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American Energy & Manufacturing Competitiveness Partnership

Rebuilding the Industrial Commons

A Primer for the AEMC Partnership Inaugural Dialogue

THE COUNCIL ON COMPETITIVENESS has developed this report with the support of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, in fulfillment of Contract #DE-EE0006099.000.

Printed in the United States of America

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Washington, D.C.
April 11-12, 2013

Over the next two days, the Council on Competitiveness and the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy (EERE) will host the first in a series of dialogues as part of the American Energy and Manufacturing Competitiveness (AEMC) Partnership; a three-year effort to bring together national leaders to address a rapidly shifting national and global energy landscape.

"By bringing together top minds and leaders to discuss this important topic, we will not only generate new insight into our energy and manufacturing challenges, but we will devise real solutions to prioritize and solve these challenges," said the Honorable Deborah L. Wince-Smith, President & CEO of the Council on Competitiveness. "I am confident the AEMC Partnership will put the United States on a track to improve dramatically its economy, the prospects for U.S. job growth, the environment, national security and our standard of living."

Over the coming year, the Council and EERE will work together across the country in the AEMC Partnership to define key barriers, challenges and problems in the manufacturing of clean energy and energy efficient products, as well as to generate potential models for scalable, public-private partnerships to increase the competitive manufacturing of clean energy and energy efficient products in the United States.

The AEMC Partnership will convene three additional regional dialogues in 2013, culminating in a major, annual, Washington, D.C.-based, cornerstone energy and manufacturing summit in December of 2013.

Rebuilding the Industrial Commons
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Introduction

Despite a mid-2012 growth slump, the U.S. manufacturing sector has been steadily growing for almost three years,[1] often being referred to by analysts as an economic "bright spot."[2] Pundits have also lauded the growing number of American companies moving their manufacturing operations back to the United States (i.e. re-shoring).[3] Although there are less than 100 firms known to have brought production back to the United States, there are likely many more companies making this shift.[4] While individual firms will have unique reasons for adding domestic production jobs or re-shoring parts of their supply chain, some common factors have been identified as driving this shift:

- Labor costs in the developing world—namely China—have been rising relative to the more developed world.[5]
- Real wages in American manufacturing have declined by 2.2 percent since 2005—largely driven by the financial crisis.[6]
- The recently commercialized extraction of shale gas has lowered U.S. energy costs relative to the rest of world—breathing new life into struggling industries such as steel production.[7]
- The dollar has been weakening relative to the Chinese renminbi.[8]
- Combined, these factors make investment in U.S. manufacturing more attractive for both domestic and foreign firms.

1 Bureau of Labor Statistics, "Data, Tables, & Calculators by Subject—Manufacturing," Accessed March 27 2013.

2 Norris, Floyd, "Manufacturing Is Surprising Bright Spot in U.S. Economy," *The New York Times*. 5 January 2012.

3 *The Economist*, "Reshoring Manufacturing: Coming Home," 19 January 2013.

4 Ibid.

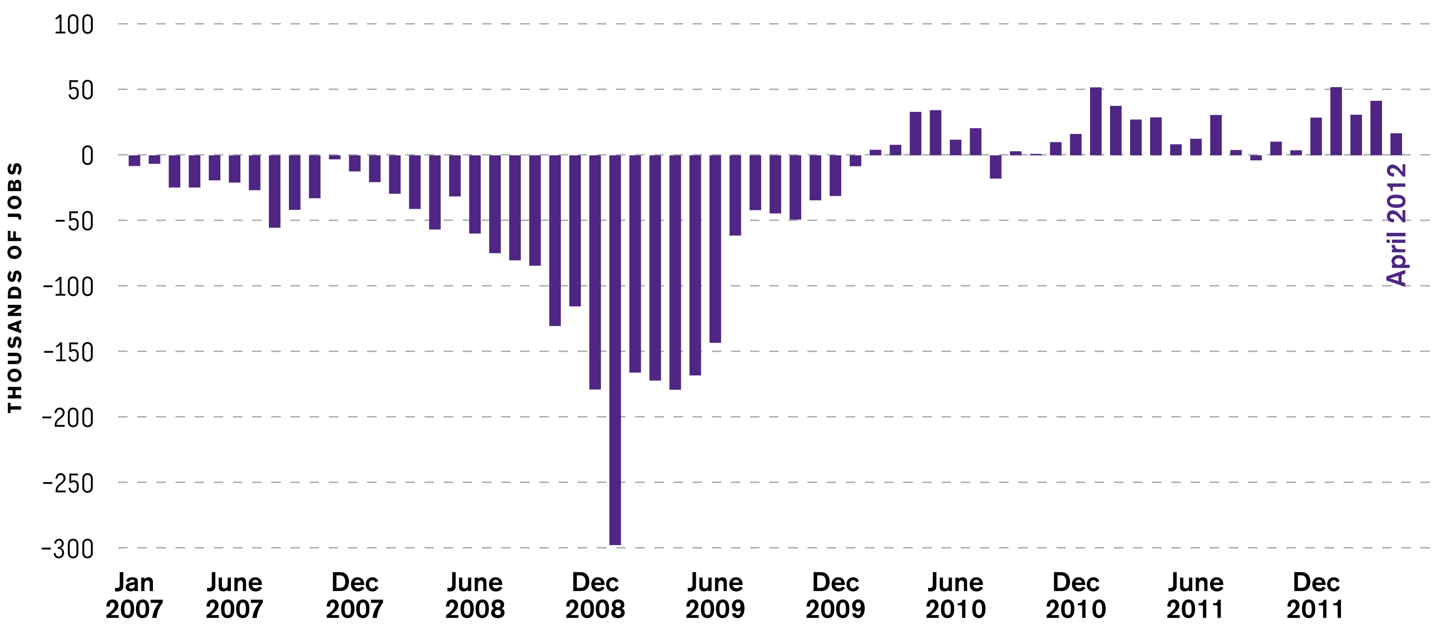
5 Ibid.

