renewable sources of energy. Through smart and strategic policy choices, Pennsylvania's leaders can attract solar jobs and help meet a portion of the state's energy needs. Pennsylvania can establish policies that encourage growth and technological innovation to meet the demands for solar products from a strong in-state market and capitalize on export opportunities in regional, national, and international markets.

This chapter provides a guide to further strengthening and developing Pennsylvania's emerging solar cluster. After analyzing Pennsylvania's existing solar supply chain and discussing the state's potential for creating good-paying solar jobs, the chapter culminates in policy recommendations for future growth. These recommendations chart a course for Pennsylvania's policymakers to enhance the solar sector market.



Solar cells are assembled to create a solar panel.
Photo Credit. Pacific Northwest National Laboratory / Foter / CC BY-NC-SA

Strengths, Weaknesses, Opportunities, and Threats for Solar Technology in Pennsylvania

STRENGTHS	WEAKNESSES
• Progressive regulatory policy (e.g., third-party ownership, net metering) favor residential and commercial solar development • Pennsylvania is home to nearly 500 solar businesses employing 2,800 people, making it one of the largest U.S. solar employers[1] • Pennsylvania has adopted an Alternative Energy Portfolio Standard (AEPS) requiring 8 percent of its energy generation be sourced from renewable energy, such as solar and wind[2]	• Low solar renewable energy credit prices leave little incentive for in-state solar development[3] • Building a strong Pennsylvania solar panel manufacturing base is challenging due to low-cost production in international markets • AEPS solar carve-out of 0.5 percent is too low to drive solar market growth[4]
OPPORTUNITIES	**THREATS**
• Strong centers for innovation at public universities and a statewide technology development program • Neighboring states creating demand for solar energy through aggressive policies	• Other states are aggressively and successfully pursuing solar manufacturers • Foreign solar panel manufacturers hold significantly more global market share than U.S. manufacturers[5]

There are currently more than 470 solar companies offering a variety of solar products and services throughout Pennsylvania.[6] The state is particularly strong in solar installation and manufacturing.[7] According to the Solar Energy Industries Association (SEIA), Pennsylvania currently boasts 249 MW of solar energy, which ranks the state twelfth in the country for installed solar capacity.[8] Altogether, Pennsylvania's installed solar energy has the capacity to power approximately 29,000 homes.[9]

Over the past ten years, Pennsylvania has taken steps to establish the state as a leader in developing renewable technologies, including solar. In 2004, Pennsylvania policymakers enacted the Alternative Energy Portfolio Standard (AEPS), which mandates that 18 percent of the state's electricity must come from advanced

Pennsylvania's Notable Solar Installations

Pocono Raceway Solar Facility in Long Pond, completed in 2010. It has a 3 MW capacity, which is enough to power more than 300 homes.[15]

Keystone Solar Project in Lancaster County, completed in 2012. It is one of the largest solar installations in the state, with a 6 MW capacity.[16]

energy sources by 2021—8 percent of which must come from renewables like solar and wind and the remaining 10 percent from other alternatives.[10,11] The AEPS has helped create a market for energy technologies, including solar, to grow and flourish.[12] State leaders also implemented the $100 million Sunshine Solar program in 2008, which provided rebates for homeowners and small businesses that purchased solar PV. Before exhausting dedicated funds in November 2013, the program supported nearly 100,000 kW of new PV capacity and more than 7,000 Pennsylvania property owners received rebates for solar electric projects.[13] Pennsylvania's AEPS and Sunshine Solar program helped lay the foundation for its solar economy, supporting 678 businesses.[14]

While the number of solar jobs grew nationally at 20.2 percent between 2014 and 2015,[17] Pennsylvania numbers declined by 10.8 percent.[18] Downstream jobs in solar installation were particularly hit hard.[19] These recent downward trends suggest a need for state solar policy reforms.

The recent stagnation in Pennsylvania's solar economy resulted from many interrelated factors. The low solar carve-out in the AEPS (0.5 percent) has not incentivized greater investment in solar, mainly due to the fact that out-of-state solar renewable energy credits (SRECs) can be used to comply with this requirement.[20] The reliance on out-of-state SRECS led to the oversupply and resultant decline in the price of SRECs, critical components of project financing. During this time, neighboring states enacted stronger portfolio standards and other pro-solar polices, attracting projects and jobs away from Pennsylvania.[21,22] Furthermore, current investment is also stalled by the expiration of the Sunshine Solar program.[23]

Once a regional leader, Pennsylvania now ranks behind neighboring states in per capita solar jobs and number of homes powered by solar, including New York, Ohio, and New Jersey.[24] Pennsylvania could adopt policies that boost demand for solar PV and send strong, pro-growth signals to businesses and consumers.

Working on a rooftop solar energy system
Photo Credit. Jamie Nolan / U.S. Department of Energy

Solar Market Trends

Rising Demand

The past several years have been characterized by a surge of innovation and growth in the solar industry. For example, global PV solar installed capacity has increased by a factor of nearly seventy over the last decade, from 2.6 GW in 2004 to 177 GW in 2014.[25] As a result of this growth, investment dollars are flooding the market, prices are falling, and the industry is undergoing a period of rapid innovation.

In the United States, solar PV cells are a primary source of new electricity generation. Total solar installed capacity in the first quarter of 2015 represented 51 percent of all new electricity generating capacity.[26] Strong demand has made the United States the world's fifth largest solar market in terms of installed capacity.[27] Forecasts show significant growth continuing through 2030.[28]

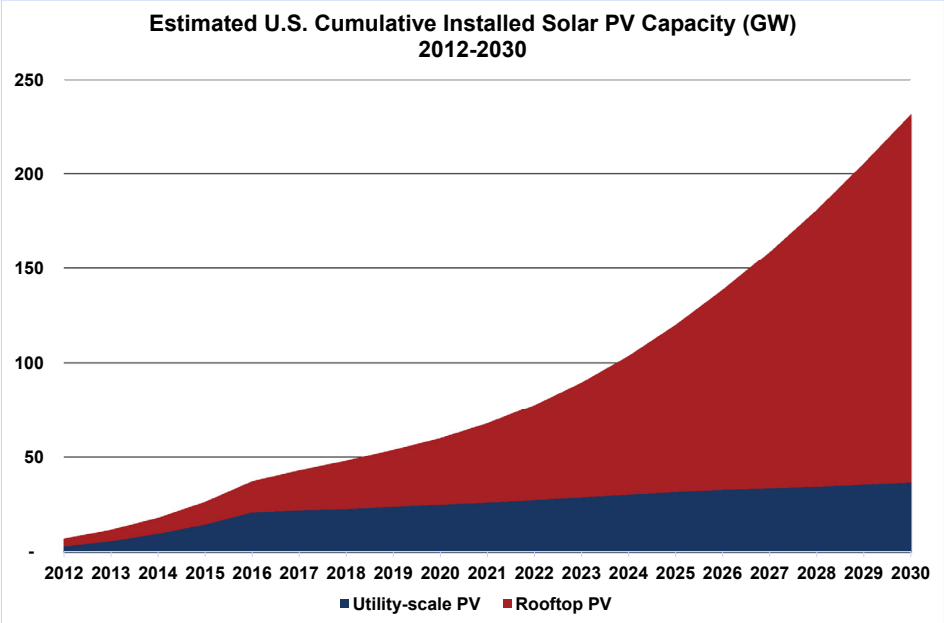


Figure 3. Rooftop PV will increasingly dominate installed solar capacity in the U.S. (Source: Bloomberg New Energy Finance, 2015 New Energy Outlook - Americas, June 2015)

The extension of the 30 percent federal solar tax credit is projected to inject $38 billion of investment, amounting to an additional 20 GW of solar power.[29] This boost in demand is also aided by the declining cost of solar, making it increasingly competitive with coal and natural gas.[30]

Falling Costs and Increasing Efficiency

In 1961, President Kennedy challenged the United States to land a man on the moon and return him safely to Earth by the end of the decade. In the same spirit, the Department of Energy's SunShot Initiative has challenged the nation once again: this time the goal is to dramatically reduce the cost of solar energy and make it competitive with other forms of electricity.[31] The program has made considerable progress in driving down the cost of solar energy to $0.06 per kilowatt-hour, without incentives, by the year 2020: the average cost of solar PV panels has decreased by more than 60 percent and the cost of a solar electric system has decreased by more than 70 percent since 2010.[32] Today, solar is cost-competitive in fourteen states where the solar levelized cost of electricity ranges between $0.10 and $0.15 per kilowatt-hour and retail electricity price comes in at $0.12 and $0.38 per kilowatt-hour.[33]

What is Levelized Cost of Electricity?
The levelized cost of electricity (LCOE) is a summary measure of the cost of energy-generating technologies. The LCOE considers an assumed lifespan and utilization level in order to quantify the per-kilowatt-hour building and operating costs of a generating plant.[34] To calculate the LCOE, a variety of factors and inputs are assessed, including capital costs, fuel costs, operation and maintenance costs, and financing costs.[35] The LCOE provides a way to compare the cost of installing a solar system to the rate of electricity charged by utilities. Due to nonexistent fuel costs for generation and very low variable operation and maintenance costs, LCOE for solar technology is mostly determined by capital and financing costs.[36]

While the cost of solar energy has declined, the efficiency of solar technology has increased. In 2014, the average capacity factor of solar projects built in 2013 was 29.4 percent, compared to 24.5 percent for 2011 projects.[37] This indicates that a newer system of the same size can now produce 20 percent more electricity than it could in the past.

What Does Rising Solar Demand and Falling Costs Mean for Pennsylvania?

The offshoring of manufacturing jobs was not driven by intrinsic geographic, technological, or cultural factors; rather, aggressive policies and low wages in competitor nations shifted American jobs overseas. The International Energy Agency conducted a detailed analysis of the manufacturing shift to China, which "suggests that the historical price advantage of a China-based factory over a

U.S.-based factory is not driven by country-specific factors, but by scale, supply chain development, and access to finance."[38] State policy can help Pennsylvania attract new solar companies and retain existing solar companies headquartered in Pennsylvania by building a market, developing the solar supply chain, promoting access to capital, and investing in solar workforce development. With the right combination of policies, solar resources, available land, and access to capital, Pennsylvania can compete nationally and globally for market-driven solar manufacturing, generation, installation, and exports.

Coupled with the state's active scientific community and high-tech workforce, this strong base enables Pennsylvania companies to compete in the expanding solar market as major suppliers. Charting the growth of specific components within the value chain can help Pennsylvania determine the best industries to leverage the state's strengths and capitalize on future growth. Specifically, the inverter and solar racking industries are projected to grow at an accelerated rate. The North American flat roof racking industry is projected to grow by an annual rate of 17.5 percent through 2018 and the solar inverter industry will have an estimated 10 percent growth by 2018.[39,40] Pennsylvania-based companies, such as solar racking company PV Racking and inverter company Alencon, can capitalize on this growth.

Increased manufacturing in Pennsylvania will create the possibility for solar technology export to neighboring states. Many Pennsylvania companies in the solar supply chain already export their products, including Morningstar Corporation, a leader in solar charge controllers and inverters.[44] Pennsylvania is well-positioned to be a major player in solar technology exports, which could strengthen the economy and stimulate job growth in the state.

Solar Manufacturing Technology

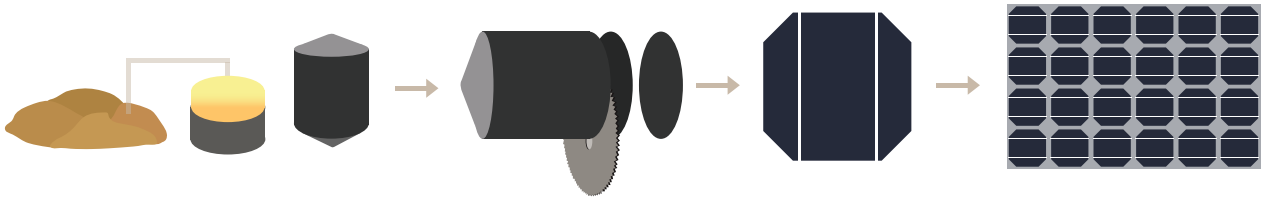
There are many types of solar cells with different manufacturing processes and assembly configurations. In order for Pennsylvania policymakers and leaders to craft forward-thinking policy that reflects the future of solar technology, it is important to understand the solar manufacturing process and advances in the space.

Philadelphia: A State Leader in Solar Initiatives

Philadelphia is a state leader in advancing solar production and policies. In 2008, Philadelphia was designated as a Solar America City by the Department of Energy, initiating a joint effort to address barriers to solar deployment.[41] The city receives both financial and technical assistance through this partnership.[42] In 2014, Philadelphia reaffirmed this commitment to solar by setting a goal of 20,000 solar roofs by 2025.[43]

The Solar Manufacturing Process

Crystalline silicon panel technology is the current standard for panels installed in the United States. There are four main steps to assemble a crystalline silicon panel.



Extracting and Purifying Silicon

The production of a PV panel begins by deriving silica from sand. After the silica is extracted, it is purified to make a high-purity silicon powder.

Manufacturing the Wafer

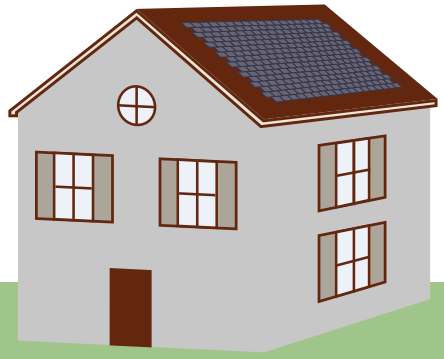
With the silicon powder, a wafer can be manufactured by doping the molten high-purity silicon with boron. Molten silicon is poured into a mold creating blocks of solid polysilicon. The block is then cut, polished, and cleaned.

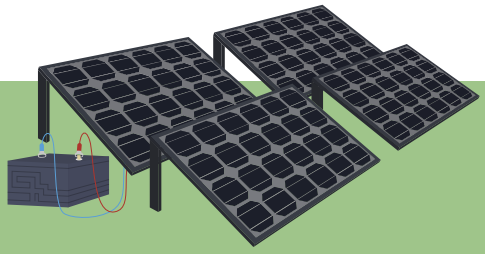
Assembling the Modules

During cell manufacturing, one side of the wafer is doped, usually with phosphorous. A conductive grid and anti-reflective coating are adhered to the top and a conductive back plate is assembled to the bottom of the cell. Cells are then combined electrically to form a module. A glass or film sheet is placed on the front and back. The module is covered by an outer frame, usually made of aluminum.

Assembling the Array

The finished solar panels are delivered to the customer. Downstream solar activities involve distribution, engineering design, contracting, installation, and servicing. There are also ancillary services involving financial, legal, and nonprofit groups that provide support for solar projects.





The Future of Solar

Research and innovation in the solar industry is leading to exciting breakthroughs

Building with Solar Cells
In the future, solar technology will be incorporated into the structure of a new building, rather than installed on a roof after construction is complete. For example, the near-medium-term future could see walls, skylights, windows, and shingles manufactured with solar materials.

Solar for the Home of the Future
"Smarter" solar panels will incorporate technology and sensors to provide real-time information about energy generation and demand. Unprecedented interconnectedness and energy management software will open the door for increased customization.

Organic Solar
Organic solar cells are a new type of carbon-based solar cell. This technology can be manufactured in innumerable applications, such as transparent paint. For example, windows could be coated in a transparent organic paint that provides electricity to the building.

Ultra-High Efficiency Solar Cells
The higher the efficiency of a solar panel, the more electricity it can create from the sun's rays. With ultra-high efficiency cells, less area is needed to obtain the same amount of electricity. Researchers project that solar cells could be four times more efficient in the near future.

Solar Soft Costs and Information Technology
Data-driven innovations will help reduce the soft costs of solar marketing and provision. Better data analytics will improve system design and uptake through performance modeling and investment projections. Lead generation firms and price comparison tools are already streamlining customer acquisition by connecting homeowners to solar installers.

Solar and Energy Storage
Solar panels only generate electricity when the sun is shining. New battery storage technology allows solar energy to be stored when excess electricity is generated during the day and then dispatched in the absence of sunlight.

Pennsylvania's Solar Supply Chain

The solar supply chain is comprised of companies working across a variety of technology categories. Several businesses in Pennsylvania are already working in the solar industry, in areas such as manufacturing and installation. Table 2 below lists each of these technology categories and the current number of in-state companies.

Table 2. Pennsylvania's Solar Supply Chain Companies (Source: SEIA)

Company Focus	Number of Companies
Architectural/Engineering	6
Consultant	19
Contractor/Installer	279
Distributor	26
Engineering, Procurement and Construction	5
Financial Company	8
Legal Services	10
Manufacturer/Supplier	94
Not for Profit	6
Project Developer	24
Research	2
Service Provider	15
Total Companies	**494**

Strengths and Areas for Growth

Pennsylvania boasts major strengths throughout the solar supply chain. The state has a number of businesses that support the production of solar cells, supplying necessary industrial gases and materials as well as manufacturing technologies. Especially significant is the presence of Arkema Inc., a leading producer of advanced materials and chemicals in the United States.[45] Solar-grade silicon is a main component in solar cells, making AMG Advanced Metallurgical Group and Advantiv Technologies Inc. integral parts of the in-state and worldwide solar cell supply chain. Pennsylvania is also home to a number of solar inverter facilities. Strong in-state companies that support solar energy integration are valuable additions to the supply chain.

Beyond manufacturing, Pennsylvania has an extensive list of contractors and installers to facilitate the growth of statewide solar deployment. Contractors and installers comprise 279 of the total 494 solar companies, or 56.5 percent of Pennsylvania's entire industry, providing service jobs that are guaranteed to stay in the state if the solar industry continues to grow. In recent years, the amount of solar that has been installed on rooftops in Pennsylvania has grown substantially and the contractor/installer sector of the solar industry has potential to grow if the right incentives are in place.[46]

Pennsylvania's solar supply chain has ample opportunity for growth. While there are many advanced materials businesses in the state, Pennsylvania can leverage this supply by promoting solar cell production companies that bring these materials together for the solar market, either offering solar cells or full panels. The long-term success of Pennsylvania's solar cluster will depend on its ability to export. For example, the state could build its solar tracking and monitoring base to expand its reach outside the state. Another opportunity is high-performance solar glass, which is among the most important components for utility-scale solar energy. Expanding this sector within the state is crucial if Pennsylvania is to position itself as an industry leader. Targeted foreign direct investment recruitment missions aimed at filling these key gaps in the supply chain provide an opportunity for Pennsylvania to grow its emerging solar industry and capitalize on export demand.

Pennsylvania's Solar Clusters

As Figure 4 shows, two dense solar clusters are forming around Philadelphia and Pittsburgh. Early-stage clusters are centered around major population hubs and the state's top engineering universities.

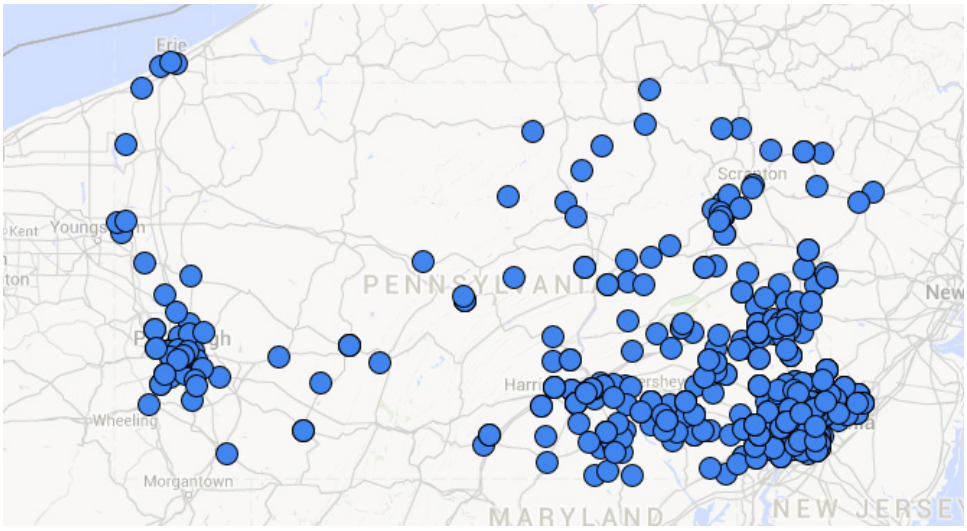


Figure 4. Pennsylvania's Solar Supply Chain Companies (Source: SEIA)

Pennsylvania's Potential for Solar Jobs

As demand for solar skyrockets, Pennsylvania has the opportunity to expand the solar economy, increase in-state spending, and employ an average of over 5,700 Pennsylvanians annually over the next fifteen years. If optimistic projections prove to be correct and Pennsylvania's solar companies are able to fill most of their supply chain needs with in-state purchases, over 86,000 direct, indirect, and induced job-years would be supported. While nearly 28,000 of those would be direct job-years in the state's solar industry, over 58,000 indirect and induced job-years could be supported if solar companies were able to procure supplies from in-state companies.