6 Ibid.

7 Brady, Jeff, "Gas Drilling Boom Brings New Life to Steel Industry," *National Public Radio*, 13 October 2011.

8 The Boston Consulting Group, *Made in America, Again*, August 2011.

Figure 1. Monthly Change in U.S. Manufacturing Jobs, January 2007–April 2012
Source: Bureau of Labor Statistics



After a decade of decline, this boost in manufacturing is a welcome development. However, competitive advantage gained largely through the comparatively low cost of production inputs is highly susceptible to world economic cycles, exchange rates and shifting factor advantages. In short, the current uptick in U.S. manufacturing is fragile. It is challenging for high-wage nations, such as the United States, to compete based on low price and high volume—i.e. commodities. The long-term competitiveness of the United States depends on its innovation ecosystem—that is, its ability to generate new technologies and translate them into new products, revitalize existing markets and create entirely new ones. It is important to ensure that recent, short-term trends do not distract from the investment needed in the U.S. innovation infrastructure to propel U.S. manufacturing into a new era of excellence that offers hope for good jobs, new innovations and a higher standard of living—in essence, America's competitiveness.

SECTION I

Clean Energy Manufacturing: the Time is Now

A vital path to revitalizing U.S. manufacturing is through harnessing the growth opportunities presented by the wide-reaching benefits of energy-efficient manufacturing and capturing competitive advantage in clean energy technology production by leveraging America's world-class science, technology and innovation capabilities.

The United States has come upon a distinct moment in the history of the energy landscape. Market and political forces—driven by industry and public support—are converging to create the national will to invest in, develop, manufacture and deploy clean energy technologies. At the same time, low-cost domestic resources and enhanced energy productivity are creating new and important opportunities for manufacturers operating in the United States to reduce their costs and grow their competitiveness. The nation must capitalize on this opportunity. As such, the inaugural dialogue of the American Energy and Manufacturing Competitiveness (AEMC) Partnership comes at a time advantageous to all interested stakeholders.

The global renewable energy (RE) sector has been on a decade-long rally, attracting $263 billion worth of investment in 2011 alone—a 600 percent increase over 2004 investment levels.[9] Driven by concerns about environmental, economic and national security—nations are expected to continue prioritizing investments in clean energy technologies. Global energy demand is projected to increase 44 percent by 2030 from 2006 values, including a 73 percent increase in energy demand from the non-OECD countries (Figure 2). Half of the new electricity generating capacity installed to meet this demand during the next 25 years, according to the International Energy Agency (IEA), will come from clean energy.[10] This will contribute, According to *Bloomberg New Energy Finance* estimates, to a global RE market expansion of up to $460 billion by 2030.[11]

The global renewable energy market is expected to grow from $263 billion of investment in 2011 to $460 billion by 2030.