These projections for job-years potential in Pennsylvania's solar industry are based on tools and analysis by the National Renewable Energy Laboratory (NREL), DOE's Office of Energy Efficiency and Renewable Energy (EERE), and Bloomberg New Energy Finance (BNEF). Additionally, the Jobs and Economic Development Impacts (JEDI) tool was utilized to estimate job-years at different levels of local supply chain concentration for rooftop solar (residential and commercial buildings) and utility-scale solar.

To highlight why clustering supply chain businesses in Pennsylvania is so important, we have estimated the number of direct, indirect, and induced jobs based on future demand and the percentage of supply chain purchases made within the state. Figures 5 and 6 show how the number of rooftop and utility-scale solar job-years vary as the local share changes. The figures show the number of direct, indirect, and induced jobs based on local purchase percentages of 25 percent, 50 percent, and 75 percent. This range was chosen to represent reasonable goals for average local purchases, as 0 percent and 100 percent both represent extremes of purchasing behavior that are less realistic. Since projections often vary, we analyzed how those supply chain differences affect three reputable estimates of future demand: EERE's Wind Vision as a high-demand scenario, BNEF as a moderate-demand scenario, and NREL's Renewable Energy Futures High Demand Baseline as a low-demand scenario. Figure 5 presents estimates for utility-scale construction and operations and maintenance (O&M) jobs. For rooftop solar, job estimates are shown in Figure 6.

In all three demand scenarios, increasing the percentage of local spending by Pennsylvania's solar companies supports thousands of job-years. For example, in the high-demand scenario, increasing in-state local purchases from 25 percent to 75 percent would support over 36,000 direct, indirect, and induced job-years. In the medium-demand scenario, that same increase in in-state

What is a Job-Year?

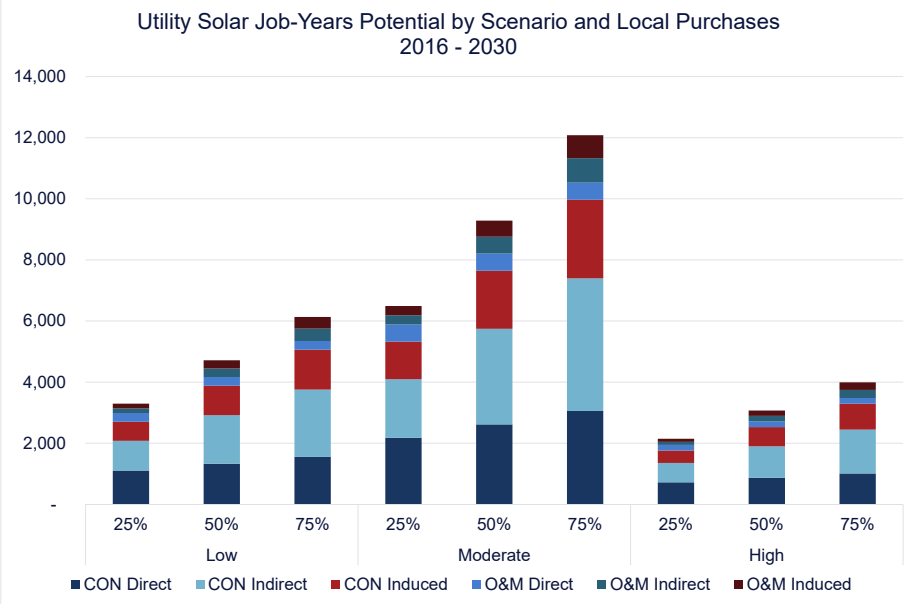
A job-year is one full-time equivalent job for one year (i.e., forty hours per week for fifty-two weeks, which is 2,080 hours per year). If two people each work a part-time job for twenty hours per week for fifty-two weeks, this is counted as one full-time equivalent job for one year, or one job-year. If one person works forty hours per week for ten years, this is counted as ten job-years.

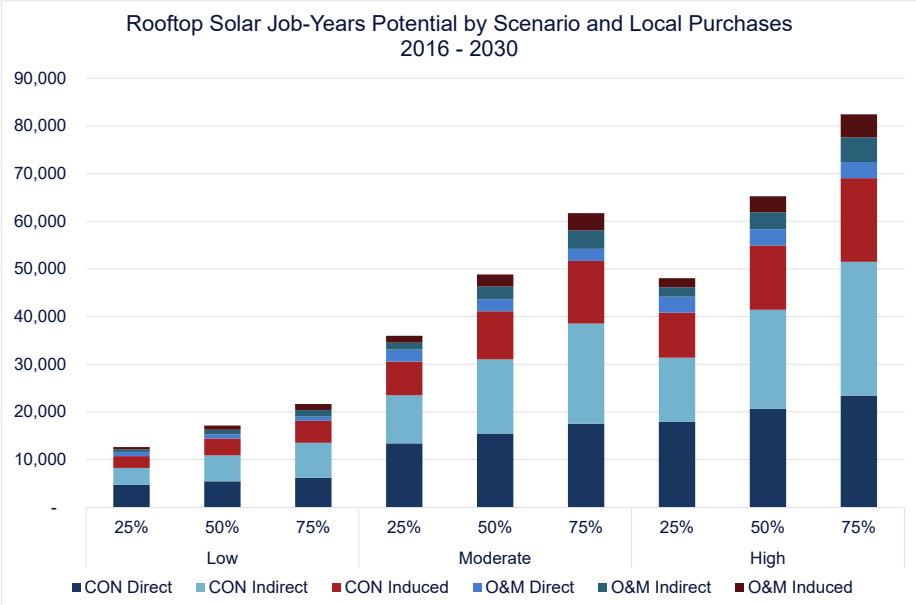
Why Use Job-Years?

By using job-years, our analysis can take into account the length of a job. In energy projects, many construction and installation jobs are short-term, while manufacturing and maintenance jobs may be long-term. Using job-years allows us to accurately count both types of jobs. For example, if ten full-time solar construction workers are expected to each spend 208 hours on a utility-scale solar project, this is measured as one job-year. Alternatively, if one full-time engineer is expected to spend fifteen years operating that same solar array, this is measured as fifteen job-years. In our analysis of Pennsylvania's solar supply chain, total job-years are aggregated over the 2016 to 2030 period.

local purchases would support over 31,000 job-years. Even in the low-demand scenario, increasing the percentage of in-state local purchases from 25 percent to 75 percent would support over 11,800 direct, indirect, and induced job-years.

If a concerted effort were made by the state to fill in the supply chain and strengthen the solar cluster, Pennsylvania companies could meet the expected demand for rooftop and utility-scale solar, supporting up to 86,000 job-years. Increasing the number of supply chain businesses can create thousands of good-paying, skilled jobs and make Pennsylvania a leader in the solar industry.





Figures 5,6. Increasing Pennsylvania's local share boosts solar job growth.

Direct, Indirect, and Induced Job-Years

In order to estimate the potential economic impact of Pennsylvania's solar supply chain, direct, indirect, and induced job-years are measured.

- Direct job-years: reflect jobs created in the solar industry to meet demand
- Indirect job-years: reflect jobs created at supply chain companies resulting from increased transactions as supplying industries respond to increased demand from Pennsylvania's solar industry
- Induced job-years: reflect jobs created throughout the local economy as a result of increased spending by workers and firms in Pennsylvania's solar industry and solar supply chain industries

Local Share

Local share is the percentage of expenditures spent in Pennsylvania. For example, if a solar installation company plans to spend $3 million on imported solar PV panels and $1 million on additional supplies from companies in Pennsylvania, the local share is 25 percent. In the JEDI model, local share is an independent variable.

Policy Recommendations

Pennsylvania can jumpstart the state's solar cluster by focusing on innovative policies that remove obstacles and boost demand within the state. Creating a robust in-state market will attract private investment, strengthen the economy, and create new value chains, which will subsequently stimulate and accelerate new export markets.

Policy 1: Create an Online Crowdfunding Platform to Support Solar Projects

In order to meet the solar carve-out in the Alternative Energy Portfolio Standard, utilities have been purchasing out-of-state renewable energy credits—Pennsylvania dollars are being spent to grow other states' solar markets.[47] Boosting in-state solar generation can keep money in the state while meeting the AEPS goals. Pennsylvania could target solar projects on schools, hospitals, and community centers to expand in-state production of solar energy. However, lack of funding and administrative burden are significant barriers to solar for these public entities. The state could streamline the process of initiating a project and raising capital by creating an online crowdfunding platform. This platform could be used to campaign for donations to finance solar projects.

Solar savings have had a positive impact on in-state school districts and hospitals. After installing solar systems, Pennsylvania school districts have had one-year savings up to $280,000 and other districts could achieve similar savings.[48] Hospitals have also saved up to $5,000 annually by going solar.[49] Schools and hospitals that install solar systems are able to participate in the AEPS program and gain revenue through the sale of RECs.[50]

Public solar project crowdfunding has been successful overseas. In the United Kingdom, the nonprofit 10:10 provides outreach and fundraising support for schools' solar campaigns.[51] Anyone can contribute to the schools' crowdfunding efforts through 10:10's online platform. The program has raised more than £400,000 in three years to build on-site solar systems for schools.[52,53] Thirty-one projects are fully funded and fifty-six currently have active campaigns.[54] Pennsylvania has the opportunity to replicate this success in its communities.

What is Crowdfunding?

Crowdfunding is the process of raising money for a project or venture through contributions from a large span of people, typically through an online platform. This type of crowdfunding does not need enabling legislation. Equity crowdfunding is the same process but contributors gain an ownership stake in that project. Equity crowdfunding has not yet been authorized in Pennsylvania. (For more information on equity crowdfunding in Pennsylvania, refer to Chapter 4.)

Pennsylvania's Solar Energy Program

The Solar Energy Program provides financing in the form of grants and loans to project developers and those wishing to install solar systems.[55] Grants are available for solar generation projects up to $1 million or $2.25 per watt, whichever is less.[56] Each grant must be matched dollar-for-dollar with additional investment funds.[57] The program is not accepting applications at this time as guidelines are being modified.[58]

Through the Pennsylvania solar crowdfunding tool, public entities would be able to establish a campaign to which the community members could donate. Since the Solar Energy Program (SEP) requires a matching investment for program grants, crowdfunding would help public entities raise the necessary funds to make use of the program. Costs associated with creating the platform could be covered by contributions from industry, general fund allocations, or SEP funds. The SEP could also allocate a limited amount of funds to enable public entities to jumpstart campaigns and coordinate fundraising efforts. Although the SEP program is currently closed while the Commonwealth Financing Authority updates guidelines, some money could be immediately released to help implement the platform. Through this innovative funding model, Pennsylvania could not only extend energy savings and educational opportunities to local communities but also stimulate the state's solar economy.