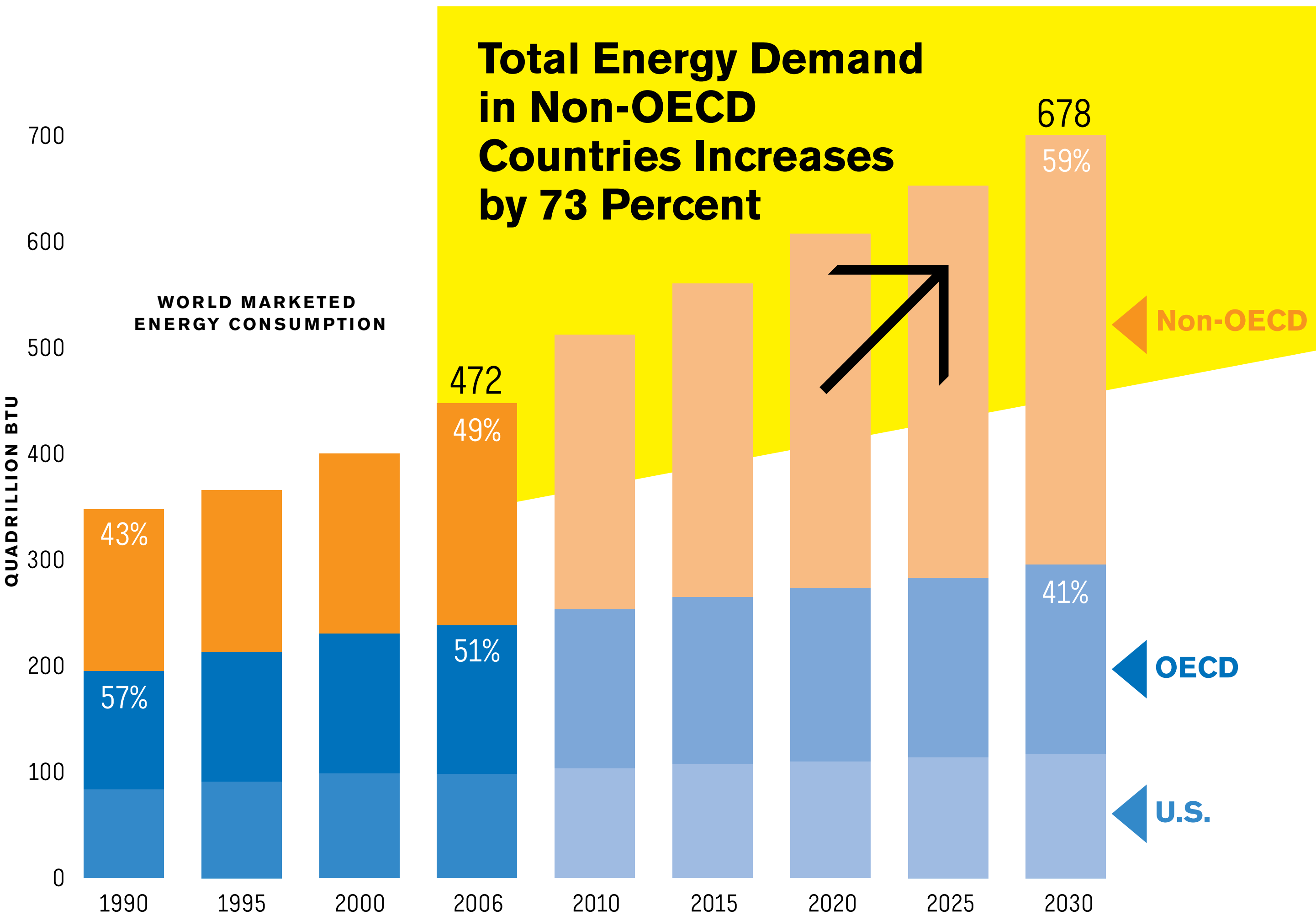
To be clear, this expansion is not limited to one nation, region or stage of development. Rapid adoption of clean energy technologies is occurring in the mature economies of the West, as well as the emerging economies of Asia and Latin America (Figure 3). Businesses, governments and communities are also embracing energy efficiency (EE), strengthening existing industrial technology markets, and creating new opportunities for businesses developing technologies and processes that reduce energy requirements. With demand for RE and EE technologies increasing in regions all over the world, the United States must gain a competitive foothold in the growing clean energy sector.

9 The Pew Charitable Trusts, *Who's Winning the Clean Energy Race?—2011 Edition*, 2012.

10 International Energy Agency, *World Energy Outlook 2011*, November 2011.

11 Bloomberg New Energy Finance, "Global Renewable Energy Market Outlook," November 2011.

Figure 2. Global Energy Demand Projected to Increase 44 Percent by 2030
Source: Energy Information Administration



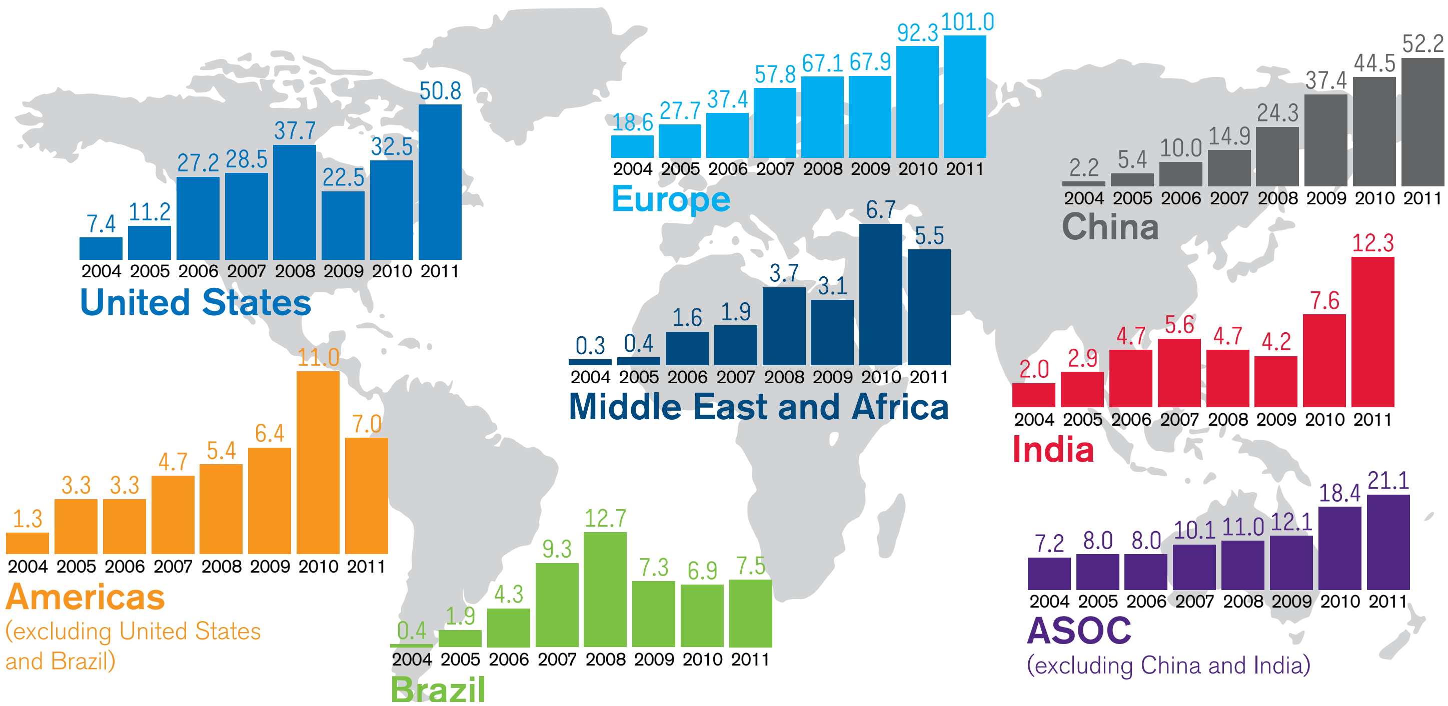
The Obama Administration has expressed its commitment to the related goals of a clean energy future and revitalized manufacturing sector for America. During his 2013 inaugural address, President Barack Obama exclaimed, "It's time to… double down on a clean energy industry that has never been more promising." Research shows that investment in clean energy helps create jobs, reduces harmful CO_2 emissions, and strengthens national security by decreasing U.S. dependence on foreign sources of oil. In the last 15 years, the amount of energy produced by wind and solar in the United States has more than doubled—with thousands of new well-paying jobs to show for it.[12] The Pew Charitable Trust estimates that 100,000 Americans were employed in the solar industry, and 75,000 in the wind industry, in 2011.[13] Moreover, emissions of CO_2 have been falling since 2005 due in part to EE improvements by vehicles, commercial buildings and utilities.[14] A Citigroup reports states that demand for oil is dropping due in part to gains in increases in EE.

12 U.S. Energy Information Administration, "Electric Power Monthly—January 2013," Accessed 28 March 2013.

13 The Pew Charitable Trusts, *Innovate, Manufacture, Compete*, 2012.

14 Bloomberg New Energy Finance, "Sustainable Energy Factbook Release," 31 January 2013.

Figure 3. Global New Investment in Renewable Energy by Region, 2004-2011 ($Billion)
Source: *Bloomberg New Energy Finance*



When combined with the increased production of domestic oil and gas, the report goes on say, energy productivity gains could help to ensure U.S. energy independence by the end of this decade.[15]

Though significant progress has been made toward cleaner and more secure energy sources, there is more work to be done. President Obama released the "Blueprint for a Clean and Secure Energy Future" in March of 2013. Included in this all-of-the-above energy strategy are investments in the development of RE and EE technologies, as well as the basic science that underpins this work. Moreover, the blueprint promotes policy measures that help build demand for these new or improved technologies into the market.

The United States needs to capture the value of current and future investments in clean energy by producing these technologies at home. In the words of Deborah L. Wince-Smith, President & CEO of the Council on Competitiveness (the Council), "America's future productivity, prosperity, and security are functions of the success of our nation's manufacturing enterprise—and, more specifically, a manufacturing enterprise enabled by and generating clean energy and energy efficient technologies."

Fortunately, the nation's policymakers have not overlooked the centrality of manufacturing to U.S. prosperity. The 2010 reauthorization of the America COMPETES Act contains numerous advanced manufacturing provisions. The Act calls for the identification of barriers to U.S. manufacturing and encourages the development of public-private partnerships to address these barriers, ultimately

15 Clark, Aaron, "U.S. May Achieve Energy Independence This Decade, Citigroup Says," *Bloomberg.com*, 15 February 2013.

enhancing U.S. manufacturing competitiveness. Building off these foundational provisions, President Obama successfully launched the creation of the National Additive Manufacturing Innovation Institute (NAMII)—the pilot facility for the National Network of Manufacturing Innovation (NNMI)—last year in Youngstown, Ohio. As the president explained, this institute "has the potential to revolutionize the way we make almost everything."

Furthermore, the president announced during his latest State of the Union address that he will take executive action in 2013 to co-create with the private sector and federal agencies (led by the departments of Energy and Defense) three additional institutes with an initial focus on manufacturing technologies that address critical needs.

The Obama Administration has also recognized the tremendous potential of industrial EE to improve the competitiveness of U.S. manufacturing by lowering energy costs and freeing up future capital for businesses to invest. In 2012, President Obama signed an executive order that—among other provisions—established a goal to have 40 gigawatts of new combined heat and power capacity installed by 2020, which has the potential to "save energy users $10 billion per year (and) result in $40 to $80 billion in new capital investment in manufacturing and other facilities that would create American jobs…" In his 2013 State of the Union Address, President Obama continued to promote the benefits of increased energy productivity by proposing the doubling the EE of the entire U.S. economy by 2030.