Policy 2: Establish a Statewide Model for Streamlined Permitting Processes

Costly and inconsistent permitting and approval processes burden the solar industry in Pennsylvania. Municipalities and counties across Pennsylvania have varying permitting procedures and fees, which significantly slows the solar installation process and increases costs to customers and installers. Furthermore, high costs due to cumbersome permitting and interconnection requirements have been shown to deter solar installers from entering markets altogether.[59,60]

Modernizing solar permitting for residential and non-residential customers is a low-cost, straightforward way to strengthen Pennsylvania's solar market. Current barriers to the permitting process include high permit fees, complex processes, and inconsistency across jurisdictions.[61] Addressing these challenges will reduce complexity, cut down soft costs, and signal to solar installers that Pennsylvania's counties and municipalities are ready for their business. Projections show that streamlining permitting processes could reduce the cost of the average residential solar project by $700 and standardizing local regulatory regimes could reduce the project cost by over $2,500.[62]

Pennsylvania can look to recent successes in reducing permitting time and costs in Vermont and Colorado. In 2011, Vermont passed legislation that simplified and standardized the permitting requirements across the entire state, as well as reduced the processing time for solar projects.[63] In Vermont, local utilities have ten days to review the standard application and raise any related issues.[64] If no issues are raised within that time frame, the project is automatically approved for construction. In Colorado, the Fair Permit Act of 2011 reduced permitting fees for solar projects, ensuring that customers were not charged more than was necessary to review their project.[65] Colorado set the fee cap at $500 for residential systems and $1,000 for non-residential projects.[66]

Pennsylvania could similarly lower soft costs and increase efficiency by creating a best practice permitting model for jurisdictions to adopt across the state. The model would streamline permitting information, applications, forms, procedures, and technical requirements and make them readily available online. Streamlining the solar permitting process is a low-cost and low-risk solution for bolstering in-state solar markets. Offering this information online allows customers and installers to submit, review, print, and pay for permits in one convenient location. Integrating a permit checklist into a website that offers access to information and resources on solar installation can reduce mistakes while curbing time related to the permitting processes.[67] By eliminating unnecessary fees and reducing the variability in permitting requirements across the state, Pennsylvania can help lower the overall soft costs of installing solar.

Over 90 percent of Pennsylvania jurisdictions use a value-based approach to determine permitting fees; three out of thirty-six Pennsylvania jurisdictions surveyed offer fixed fees that do not change with solar system size or cost.[68] This approach calculates fees based on the overall cost and size of the solar project rather than the time and effort needed to review and issue a permit. However, it costs jurisdictions roughly the same amount to review and issue a permit, regardless of size.[69] Pennsylvania could replace the value-based method with fixed fees that remain flat regardless of system size or cost and reflect the administrative burden of reviewing and issuing a permit.

Streamlined Permitting Best Practice

San Jose, California integrated the solar permitting process into their city webpage and offers extensive permitting information in one easy-to-use location.[70] The National Renewable Energy Laboratory highlights San Jose as a best practice for solar permitting.[71]

What is Community Solar?

Sometimes called shared solar, community solar projects allow customers to buy or lease part of a shared solar system.[74] The customer's share of the electricity generated by their panels is credited to their electricity bill.[75] The solar project can either be organized by a community or a utility.

Policy 3: Enable Local Communities to Develop Solar Projects

With smart policies that encourage community development, all Pennsylvanians who wish to purchase renewable power could have access to it. Currently, nearly half of all energy customers in the United States—49 percent of homes and 48 percent of businesses—are locked out of the solar market.[72] Pennsylvania is no exception. Reasons for this include the high cost of financing a PV project and a lack of property rights (for renters). Additionally, many property owners have land or buildings that are not suited for solar due to size, orientation, or shade from buildings and trees. In order to offer more local control, fourteen states and the District of Columbia have offered a new option for delivering solar power to customers who wish to purchase it through community-owned or shared solar projects.[73] Currently, Pennsylvania has no legislation enabling community-owned solar projects.

Solar Made Simple: Benefits of Community Solar[76]

- Customers buy only the amount of solar allowed by their budgets, rather than having to invest in a whole system.
- Permitting, site assessments, and interconnection hassles are all dealt with at the project level, not by individuals, saving time for customers.
- Utilities can also participate and help ensure benefits to the grid.
- Programs can be designed to allow customers to transfer their energy to new homes.
- Renters in multi-unit buildings and business owners are able to participate.

Pennsylvania could look to Colorado as an example of successful leadership in community solar. In 2010, Colorado passed the Community Solar Garden Act, which encouraged community solar projects and provided subscription guidelines.[77] The response was overwhelmingly positive with "shares in the facilities sold out in as little as thirty minutes after they were announced."[78] The state also amended restrictions to expand the potential subscriber base for projects.[79] With clear legislation, Pennsylvania could replicate Colorado's success throughout the state and encourage the development of community solar projects to benefit those communities experiencing technical and financial barriers.

There is significant interest in community solar projects in some areas of Pennsylvania.[80] Unfortunately, without legislation enabling community solar, the process for developing a project

can be cumbersome. In order to remove a significant barrier to community solar projects, Pennsylvania policymakers could pass legislation permitting community solar projects. The legislation could make clear that these projects are entitled to the same net metering laws that individual residents are subject to; virtual net metering, or allowing multiple people to sign up for the same metering system, would need to be expressly permitted. In order to further facilitate community solar, the state could give priority to leases on public land for community solar.

To maintain individual choice, the legislature could stipulate that customers will not be forced to buy power from a community solar installation. All customers could have the right to maintain their current arrangement with their chosen utility. Allowing citizens and communities the freedom to purchase their own renewable energy increases customer choice, promotes local control, and helps sustain local economies.

Policy 4: Establish a Distributed Generation Carve-out

Pennsylvania's solar market shrank over the past several years because of low solar renewable energy credit (SREC) prices and a weak AEPS solar carve-out requirement.[81] The instability of Pennsylvania's solar market reflects the need for in-state measures that provide consistent and reliable market signals for the solar industry. Pennsylvania could consider amending the AEPS to require a percentage of electricity be procured from distributed generation projects in order to encourage in-state production of renewable energy.

Two states that have been leaders on promoting in-state generation of solar energy are New Mexico and Colorado. New Mexico has implemented a 3 percent distributed generation carve-out, meaning that the state requires that 3 percent of its electricity be produced at the location of an individual's property.[86] The electricity can be used on-site or transmitted to a local investor-owned utility or rural cooperative to be used by customers in the surrounding service area.[87] Similarly, Colorado has established a distributed generation carve-out of 3 percent of investor-owned utility sales by 2020, ramping up from 1 percent in 2011.[88]

Pennsylvania's SREC Market

Renewable energy certificates (RECs) are tradable energy credits that represent 1 MWh of renewable electricity.[82] While the price of RECs can rise and fall, these credits are bought, sold, and traded between states to satisfy renewable energy goals. SRECs are credits that represent 1 MWh of solar-powered energy.[83] Virginia, Maryland, West Virginia, New Jersey, Ohio, and others can all sell SRECs into Pennsylvania.[84] A surplus of SRECs from outside the state caused prices to drop, ultimately deflating Pennsylvania's solar industry.[85]

Distributed Generation

Distributed generation refers to electricity that is generated on-site or close to where it is consumed.[89] Distributed renewable generation has several benefits: it can grow in-state renewable energy demand, improve grid reliability, and diversify the local energy supply.[90] Distributed generation can include solar, small-scale wind turbines, combined heat and power, and biomass energy.

Increasing demand for locally generated electricity could send a clear, consistent market signal to business leaders, encouraging solar installers and manufacturers to expand in-state operations. By establishing a distributed generation carve-out, Pennsylvania can diversify its fuel mix, provide reliable energy, and promote in-state generation, creating good-paying jobs for Pennsylvanians.

Chapter Summary

Pennsylvania has succeeded in laying the foundation for growing its advanced energy economy through solar development. Smart, strategic policy choices can help leverage the state's existing solar businesses and regulatory standards to create a thriving solar cluster. Although Pennsylvania has made commendable progress in its renewable energy policies, policymakers have several opportunities to incentivize in-state generation and maximize the economic benefits of a strong solar sector. By establishing an online solar crowdfunding platform, streamlining permitting to reduce the soft costs associated with installing solar, enabling community solar projects, and establishing a carve-out for distributed generation in the AEPS, Pennsylvania leaders could strengthen and expand the state's commitment to the advanced energy economy.

Roof-integrated solar photovoltaic shingles
Photo Credit. U.S. Department of Energy

Chapter 4: Innovation Ecosystem and Access to Capital

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

Non-Dilutive Capital

Non-dilutive capital funding, such as grants and loans, does not affect ownership of a company. These funding sources may carry interest rates or have restrictions on how they are used, but will not impact the shares of the company.

In today's competitive, globalized economy, businesses are more likely to thrive in cities and states that offer a rich innovation ecosystem and break down barriers to capital. 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. State and local government institutions, as well as private entities, can take action and collaborate to maximize the impact of innovation, support new and expanding businesses, and create good-paying jobs in Pennsylvania.

Innovation ecosystems promote research and development (R&D), bring new technologies to market, and incubate early-stage businesses. Simplifying the transfer of ideas from the lab to the marketplace accelerates further entrepreneurship and job creation. Robust innovation ecosystems include efficient intellectual property protection mechanisms, mentoring for entrepreneurs, and engagement of business and venture capital.

Access to capital is critical for the success of advanced energy technologies. New and growing businesses face severe financial hurdles during technology development, commercialization, and expansion. Having access to investors and non-dilutive capital can be the difference between success and failure. In order to maximize the success of advanced energy businesses that create good-paying jobs, states should consider actively facilitating access to capital.

Seamless connections between researchers, entrepreneurs, investors, and non-dilutive capital are vital for advanced energy technology businesses to thrive. The new energy economy is a race, and only businesses capable of bringing innovative ideas to the marketplace quickly and efficiently will be considered winners.

Pennsylvania's Innovation Ecosystem

Pennsylvania is a research powerhouse with robust innovation ecosystems in Pittsburgh, Philadelphia, and smaller communities connected to research universities. In total, the commonwealth

boasts eight public and private research universities. Temple University alone has a $6.2 billion economic impact on Pennsylvania.[1]

Pennsylvania's investment in knowledge-based capital is among the highest in the nation. The commonwealth ranked sixth in the nation in R&D spending in 2013, the most recent year with available data.[2] With a commitment to R&D, a diverse array of university technology transfer efforts, and relatively strong venture investment, Pennsylvania has a healthy foundation for the development of advanced energy businesses.