The focus on energy productivity and clean energy manufacturing is driven not only by the Obama Administration and Washington, D.C., community, but also by business leaders, the general public, and a range of think tanks and academic research institutions. In February of 2013, the Harvard Business School (HBS) published a survey focused on the state of U.S. competitiveness, including nearly 7,000 HBS alumni from 50 states and 115 other countries, as well as the views of more than 1,000 members of the general public. When asked about a set of policies that would improve U.S. competitiveness, a strong majority of business leaders and the general public supported the federal government prioritizing support "for clean energy manufacturers in the U.S. to invest and develop new technologies."[16]

In preparation for this dialogue, the Council documented 184 distinct public policy recommendations supporting EE and RE technologies, and manufacturing, made during the last four years by a range of non-profits, think tanks, research institutions and governmental agencies.[17]

These converging business, public and political interests have created a golden opportunity for the United States to move into a remarkable new era of industrial transformation, sustainability, innovation and market opportunity, while improving competitiveness and boosting American prosperity. The nation's innovation institutions—businesses, universities and national laboratories—must come together to optimize the U.S. energy portfolio and manufacturing capacity for long-term growth in productivity and prosperity. This is the context in which the Council and the U.S. Department of Energy (the Department) Office of Energy Efficiency and Renewable Energy (EERE) have come together to create the AEMC Partnership.

16 Harvard Business School, *Competitiveness at a Crossroads*, February 2013.

17 The Council on Competitiveness, *The Power of Partnerships*, April 2013.

SECTION II

American Energy & Manufacturing Competitiveness (AECM) Partnership

The AEMC Partnership is a 3-year effort by the Council and the EERE to bring together national leaders to address a rapidly shifting national and global energy landscape. In discussions, participants will uncover actions that can be taken during this distinctive time to enable America to bolster dramatically its energy, manufacturing and economic competitiveness during the next 20, 30, 40 years and beyond. This is a new partnership formed under the EERE's Clean Energy Manufacturing Initiative, a strategic integration and commitment of manufacturing efforts focusing on American competitiveness in clean energy manufacturing.

The AEMC Partnership is broadly divided into two phases, the first of which has been completed in preparation for this dialogue (See Section IV, "AEMC Partnership Phase 1: Mapping the Landscape"). The AEMC Partnership Inaugural Dialogue signifies the beginning of the 2013 portion of phase two, which will include a series of three successive dialogues to generate new insights pertaining to the overall goals of the Partnership—as well as present at least one concept for a public-private pilot project to advance further the initiative's goals. This year will culminate in an Inaugural American Energy and Manufacturing Summit in December 2013 in Washington, D.C. Future dialogues will continue this conversation during the next two years.

The focus of the Partnership will be to identify means to:

- Increase U.S. competitiveness in the production of clean energy products.
  - Strategically invest in technologies that leverage American competitive advantages and overcome competitive disadvantages.
- Increase U.S. manufacturing competitiveness across the board by increasing energy productivity.
  - Strategically invest in technologies and practices to enable U.S. manufacturers to increase their competitiveness through EE, combined heat and power, and taking advantage of low-cost domestic energy sources.

The goals of the Partnership are to:

- State and define key barriers, challenges and problems in U.S. competitiveness in manufacturing of clean energy products, EE products and advanced manufacturing products.
- Dive deeply into these problems and generate possible policies, solutions and models where the U.S. public and private sectors can work together to prioritize and solve these problems.
- Catalyze policy solutions–presenting several models for scalable, public-private partnership pilot projects–to increase competitive manufacturing of RE and EE products in the United States.
- Generate a proposal of at least one public-private partnership model that could be carried out by EERE and/or the Council to increase the competitive production of clean energy products, EE products and advanced manufacturing products in the United States.
- Understand, elevate and increase awareness of the importance and benefits of competitive clean energy manufacturing in the United States, and explore other important energy and manufacturing issues impacting U.S. competitiveness.
- Understand how energy game-changers, like breakthrough technologies, impact U.S. clean energy and EE manufacturing.

SECTION III

Industrial Commons and PPPs

The AEMC Partnership seeks to boost U.S. competitiveness in clean energy product manufacturing and U.S. manufacturing competitiveness through enhanced energy productivity. Public-private partnerships (PPPs) and their capabilities and benefits are a valuable mechanism to explore.

What the recent uptick in manufacturing output obscures is what Gary P. Pisano and Willy C. Shih of the Harvard Business Review have called "the erosion of the industrial commons." Industrial commons, according to Pisano and Shih, are geographically rooted "collective R&D, engineering and manufacturing capabilities that sustain innovation."[18] This concept is at the center of the "clusters of competitiveness and innovation" work by the Council and Professor Michael Porter of the Harvard Business School.[19] Moreover, it is a key theme—under the names of innovation infrastructure or shared infrastructure—in recent writings on U.S. leadership in advanced manufacturing by the President's Council of Advisors on Science and Technology (PCAST) and the National Science and Technology Council (NSTC).[20] [21] A rich industrial commons—or innovation infrastructure—is essential if the United States intends to overcome competitive disadvantages in the technologies of clean production and to increase industrial EE.

Industrial commons are widely studied because of their ability to create a powerful, virtuous circle that feeds the growth of the vital innovation inputs, reduces the benefits of offshoring, and—most important—boosts regional productivity and prosperity. For example, biological scientists and engineers flock to the biotechnology cluster in the greater Boston area to tap regional knowledge networks and increase their chances of employment. Biotechnology firms are attracted to those same knowledge networks, as well as partnership opportunities with complementary firms and access to top talent in the field.[22] A robust supply chain also will emerge to meet the equipment and service needs of both firms and researchers.

These centers of innovation—labor markets, businesses and universities—are more effective when they work together. This is due to the knowledge spillover effect—the inability for a firm to keep know-how completely private, which is common in knowledge-intensive sectors of the economy.[23] When located in a network, intellectual, financial and human capital flow between institutions at every phase of technology development, boosting the innovative capacity of all institutions involved. Moreover, recent research has revealed that for particular high-technology sectors—such as advanced materials fabrication, superminiaturized assembly and specialty

18 Pisano, Gary P. and Willy C. Shih, "Restoring American Competitiveness," *Harvard Business Review*, July-August 2009.

19 The Council on Competitiveness, Michael E. Porter, Monitor Group, ontheFrontier, *Clusters of Innovation Initiative: Regional Foundations of U.S. Competitiveness*, October 2012.

20 President's Council of Advisors on Science and Technology, *Report to the President on Ensuring American Leadership in Advanced Manufacturing*, June 2011.

21 National Science and Technology Council, *A National Strategic Plan for Advanced Manufacturing*, February 2012.

22 Boston Consulting Group, *Made in America, Again*, August 2011.

23 Audretch, David B. and Maryann P. Feldman, "Knowledge Spillovers and the Geography of Innovation," *Handbook of Regional and Urban Economics*, Edition 1, Volume 4, Number 4, 2004.

chemicals (all important to clean energy technologies)—the presence of manufacturing in this regional network is a necessary innovation input.[24] All the benefits of this ecosystem produce social returns that are not available outside the ecosystem. Losing these social returns may outweigh the cost benefits of offshoring production, R&D, or both. This is exactly the type of dynamic that can help ensure the clean energy and EE products invented in the United States are produced here.

Industrial commons also can spur completely new industries. A historical example of this is when the U.S. military decided to establish armories—arguably the most successful public-private partnership in history—and have them produce weapons with interchangeable parts. This resulted in the development of the American system of manufacturing and the development of an industrial commons that provided the foundations for the manufacture of sewing machines, textile machinery, furniture, locks, clocks, bicycles, locomotives, machine tools and eventually automobiles.[25]

A more recent and relevant example is the success of solar panel manufacturing in China, Japan, Taiwan and Korea. Capabilities developed in the manufacturing of consumer electronics—flat panel displays—and semiconductors in the 1980s and 1990s allowed these countries to transition easily into solar panel manufacturing, which are based on the same foundational technologies and processes.[26] These regional capabilities in Asia explain—at least in part—the disadvantages the United States faces when competing in the clean energy economy.

The lesson is that future—seemingly unrelated—advances in clean energy science, technology and manufacturing are deeply connected to industrial commons. For example, the Department is focusing

Critical Materials Hub

A sustained, multidisciplinary effort to develop solutions across the lifecycle as well as reduce the impact of supply chain disruptions and price fluctuations of materials critical to technologies that enable wind turbines, solar panels, electric vehicles, and energy efficient–materials that could affect clean energy technology deployment in the coming years.

This hub plans to focus on:

- Diversifying supply;
- Developing substitutes;
- Improving reuse and recycling; and
- Conducting crosscutting research.

24 Pisano, Gary P. and Willy C. Shih, "Producing Prosperity," *Harvard Business Press*, 2012.

25 Hounshell, David A., "From the American System to Mass Production," The Johns Hopkins University Press, 1984.

26 Pisano, Gary P. and Willy C. Shih, "Restoring American Competitiveness," *Harvard Business Review*, July-August 2009.

on the advancement of high performance, lightweight materials to advance its EE mission. The ability to manufacture these products at scale, however, is dependent on tapping into the advanced materials industrial commons that are embodied in diverse industries such as aerospace, automotive, medical device, and consumer products.[27] Unfortunately, U.S. presence in these sectors has been fragmented by the decline of American manufacturing and the corresponding erosion of the industrial commons.

As the creation of industrial commons is both a public and private effort, so is their decline. Government commitment to R&D overall began to wane after the turn of the century and has been focused toward basic research more than applied research, as well as shrinking relative investments in the physical sciences.[28] Businesses have also been neglecting industrial commons. There has been a flight of hard assets to foreign competitors driven by a "buy verses build" paradigm enabled by the rise of a highly competitive world that offers more than just cheap labor. Data from Compustat shows that in the 2000s, U.S. companies began shifting investments from R&D and capital expenditures to stock dividends and buybacks, thus reducing their investment in manufacturing assets in the United States and abroad.[29] The decline of American industrial commons was certainty enabled by a challenging global landscape, but it was by no means inevitable. Decisions by both the private and public sector contributed to a lack of in investment in the foundational resources needed for a relevant, flourishing and innovative advanced manufacturing sector.