Research Institutions and Initiatives

Pennsylvania is home to a robust network of research universities leading the way in a variety of applied research efforts. For example, the Energy Research Center (ERC) at Lehigh University is a multidisciplinary group researching energy conversion, power generation, and environmental control. The ERC is active in several joint research projects involving Lehigh University faculty, staff, and students, as well as stakeholders from private industry.[3] At Penn State, the Indoor Environment Center focuses on reducing energy use, while also making indoor spaces safe and more thermally, visually, and acoustically comfortable.[4]

At Philadelphia's Navy Yard, the Consortium for Building Energy Innovation (CBEI), a cross-sector collaborative group of fourteen organizations, has a goal of 50 percent reduction of energy use in existing buildings by 2030. The CBEI includes industrial firms, research universities, national labs and the Department of Energy.[5] Pittsburgh is home to the Department of Energy's National Energy Technology Laboratory. Although the lab is devoted to fossil energy research,[6] its technology expertise includes carbon dioxide capture and storage[7] and fuel cells.[8]

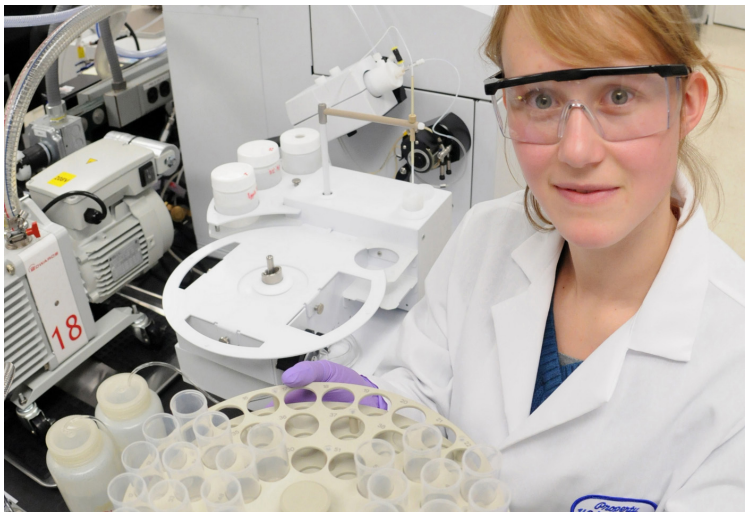


Photo Credit. Argonne National Laboratory / Flickr / CC BY-NC-SA

Pennsylvania Infrastructure Technology Alliance

Lehigh University's Center for Advanced Technology for Large Structural Systems and Carnegie Mellon's Institute for Complex Engineered Systems formed the Pennsylvania Infrastructure Technology Alliance (PITA) to improve knowledge transfer, talent retention, and technology innovation in the state. PITA draws on expertise from private companies, university faculty, and students to drive research and education projects and support the creation of startups in Pennsylvania.[9]

Resources for Startups

Creating an environment that fosters and empowers entrepreneurs is critical to the success of innovation ecosystems. Additionally, effective innovation ecosystems facilitate the flow of knowledge-based capital (KBC) through strong networks of incubators, accelerators, investors, universities, and industry professionals.[10] KBC has the greatest impact when resources and information flow easily between firms in an economic cluster.[11] As a result, a competitive approach to the advanced energy sector requires specialized entrepreneurial networks that improve deal flow and knowledge spillover.[12] Pennsylvania currently addresses the critical link between technology innovation and adequate resources for entrepreneurs by maintaining world-class university incubators and facilitating technology transfer throughout the state.

The commonwealth is home to a variety of startup incubators and accelerators. For example, the AlphaLab Network in Southwest Pennsylvania is a collaboration between AlphaLab, AlphaLab Gear, and Innovation Works—the seventh top seed-stage investor in the country.[13,14] The latest class of startups included advanced energy technologies, such as smart meters on industrial gas tanks, lightweight carbon freight, and battery-powered "mini-taxis."[15] The accelerators in the AlphaLab Network provide companies with a $25,000 investment in exchange for 5 percent equity.[16]

The Greater Philadelphia Alliance for Capital and Technologies is a resource for early-stage growth companies in technology and healthcare industries.[20] The organization aims to create a strategic hub of early-stage companies, increase the region's economic competitiveness, and facilitate networking opportunities through industry-specific events, investor-only events, membership breakfasts, and roundtable discussions.[21]

Innovation Works

Innovation Works (IW) is a part of the Ben Franklin Technology Partners. They have over $52 million of investments in more than 160 technology startups. These companies have gone on to raise over $1.5 billion in follow-on funding.[17] Additionally, IW has invested $64 million in more than 200 technology startups. In 2014 alone, IW invested $5.6 million, which helped generate 74 new products and 329 jobs.[18]

Accelerator Best Practices

Studies on accelerators have found that successful incubation and acceleration is related to the provision of intensive business mentoring and practical resources, such as accounting support, interns, office space, and discounts on essential services.[19]

The Efficiency Network

Headquartered in Pittsburgh, The Efficiency Network (TEN) brings together local partners in the private sector to finance and design smart building technologies for energy efficiency improvements. The network includes more than two dozen energy and contracting firms,[22] which allows for extensive knowledge spillover and a favorable environment for innovation.

Government Programs

Pennsylvania's Innovation Partnership is an example of collaboration between economic development organizations and small business assistance providers.[23] The organization helps clean energy, as well as energy-related life sciences, advanced manufacturing, nanotechnology, and communications technology companies. Innovation Partnership offers proposal writ-ing assistance and other services to make federal funding more accessible for Pennsylvania companies.[24]

The Keystone Innovation Network (KIN) leverages existing state investments by integrating the Keystone Innovation Zones and Innovation Grant programs. Through this integrated approach, KIN brings together companies, universities, researchers, students, and entrepreneurs to take advantage of important technology transfer and business development resources. KIN's competitive grant program is administered by the Technology Development Authority and aims to accelerate commercialization, develop technology transfer infrastructure, and capitalize on intellectual property rights, tax incentives, funding, and other supportive services.[25]

Pennsylvania provides several tax incentives for technology innovation and advanced energy sector investments. For example, the Keystone Innovation Zone Tax Credit Program (KIZTCP) has consistently gained popularity and momentum since its inception in 2006. In 2014, 227 companies claimed tax credits through the program, totaling $17.1 million. This record amount was still well below the annual cap of $25 million.[29] Pennsylvania's Research and Development Tax Credit provides a 10 percent credit for R&D investments over a base period, which can be carried forward for up to fifteen years. The program has a prorated annual cap of $15 million. Projects that involve new construction in deteriorating areas can benefit from the Local Economic Revitalization Tax Assistance Program.

University Research Commercialization Grant

The Ben Franklin Technology Development Authority supports university research by helping to commercialize technologies that have high potential for positive economic and workforce development impacts.[30]

The Keystone Innovation Zone Tax Credit Program

- The program provides up to $100,000 in tax credits per year, out of an annual pool of $25 million[26]
- The tax credit can be claimed against personal income tax, corporate net income tax, or capital stock franchise tax[27]
- Tax credits can total 50 percent of the increase in gross revenues from the preceding year, if the company meets the following conditions:
  1. Located within the boundaries of a Keystone Innovation Zone;
  2. In operation less than eight years; and
  3. Operates within a targeted industry, which varies from zone to zone.[28]

Pennsylvania's Access to Capital

Access to capital is essential for growing businesses and bringing products to market. Unfortunately, many entrepreneurs are unable to obtain the necessary capital to sustain their companies through the commercialization phase. As shown in Figure 7, companies nationwide face funding shortages during the prototyping and commercialization phases, commonly known as the "valleys of death." In 2014, approximately 75 percent of all venture capital funding went to companies in California, New York, and Massachusetts.[31] This makes obtaining funding for companies in the other forty-seven states even more difficult. Pennsylvania has a strong history of prioritizing early investment to help new companies survive the double "valleys of death" and bring innovative technologies to market.

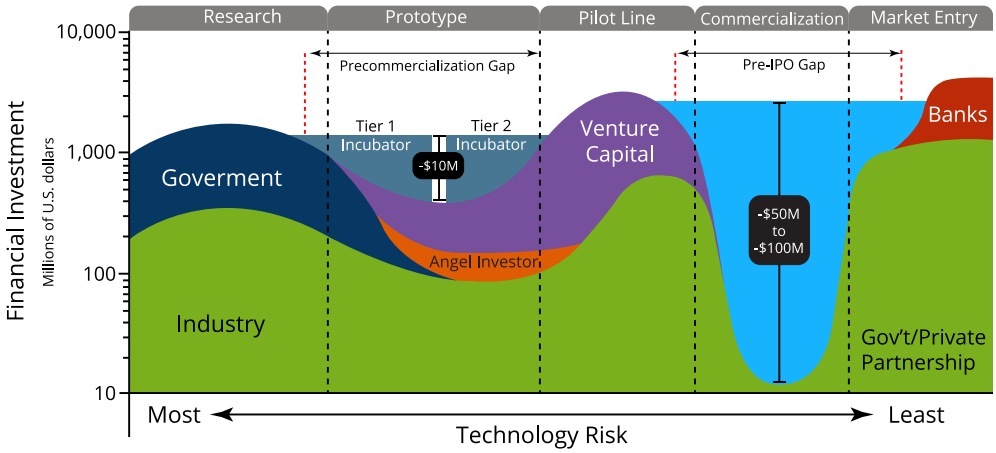


Figure 7. New technologies need help crossing the second "valley of death" during the commercialization process (Source: U.S. Department of Energy)

Venture Capital Funds

In 2015, Pennsylvania outpaced many of its regional peers in venture capital invested—the state ranked thirteenth in the country.[32] Statewide funding for 2015 totaled $638.2 million for 201 deals, up 21 percent from $525.4 million in 2010.[33] As of 2013, Pennsylvania was home to twenty-seven venture capital firms.[34] While these sums seem like substantial levels of investment, only a small fraction of the money has been routed to energy-focused startups. According to the National Venture Capital Association, investment in energy companies represented only 5 percent of the $29.9 billion total venture capital invested in the United States in 2014.[35]

Innovate in Pennsylvania is a program designed to inject $100 million of investment into the state's innovation ecosystem.[36] Once funding has been secured, the Pennsylvania Department of Community and Economic Development will allocate the $100 million as follows: 50 percent to the public venture capital fund, Ben Franklin Technology Partners; 45 percent to the Ben Franklin Technology Development Authority; and 5 percent to Pennsylvania's three regional public biology research centers.[37]

Ben Franklin Technology Partners is a well-established economic development organization that delivers a 3.6-to-1 return on investment for every public dollar received. Approximately 140,000 new jobs are attributed to the organization and the economic activity it has spurred within the state.[38] Similar to other economic development organizations, Ben Franklin Technology Partners is governed by a board that includes individuals from academia, industry, and public service.[39] Investments are financed through a combination of state funding and previous successful ventures repaying their loans.

The Ben Franklin Technology Development Authority (BFTDA) administers a number of competitive grant programs to assist small businesses in the technology transfer process.[42] The vast majority of the BFTDA's annual appropriation is dispersed directly to Ben Franklin Technology Partners where it is allocated to various investments through the regional offices.[43] The BFTDA invests in various projects, including proof-of-concept support in the form of university research grants.[44]

Non-Dilutive Capital

Under the direction of the Commonwealth Financing Authority, the Department of Community and Economic Development and the Department of Environmental Protection administer the Alternative and Clean Energy, Renewable Energy, and High Performance Building Programs.[48,49] The first two programs provide grants and loans to businesses engaging in the utilization, development, and construction of advanced energy projects within the state. This includes loans and grants for component manufacturers of geothermal systems or wind energy generation and distribution projects. The High Performance Building Program follows a similar loan and grant model with a focus on building improvements.[50]

Regional Headquarters[40,41]

Ben Franklin Technology Partners has four regional headquarters located in:

- Philadelphia
- Pittsburgh
- University Park
- Bethlehem

New Venture Investment Program

The Ben Franklin Technology Development Authority's New Venture Investment Program allocates $45 million of loans to venture capital firms who will invest the funds in growth-stage Pennsylvania companies. At least 50 percent of the companies that receive funds must be in underserved regions of the state. "Underserved" is defined as outside of Philadelphia or any other metropolitan areas with fewer than one million residents.[45] The program requires participating venture capital firms to invest three dollars for every one dollar of public money invested.[46] After the required matches are met, the program's anticipated impact is $240 million.[47]

Alternative and Clean Energy Program

The Alternative and Clean Energy Program disperses loans equal to $40,000 for every new job created by a project, with a strict cap of $5 million or 50 percent of total project cost. The program requires a dollar-for-dollar investment match.[51]

Renewable Energy Program

The Renewable Energy Program provides loans up to $40,000 and grants up to $5,000 for every new job created by a project. Loan amounts are capped at $5 million, and grants are capped at $1 million. The program requires a matching investment and offers 75 percent loan guarantees up to $5 million.[52]

The Partnerships for Regional Economic Performance (PREP) encourages regional coordination in economic development efforts. PREP offers workshops, training, one-on-one counseling, and incentives to new and growing businesses.[53] In 2014, PREP provided 3,600 unique clients with 190 workshops and over 29,000 hours of counseling. The net impact of this effort included $135 million in increased or retained sales and more than 2,700 new or retained jobs.[54]

Pennsylvania offers a variety of programs to provide access to capital for small businesses:

- The Pennsylvania Capital Access Program (PennCAP) works with partner banks to offer small businesses favorable loans of up to $500,000 to purchase land, buildings, machinery, equipment, and working capital.[55]
- The Business Opportunities Fund (BOF) gives small businesses access to installment loans, lines of credit, and technical assistance.[56]
- The Pennsylvania Economic Development Financing Authority's Bond Financing Program provides cost-effective financing to projects of all sizes by issuing bonds, selling the bonds to investors, and lending the proceeds to eligible businesses.[57]

Pennsylvania facilitates access to working capital for technology startups through the Second Stage Loan Program.[58] Additionally, the Pennsylvania First Program incentivizes local job creation through a privately matched competitive grant process based on economic impact in the state.[59] Finally, the Market Access Grant is a $3,000 matching grant that helps companies increase their capacity to enter foreign markets.[60]

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Tax Incentives

Pennsylvania is highly focused on reenergizing the state's industrial infrastructure through redevelopment, revitalization, and new industry. As a result of this effort, several existing tax credits and exemptions are available to the growing advanced energy industry. For example, the Job Creation Tax Credit applies to companies that create at least twenty-five jobs or expand their existing workforce by 20 percent or more.[61] There are higher incentives for hiring individuals who were previously unemployed.

In addition to the Keystone Innovation Zones, there are several other special zoning programs that include tax credits and exemptions, such as the Keystone Opportunity Zone, Keystone Special Development Zone, and Enterprise Zones.[62] Pennsylvania possesses rather comprehensive policy mechanisms that can be leveraged to spur the creation of advanced energy jobs. To solidify its competitive position in regional, national, and global markets, the state should continue to foster innovation and leverage smart capital policies.

Policy Recommendations

If Pennsylvania wants to be a national leader in smart buildings and solar manufacturing, the commonwealth needs to further build out its innovation ecosystem and expand access to capital. Prioritizing smart policies and creative solutions would help transition new technologies to market faster and create good-paying jobs for Pennsylvanians.

Policy 1: Create an Intrastate Securities Exemption for Equity Crowdfunding

Pennsylvania only received 1 percent of venture capital investment in 2015.[63] Although the state makes efforts to increase venture capital investment, Pennsylvania could further expand sources of funding for early-stage companies by allowing intrastate equity crowdfunding. Over the past four years, twenty-six states and the District of Columbia have enacted intrastate securities exemptions that allow equity crowdfunding from non-accredited investors.[64] These exemptions align with updates to the federal exemption for equity crowdfunding under Title III of the JOBS Act.[65]

Establishing this exemption would open up a new pool of investors in Pennsylvania that could invest in local startups. Intrastate exemption rules allow the state to determine limits on equity offerings from companies and maximum investment amounts by non-accredited investors. These limits often exceed federal rules, giving states the ability to compete as the most lucrative

Types of Investors

- Accredited Investors are individuals with earned incomes that exceed $200,000 (or $300,000 with a spouse) for two consecutive years or a net worth (not including their home) of $1 million or more.[69]
- Equity Crowdfunders are non-accredited investors allowed to invest in companies with restrictions on how much they can commit.

option for intrastate investment.[66] In 2015, 102 companies filed for this exemption; some of them even moved across state lines to become eligible.[67,68]

Pennsylvania's leaders should consider enacting a crowdfunding exemption to allow capital from non-accredited investors to flow into the state's businesses, bolstering startups and creating jobs.

Policy 2: Establish an Early-Stage Capital Gains Tax Exemption

A capital gains tax is applied to the sale of an asset that was purchased at a lower cost than it was sold. For example, if an individual purchases stock in a company and then sells when the company is worth more, the profits made on this sale, or capital gains, are taxed. For this reason, high-risk early-stage companies can have difficulty finding investors.

A state or national policy that eliminates or reduces the rate of capital gains taxes could incentivize investors. States could use this incentive to spur innovation in specific industries and encourage investors to commit their money to homegrown companies. Pennsylvania could implement an early-stage capital gains tax exemption to incentivize investment in advanced energy startups. Pennsylvania could reference successful early-stage capital gains tax exemption policies in other states and countries.

Successful Capital Gains Tax Exemption Policies

Similar capital gains tax exemption programs have been successful in the United Kingdom: the Enterprise Investment Scheme (EIS) and Seed Enterprise Investment Scheme (SEIS) are tax-based venture capital schemes that provide tax relief to investors in high-risk companies. The EIS started in 1994 with the aim to help small, high-risk companies build capital by offering tax relief to investors.[70] In 2012, the government established the complementary SEIS, which offers tax relief at a higher rate for early-stage investment.[71] Approximately 22,900 companies have benefited from the EIS, raising over £12.2 billion in funds since the program began in 1994.[72] From 2013 to 2014, SEIS spurred a total of £164 million of investment in 2,000 companies.[73]

Policy 3: Facilitate Partnerships within the Energy Innovation Ecosystem

Due to the complex nature of the advanced energy space, having effective partnerships across sectors is critical to fostering innovation and growing the industry. Strategic alignment between Pennsylvania's leading research universities, private companies, nonprofits, and government entities could accelerate advanced energy sector growth and create good-paying jobs. Efforts to improve cross-sector organization could include the advancement of shared policy objectives, the enhancement of visibility around energy innovation issues, and the coordination of resources.

Collaboration is especially important given the increasing amount of capital directed toward early-stage research and development—the U.S. government plans to double its current level of investment in advanced energy over the next five years.[74]

Aligning various stakeholders in the energy innovation ecosystem can help attract capital, bring breakthrough research to market, and make Pennsylvania a key player in the advanced energy space.

> Recognizing the importance of coordination within and across sectors, the state of Ohio funded the Ohio Federal Research Network in July 2015. Wright State Applied Research Corp. will receive $20 million over the course of two years and Ohio State University will receive an additional $5 million to establish collaboration between the state's research universities, Wright-Patterson Air Force Base, NASA Glenn Research Center, and the private sector.[75] Approximately half of this funding will be used to create a model of how the research network will run. The goal of the Ohio Federal Research Network is to bring in $300 million in new federal research contracts to Ohio-based companies in the next five years. It is estimated that this funding will result in 2,500 new jobs, $250 million in private sector investment, and the creation or expansion of 100 companies.[76]

In order to strengthen the state's advanced energy sector, the Pennsylvania Department of Community and Economic Development could invest in coordination efforts throughout the innovation ecosystem, which would attract more public and private research money and venture capital funding to Pennsylvania. Proactively aligning efforts will help Pennsylvania compete and continue to thrive as an engine for innovation.

Chapter Summary

Pennsylvania has demonstrated a strong commitment to the state's innovation pipeline, providing support to emerging companies through its public university system, venture capital funds, and strong partnerships with the private sector. Additionally, Pennsylvania offers a compelling range of incentives from property tax abatements, business tax credits, and other mechanisms to help retain and nurture emerging companies. Policymakers can maintain Pennsylvania's competitive edge by implementing an intrastate equity crowdfunding exemption, creating a capital gains tax exemptions for investments in early-stage companies, and improving innovation ecosystem coordination. These types of pro-market, forward-thinking policies would allow Pennsylvania's advanced energy entrepreneurs to continue to innovate, bring ideas to market, and create good-paying jobs.

Chapter 5: Workforce Development

A skilled workforce is fundamental to the success of an industrial cluster. Sector-based workforce development goes hand-in-hand with cluster development. If firms in the same sector are able to coordinate with the government, schools, and related non-profits on policies and programs to train workers for their sector, they will be better equipped to identify their employment needs and find skilled workers to fill available jobs.

Many jobs in the solar and smart building sectors require skilled workers. As such, sector-based workforce development provides an opportunity to increase the number of good-paying positions for Pennsylvania's residents. This is especially important given the Great Recession's impact on wage growth. While the commonwealth's unemployment rate has fallen from 8.7 percent in 2010 to just over 5 percent in 2015,[1] inflation-adjusted wages have been declining: Pennsylvania's median wage fell 3 percent between 2010 and 2013.[2] While all segments of the population saw their wages decline during the recession, the bottom 20 percent of workers saw the greatest drop in wages (over 4.3 percent).[3]

Advanced energy and manufacturing sectors offer the opportunity to significantly expand employment and economic opportunities available to Pennsylvania residents. Indeed, advanced manufacturing accounts for 12 percent of the state's GDP and approximately 10 percent of employment.[4] The commonwealth can address current skill gaps and structural challenges in the solar and smart building sectors and increase the pool of qualified workers by investing in training programs. By stoking advanced energy clusters, the commonwealth can provide more good-paying jobs for its dedicated labor force and encourage Pennsylvanians to pursue careers in their home state.