Fortunately, the private sector has a long history of partnering with the public sector to build—and rebuild—innovation infrastructure. The second industrial revolution was spurred by public investments in national railroad and communication systems. This allowed the private sector to leverage economies of scale, which enticed private firms to make large-scale investments in production, distribution and eventually R&D. The funding of the national highway system during the Eisenhower Administration had a similar effect. This interplay of public and private co-investment began the growth of industrial commons that firmly took hold after World War II, when the federal government took responsibility for supporting basic scientific research. Another oft-cited example is that of SEMATECH—an unprecedented industry/government partnership that is credited by some as sustaining U.S. leadership in the semiconductor industry after the rise of competition from Japan and Europe in the 1980s. These examples—among others—have led academics, business leaders and non-government organizations to see the creation of new public-private partnerships as a key component in boosting the competitiveness of U.S. manufacturing of clean energy and EE products.[30]

Though businesses, universities and communities will ultimately be responsible for rich, clean energy manufacturing industrial commons, public-private partnerships are distinctly capable of promoting the factors that encourage their development. As previously explained, innovation infrastructure is deeply connected to the regional clustering of firms, talent and research institutions. Research on agglomeration effects and empirical evidence reveal that there are three broad factors that entice clustering: labor market pooling, common infrastructure and knowledge spillovers.[31] Some of the most productive and innovative technology clusters—such as Silicon Valley, Route 128 and Research Triangle— have developed organically, though largely through the investments of both the public and private sectors. Nonetheless, deliberate actions can be taken to promote the factors that incentivize clustering, and public-private partnerships are uniquely capable of these actions.

27 Pisano, Gary P. and Willy C. Shih, "Restoring American Competitiveness," *Harvard Business Review*, July-August 2009.

28 The National Science Foundation, *Science and Engineering Indicators 2012*, "Chapter 4. R&D: National Trends and International Comparisons," Accessed 28 March 2013.

29 Pisano, Gary P. and Willy C. Shih, "Producing Prosperity," *Harvard Business Press*, 2012.

30 The Council on Competitiveness, *The Power of Partnerships*, April 2013.

31 Marshall, Alfred, *Principles of Economics*, MacMillan, 1980.

Examples of three factors and the actions taken by three PPPs to address them.

Developing Skilled Labor	Shared Infrastructure	Knowledge Spillover
The National Additive Manufacturing Innovation Institute (NAMII) is committed to developing the labor force necessary for an additive manufacturing ecosystem to prosper in the United States. This is achieved by including community colleges and workforce development organizations as partnership members, and by ensuring workforce training and educational outreach are part of the projects NAMII selects and funds. A regional workforce with the unique skills in advanced additive manufacturing draws enterprises hoping to tap this labor pool.	The Manufacturing Demonstration Facility (MDF) at Oak Ridge National Laboratory (ORNL) provides industry access to physical and virtual tools, as well as R&D expertise for the design, evaluation and rapid prototyping of new technologies and optimizing essential manufacturing processes. This common innovation infrastructure may factor into a firm's calculus for siting a production facility—just as firms calculate siting decisions based on the availability of traditional public infrastructure like airports and seaports.	The most common form of knowledge spillover occurs with the movement of workers between complementary firms. The Industrial Technology Research Institute's (ITRI) built-in quota for annual employee turnover promotes diffusion of public and private co-development knowledge into the external market, in addition to helping ensure innovation does not stagnate within the Institute.

The benefits of PPPs go well beyond the elemental contributions they make to industrial commons. PPPs strengthen the ideas-to-market chain (the perennial challenge of science and technology policy) and increase the return on R&D spending by linking knowledge creation, sources of capital and enterprises that can deploy new technologies.[32] Additionally, PPPs that include both small and medium-sized enterprises (SMEs) and large corporations as members increase the chances of success for innovative SMEs, revitalize the corporations and strengthen local supply chains—all of which generates new jobs.[33] Large companies also find advantage in providing SMEs with capital equipment—such as high performance computing. This strengthens the full supply chain, improves the competitiveness of all stakeholders, further strengthens local ties and creates disincentives to offshoring.

Partnering employers with educational institutions—namely community colleges—is tremendously valuable for working Americans, as labor market needs are not easily communicated between employers and employees. Public-private partnerships form a mechanism to convey rapidly the workforce needs of manufacturing firms to the local labor pool and can help develop the necessary training programs. This is pivotal tool in addressing the well-known skills gaps that many U.S. manufacturers face.[34]

Industrial commons are critical to the nation's innovative capacity, which is essential to sustaining competitive advantage in a world where advantages are constantly shifting. Unfortunately, both the private and public sectors have neglected this innovation infrastructure. Nonetheless, public-private partnerships are particularly capable of rebuilding the industrial commons. The AEMC Partnership is a forum for national leaders from businesses, universities, labor and national laboratories to inform and develop a public-private partnership with the potential to increase U.S. competitiveness in the production of clean energy products and increase U.S. manufacturing competitiveness across the board by increasing energy productivity.

32 Kanter, Rosabeth Moss, "Enrich the Ecosystem", *Harvard Business Review*, March 2012.

33 Ibid.

34 American Society for Training & Development, *Bridging the Skills Gap*, October 2012.

SECTION IV

AEMC Partnership Phase 1: Mapping the Landscape

To inform the AEMC Partnership Inaugural Dialogue, help cultivate topics for the subsequent progressive dialogues, and provide a foundation the larger goals of the AEMC Partnership, the Council performed an extensive literature review and "mapping" of 184 past and current research efforts across the United States and internationally to:

- Understand the scope of research to date on the links between EE efforts, RE and manufacturing competitiveness; barriers to manufacturing competitiveness as they relate to energy; and models for PPPs for fostering competitive industries.
- Identify links, barriers and public-private partnership models that have not been studied or on which studies are out of date.