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.[5] Leaders in the commonwealth can focus efforts on those regions and populations still experiencing high unemployment.

Workforce Development Strengths

Pennsylvania's robust workforce development system provides a strong base for professional and technical skill expansion. Current efforts include PA CareerLink®, WEDnetPA, the state's community college and higher education system, and numerous local and regional programs offered by employers, state agencies, and community-based organizations. Pennsylvania also promotes various workforce expansion and professional training opportunities specific to the advanced energy sector.

Workforce Development Network

Workforce Development Network PA (WEDnetPA) is a flagship program for supporting worker training in Pennsylvania. As part of the program, the commonwealth reimburses businesses interested in training current and new employees. WEDnetPA pays up to $450 annually per trainee for essential skills training and $850 annually per trainee for advanced technology training, which includes skills that are critical to the smart building and efficiency industry.[6] The program has helped more than 17,000 employers train over one million employees since being established in 1999.[7]

Universities and Community Colleges

Pennsylvania is home to several highly ranked universities that train students in a variety of professional and academic programs. Carnegie Mellon University, Lehigh University, Pennsylvania State University, University of Pennsylvania, and University of Pittsburgh furnish a highly skilled workforce by providing degree programs and training that positively impact advanced energy industries. Notably, Pennsylvania ranks sixth in the nation in STEM degrees conferred per capita, offering a pool of highly advanced and technologically sophisticated professionals.[8]

Photo Credit. PSNS & IMF / Foter / CC BY-NC-SA

Energy Engineering Degree Programs

The energy engineering degree programs offered at Penn State University and Penn State Hazleton set Pennsylvania apart from other states. The first of its kind in the country, the Penn State program offers "courses focused on renewable energy and electrochemical engineering as well as professional electives on business, finance, and management."[9] During the first two years of the program, coursework is similar to other engineering degrees; however, in the last two years, students take classes related to energy engineering, such as thermodynamics and physical and chemical processing applied to energy industries. Students at Penn State Hazleton complete their degree with a senior design project of their choice.[10] The program also offers internship opportunities with the Department of Energy and a range of career opportunities for graduating students.[11]

Pennsylvania's fourteen community colleges play a crucial role in pro-viding students with the practical skills they need to enter the job market. Some colleges offer specialized advanced energy programs. For example, Luzerne Community College offers a certificate program in sustainable energy technology.[12] Similarly, Northampton Community College offers an associate's degree in heating, ventilation, air conditioning, and refrigeration (HVACR) equipment installation.[13]

Apprenticeship Programs

Pennsylvania is home to a number of training programs that focus on skills in electrical wiring, HVACR, and construction. These skills apply directly to jobs in the solar and smart building sectors. Laborers' District Council of Eastern Pennsylvania, for example, offers several two-year programs with 4,000 hours of on-the-job training.[14] Additionally, Secco (an electrical, lighting, and HVAC servicer) provides four-year programs with a combination of classroom and on-the-job training.[15] Ironworkers Local 404 offers a three-year program that allows students to earn a minimum wage of $18 per hour.[16] Despite these programs, Pennsylvania still lags behind other states: the commonwealth ranks twenty-ninth in the country for per capita apprenticeship opportunities, which suggests a chance for growth among Pennsylvania businesses.[17]

Building Efficiency Certification

FirstEnergy's residential audit program and the commonwealth's weatherization programs both mandate the use of energy auditors with professional certification.[18] Organizations such as AFC First's Green Energy Training Academy offer courses to contractors and auditors in building efficiency construction, energy performance management, thermography, and energy modeling. Program participants can earn a variety of industry-recognized certificates from the Building Performance Institute (BPI) and Residential Energy Services Network, including certifications for home energy survey professionals, building analysts, and home energy raters.[19] The Smart Energy Initiative of Southeastern Pennsylvania also offers training and exam prep for BPI, HVAC, and LEED certifications.[20]

Solar rooftop training
Photo Credit. pennstatenews / Foter / CC BY-NC-ND

Solar Training

Infinite Solar is a private training center that offers programs for individuals interested in working in the solar industry.[24] The center offers courses in both solar photovoltaic and thermal design and installation. Pennsylvania also benefits from the Mid-Atlantic Solar Resource and Training Center housed at Penn State University. The center offers certification courses for solar training instructors and a master's program in renewable energy and sustainability systems. The Solar Education and Resource Center also partners with other organizations, such as the National Roofing Contractors Association, to provide training in roof-integrated solar.[25] These types of programs help job seekers gain the necessary skills to enter and advance in the solar energy job market.

PA CareerLink®

Pennsylvania's Department of Education and Department of Labor and Industry have implemented programs to train and connect workers with potential employers. PA CareerLink® is a program offered throughout the commonwealth (in addition to an online service) that helps job seekers search for job openings, create resumes, and apply for jobs. Currently PA CareerLink® has more than 390,000 applicants registered through its online portal.[21] In addition to providing training, the program also offers individualized services to obtain satisfactory employment and prepare for General Educational Development tests.[22] PA CareerLink® gives priority to local veterans by offering them special services, such as referral services and job development.[23]

Policy Recommendations

To ensure the success of the commonwealth's advanced energy sector, Pennsylvania policymakers must commit to workforce development efforts that target solar and smart building skill gaps. Pennsylvania can build upon existing education, training, and certification programs to capitalize on expansion opportunities in the commonwealth.

Policy 1: Incentivize Businesses to Create More Apprenticeship Opportunities

In order to match Pennsylvanians with jobs in the solar and energy efficiency industries, workers must have the necessary skills. Creating more apprenticeship opportunities and certification programs tailored to the needs of local solar companies can provide workers with the necessary tools to be competitive in the job market. Pennsylvania's leaders could achieve this by leveraging the state's technical college system and WEDnetPA's existing partnerships with private companies and by offering financial incentives for businesses to establish these programs.

Companies need skilled employees to help grow their businesses, and workers require in-class and on-the-job learning opportunities to gain the necessary skills to succeed in their careers. Apprenticeships offer an opportunity for job seekers to gain valuable skills, while also providing employers with a chance to determine if workers will be successful. Despite the strong educational programs currently available in Pennsylvania, the commonwealth had only 12,487 registered apprenticeships in 2015,[26] placing the commonwealth twenty-ninth in the country for per capita apprenticeship opportunities.[27] Building successful and plentiful apprenticeship programs requires a partnership between employers, educational institutions, and the government. Pennsylvania's WEDnetPA program lays the groundwork for such partnerships and, ultimately, successful apprenticeship opportunities.

South Carolina's Apprenticeship Carolina™ system offers a simple model for improving apprenticeship opportunities statewide. The state's successful system offers employers a modest $1,000 state tax credit per apprentice per year.[28] Additionally, the state engages businesses through training consultants who work with employers to guide them through the process of establishing a qualifying apprenticeship program. The program has served over 13,000 apprentices and averages more than 120 new apprentices per month.[29] Registered apprenticeship programs have a significant return on investment: tax returns over the career of an apprentice amount to more than $27 per dollar invested and career earnings are on average $240,037 higher among program graduates compared to similar nonparticipants.[30]

Pennsylvania could provide tax incentives for businesses that hire and train apprentices. Additional incentives could include partial funding for the apprentice's in-class education through the existing WEDnetPA program. The existing partnership between the commonwealth, community colleges, and businesses could be leveraged to promote apprenticeships that yield high-wage jobs.

Installing a residential smart meter
Photo Credit. pgegreenenergy / Foter / CC BY

Policy 2: Develop Certificate and Degree Programs around High Performance Buildings

The lack of knowledge regarding high performance buildings is a major workforce development barrier in the smart building space. To address this knowledge gap, Pennsylvania could look to its universities and technical colleges to provide certificate programs in energy efficiency and high performance building assessment. While various community colleges in the commonwealth already offer relevant degree and certificate programs, Pennsylvania could establish a specialized degree program at several community colleges that specifically focuses on high performance building construction.

Pennsylvania's leaders could work with universities and technical colleges to create more programs focused on high-demand skills such as data analysis, controls, and programming. Developing these programs in the community college system would be especially valuable because, as other states have shown, many of these skills can be acquired within two years. Allowing students to graduate in the shortest time possible should reduce program costs, making these programs affordable and accessible to more Pennsylvanians. With these certificates and programs, graduates would be prepared to enter the efficient building workforce in a variety of good-paying, skilled roles, including installers, operators, code officials, LEED experts, home energy raters, and smart building managers.

Pennsylvania could also establish skill or certification standards in the emerging smart building and solar industries that receive assistance through the Keystone Innovation Zone Tax Credit Program. Incentive dollars could be tied to the employment of workers with appropriate certifications or the provision of apprenticeships that allow workers to gain experience working in the solar and smart building industries.

Policy 3: Provide Pathways for Adults to Return to College

Pennsylvania ranks forty-ninth in the nation for percentage of residents aged 25 to 49 without bachelor's degrees who are pursuing postsecondary education.[33] For the last year of available data, only about 4.5 percent of Pennsylvania residents in this demographic are enrolled in certificate or degree programs, significantly below the national average of 7 percent.[34] Possible reasons for this low enrollment rate include time and cost pressures, distance from colleges, need for remedial courses, and credit transferability.[35] This low rate represents an opportunity

Community College Programs

In other states, community colleges have filled this knowledge gap by offering degrees and certificates tailored to the skills needed to operate a high performance building. For example, Laney College, a community college in Oakland, California, houses the Environmental Control Technology program, which offers three certificate and degree programs for high performance building education.[31] The college is also in the process of establishing a Building Performance and Energy Efficiency degree to expand student learning beyond individual systems within a building, providing a holistic, integrative approach to managing smart buildings. These programs help students acquire skills in system programming, building operations, performance measurement, and sustainable design. Typical courses include Control Systems Networking, Psychrometrics and Load Calculations, and Energy Management and Efficiency in Building Systems.[32]

to reduce barriers for adults in Pennsylvania to pursue higher education while working.

Pennsylvania has already made strides in this area through its "reverse transfer" policy, which enables students to transfer credits from a bachelor's degree program to associate's degree programs in the commonwealth.[36] Pennsylvania could expand this success and establish a statewide program that targets adult workers who have already started a degree and offer them support to return to college to finish their degree.

In Kentucky, Louisville's Degrees at Work program provides a possible model to follow. The nationally recognized program supports adults interested in furthering their education while working. The program emphasizes establishing partnerships between students, the business community, and educational institutions, which lowers barriers for workers to return to school and enables employers to upgrade the skills of their workforces.

> Degrees At Work (DAW) is designed to help ease the process for workers to attend or return to school and complete a degree. The program was launched through Greater Louisville, Inc. (the Chamber of Commerce in the metropolitan Louisville area), the Lumina Foundation, local employers, and educational institutions. The program's goal is to help 15,000 working adults in Louisville achieve a degree by 2020.[37] DAW provides a variety of resources, including tuition assistance, financial aid and scholarships, flexible work schedules, on-site classes, career and educational counseling, and peer mentoring.[38] In addition, DAW offers companies free ed-ucational assessments.[39] These assessments compare the educational attainment of a company's workforce to industry peers, which provide a better understanding of the skill strengths and deficiencies of current employees, and help make the case for investment in training and education opportunities.

DAW incentivizes employers to invest in the education of their employees, which creates a multiplier effect. DAW offers support services to both educators and employers, reduces barriers for adult employees to pursue education, and makes it easier for employers to offer educational opportunities to their workers. While a similar program in Pennsylvania would require significant upfront costs, the potential return on investment could be very high.

Chapter Summary

Pennsylvania has a number of existing workforce development strengths, including PA Careerlink®, WEDnetPA, and its nationally renowned universities. Furthermore, many training programs in the commonwealth currently offer certifications and training programs for workers in the advanced building and solar energy industries. Pennsylvania has the opportunity to build on these existing strengths and improve its workforce development in three areas: incentivizing employers to offer more apprenticeships, establishing certificate and degree programs in building efficiency, and making it easier for adults to pursue postsecondary education and training. Implementing these recommendations could attract good-paying jobs, furnish the workforce with highly trained individuals, and prepare Pennsylvania for the advanced energy economy.

Conclusion

In order to build on Pennsylvania's success in the advanced energy space and position the state for continued growth, policymakers will need to make advanced energy a priority. The purpose of *The Pennsylvania Jobs Project: A Guide to Creating Advanced Energy Jobs* is to analyze the state's advanced energy economy in order to create recommendations specifically tailored to the state's needs. The policies recommended in this report are complementary and intended to help the state grow demand for advanced energy technologies, manufacture products within the state, enable entrepreneurship for technological advances, fund innovation with accessible capital, and equip workers with the skills required for the state's future economy.

Policy leadership in the advanced energy space can play an important role in promoting Pennsylvania's advanced energy clusters and creating quality jobs for Pennsylvanians. Advanced energy clusters focused on smart building and solar offer a great opportunity for the state to grow its economy, create jobs for the state's residents, and become a leader in the production and deployment of advanced energy technology.

If Pennsylvania's policymakers take swift and purposeful action to grow the smart building and solar clusters, these industries can support up to 11,600 jobs per year through 2030.

Pennsylvania has the right mix of strengths to leverage this opportunity. With smart, forward-thinking policies, the state can diversify its economy and create thousands of middle-class jobs for hard-working Pennsylvanians.

For more information about advanced energy technologies and best practice policies, visit http://americanjobsproject.us/.

Appendix

Jobs Modeling Methodology

Economic Impact Methodology

The American Jobs Project combines existing tools, analyses, and projections from several reputable sources to estimate job creation. Rather than providing a specific estimate, we show jobs potential across a range of possible outcomes. All jobs are shown in job-years that exist during the analysis timeline (2016–2030).

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.

The solar jobs analysis used the Job and Economic Development Impacts (JEDI) model and evaluated growth estimates across different levels of local share spending for scenarios from the National Renewable Energy Laboratory's Renewable Electricity Futures, the Department of Energy Office of Energy Efficiency and Renewable Energy's Wind Vision, and Bloomberg New Energy Finance. Smart building and energy efficiency jobs utilized the JEE-1 Model from the U.C. Berkeley Don Vial Labor Center and evaluated energy efficiency compliance scenarios from the Energy Information Administration's Annual Energy Outlook 2015 Clean Power Plan analysis.

Tools for Economic Impact Analysis

A number of modeling tools are available for estimating economic impacts from advanced energy industry growth. This report employs two of the most common tools available: Jobs and Economic Development Impact (JEDI) and Impact Analysis for Planning (IMPLAN). Results from the JEDI model only show job gains and do not evaluate losses in other industries. They are based on approximations of industrial input-output relationships, and do not include intangible effects.[1] The JEDI model is widely used because it estimates the economic impacts of construction and other project elements at the local (usually state) levels.[2] IMPLAN estimates the economic impact of each dollar invested into a sector and the resulting ripple, or multiplier, effects across the econ-

omy.[3] Multipliers are used to generate the economic impacts of the project across three different categories of jobs: direct, indirect, and induced.[4] Not all advanced energy technologies can be modeled with JEDI. For smart building and energy efficiency jobs, we utilized the Jobs from Energy Efficiency (JEE-1) model.

It is important to note the limitations of these modeling methods. As mentioned, the estimates shown are only gross job-year creation. Job losses in industries that compete with those in our analysis are not evaluated. Models do not dictate behavior, so indirect and induced jobs 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.

Solar

JEDI was used to estimate jobs potential for the solar industry in Pennsylvania. We show the jobs potential from several scenarios based on different percentages of local share, i.e., how much of the total industry supply chain and service expenditures could happen in the state to serve local and national demand. In the report, we show a range of 25 percent, 50 percent, and 75 percent of local share (0 percent would represent an unlikely situation where no products or services are purchased in the state and 100 percent would represent an equally unlikely scenario in which all products and services are provided by a perfect in-state supply chain). The true potential likely lies somewhere in between, but is dependent on the options and incentives for purchasing local goods and hiring local firms to provide services. In cases where there were only regional estimates, we assume that Pennsylvania would maintain its current weighted average of solar capacity in the region over time. Where detailed information was not available for rooftop solar, estimates are based on "Tracking the Sun" weighted average distribution for residential, small commercial and large commercial buildings.[5] This was also used for average capital costs per megawatt-hour for analyses in JEDI. Job-years included in this analysis represent all job-years that exist during the timeframe of 2016–2030. Data used in the JEDI analysis were collected from the following three sources.

DOE Office of Energy Efficiency and Renewable Energy: Wind Vision

The Wind Vision Study Scenario includes projections for utility-scale solar PV and rooftop solar PV deployment.[6] The input parameters are similar to those found in the DOE's 2012 SunShot Vision Study, a comprehensive review of U.S. solar electricity generation potential that was managed by NREL.[7,8] The Wind Vision projections are based on updated assumptions about the phasing out of the solar investment tax credit.[9] Wind Vision's cost assumptions are based on SunShot Vision Study's 62.5 percent solar cost reduction scenario, where the 62.5 percent reduction is reached in 2020 and a 75 percent reduction is reached in 2040.[10] Wind Vision's authors compared those cost estimates to a sample of leading costs projections and found them to be consistent with the average estimates in the literature.[11]

National Renewable Energy Laboratory: Renewable Electricity Futures

The National Renewable Energy Laboratory's Renewable Electricity Futures study examines the extent to which renewable energy supply can meet U.S. electricity demands over the next several decades.[12]

> The study explores electricity grid integration using models with unprecedented geographic and time resolution for the contiguous United States to assess whether the U.S. power system can supply electricity to meet customer demand on an hourly basis with high levels of renewable electricity, including variable wind and solar generation.[13]

The study explores very high renewable electricity generation levels between 30 percent and 90 percent of all U.S. generation in 2050, with a particular focus on 80 percent.[14] The Incremental Technology Improvement scenario was used for our projections.

Bloomberg New Energy Finance

Data from the "Medium-term outlook for US power: 2015 = deepest de-carbonization ever" report were provided by BNEF.[15] The projections build off an empirical process of research, based on market projections, data from the Energy Information Administration, and interviews with industry stakeholders. These projections are updated and published annually, though the back-end data is private and cannot be shared except by permission. BNEF graciously provided the data to us on the condition that we would

not publish it and only use it for our economic impact analyses. This in no way implies an endorsement of our project or our projections by BNEF.

Smart Building and Energy Efficiency

The U.C. Berkeley Don Vial Center on Employment in the Green Economy developed the Jobs from Energy Efficiency (JEE-1) model to quickly estimate direct job outcomes of different policy scenarios related to smart building and energy efficiency efforts. While the JEDI model and other tools are commonly used to estimate the job benefits of renewable energy projects and policies, the absence of a similar tool for employment related to energy efficiency makes it difficult for policymakers and advocates to quantify the economic development benefits of energy efficiency policies and investments without sophisticated and time-intensive analysis. The JEE-1 model is a simple, quick, and relatively easy to use tool that can estimate gross direct job creation of alternative scenarios.

The model is based on job-years per gigawatt-hour multipliers calculated for different energy efficiency program types across four primary sectors: residential, commercial, MUSH, and industrial/agricultural.

The JEE-1 model is based on the best available literature on (1) total cost of saved energy, (2) effective useful life estimates of energy efficient products, and (3) jobs per million dollar investment in energy efficiency.

Indirect and induced jobs are estimated using a simple range of multipliers common to energy efficiency job estimates: 2.0, 2.5, and 3.0.

Energy Information Administration: Annual Energy Outlook 2015 Clean Power Plan Analysis

This report considers the proposed Clean Power Plan as modeled using EIA's National Energy Modeling System (NEMS). NEMS is a modular economic modeling system used by EIA to develop long-term projections of the U.S. energy sector, currently through the year 2040.[16]

The level of regional disaggregation in NEMS varies across sectors. For example, Lower 48 states electricity markets are represented using twenty-two regions, coal production is represented by fourteen regions, and oil and natural gas

production is represented in nine regions. In many but not all cases, regional boundaries follow state borders. To the extent possible, this analysis represents the Clean Power Plan using regional targets derived from the state-level targets in the Environmental Protection Agency's proposal.

The Reference case projections developed in NEMS and published in the Annual Energy Outlook 2015 generally reflect federal laws and regulations and state renewable portfolio standards in effect at the time of the projection. The Reference case does not assume the extension of laws with sunset provisions. In keeping with the requirement that EIA remain policy-neutral, the Reference case does not include proposed regulations such as the Clean Power Plan.

By explicitly modeling the intensity targets, NEMS does not require or assume specific levels for individual compliance strategies. The discussion of EIA's analysis presents results in terms of the compliance options used to meet the regionalized Clean Power Plan targets.[17]

The scenarios used for the smart building and energy efficiency analysis were Base Policy, No Energy Efficiency Compliance, and High Energy Efficiency Compliance. These projections represent the range of expected reductions in energy consumption due to smart building and energy efficiency. This was measured as the net annual difference between the Base Case (business as usual) scenario's total energy consumption and the three Clean Power Plan scenarios for residential, commercial, and industrial sectors.

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