The purpose of this literature review is to provide a resource for the AEMC Partnership dialogue series for establishing effective PPP models to advance competitive manufacturing of clean energy products in the United States, and to advance the competitiveness of manufacturing in the United States across the board through enhanced industrial energy productivity. The findings in this report will be discussed, and expanded on in dialogues to design critical PPPs for advancing the Partnership's goals. The literature review is documented in the Council publication *The Power of Partnerships* and the accompanying infographic titled *A Summary of Public-Private Partnerships*, both of which can be found at www.compete.org. Below is a summary of key findings.

Manufacturing Barriers

The Council has derived and summarized seven barriers in the United States that relate to manufacturing clean energy products and enhancing energy productivity in the manufacturing sector. These barriers fall under three broad categories: Enabling Innovation, Securing the Talent Pipeline, and Improving the Business Climate.[35]

Barriers to ***innovation*** in clean energy technologies, foundational advanced manufacturing technologies and manufacturing processes include:

- **Capital Requirements:** The two "valley of death" zones wherein start-up companies struggle to meet their capital requirements present a barrier to both technology development and manufacturing at scale.
- **Innovation Infrastructure:** A lack of shared infrastructure and expertise from which industry scientists and engineers can draw to increase speed and lower costs on the path to production and commercialization hinders innovation and decreases the likelihood that production is established in the United States.
- **Low Investment in Advanced Manufacturing Technology:** The current level of investment in advanced manufacturing technologies and processes that would convey an advantage to the United States, if leveraged here first, is currently too low.

35 Note: These categories were adapted from the July 2012 President's Council on Science and Technology report, *Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing*.

The ***talent*** barrier, also referred to as the "skills gap," is consistently ranked by CEOs as the top impediment to manufacturing competitiveness. This barrier refers to the limited availability of skilled workers—such as researchers, scientists, engineers, skilled welders and production technicians—to meet the needs of manufacturing firms.

Business leaders and industry associations will often cite the ***business climate*** as a barrier to locating manufacturing in the United States:

- **Structural Costs:** As defined by the Manufacturing Institute and the Manufacturers Alliance for Productivity and Innovation (MAPI), structural costs include the U.S. expense of corporate taxes, employee benefits, tort litigation, regulatory compliance and energy costs. High structural costs, compared to the costs of operating a facility within the borders of America's largest trading partners, drive manufacturing abroad.
- **Public and Cyber Infrastructure:** The diminishing quality of physical (largely public) and cyber infrastructure on which manufacturers rely—including roads, rail, ports, dams, air transport, energy transmission, communication networks, and water supplies—is currently in need of significant investment and improvement.
- **Trade Policy:** Trade barriers include (1) the cost to U.S. manufacturers to source and export globally versus their competitors, (2) U.S. export controls, and (3) non-tariff trade barriers and market distortions that arise from foreign government subsidies to their domestic producers.

The Council acknowledges a fourth type of manufacturing barrier that has been labeled "Addressing Clean Energy Market Risks" and includes issues such as split incentives, technical risks, low-cost incumbent energy sources, bounded rationality, etc., that tend to lower global demand for clean energy technologies and, thus, limit the potential for domestic production of these technologies. Though outside the scope of the barriers discussion, clean energy market risks were explored as they relate to PPPs.

Policy Analysis

Of the 184 sources, 28 studies produced public policy recommendations to the federal government. As such, these reports received a more extensive side-by-side analysis. Each recommendation was categorized and grouped with similar recommendations made within the 28 studies. This expansive dataset is located on the Council website (www.compete.org). The most commonly targeted subjects across the reports are tax policy, improving innovation institutions, procurement, talent and research. Fourteen of the reports advocated for the creation of public-private partnerships to spur U.S. clean energy innovation, manufacturing and increased industrial energy productivity.

Public-Private Partnership (PPP) Analysis:

There were few PPPs that focused solely on clean energy and enhanced energy productivity. The Council performed a cursory review of 30 domestic and international PPPs, 19 of which were chosen because of their relevance to clean energy manufacturing competitiveness and energy productivity. Additional PPPs will be considered and explored in the forthcoming dialogues.

Those 19 PPPs examined were further analyzed across 23 different characteristics used to populate a side-by-side analysis, also available on the Council website (www.compete.org). Those 19 PPPs also were grouped into four broad categories.

Early Market PPPs tend to focus predominantly on research for technologies that are less established in the market and/or have few mature firms able or willing to support a PPP on their own. Some Early Market PPPs also engage in prototyping and early commercialization activities. Several of the Energy Innovation Hubs fall into this category, working for example on battery technologies, rare earth mineral substitutes or artificial photosynthesis. Industry often partners in such hubs, but tends not to lead them due to the earlier stage of the market or technology.

Mature Market PPPs seek to advance the objectives of more mature industries. These PPPs tend to be industry-led and focus on pre-competitive research, cooperative research on advanced manufacturing technologies, or standards. The technologies addressed by these PPPs can be early-stage or more mature, but there are enough mature companies in the market that the private sector engages heavily in the leadership.

Test Bed / Demonstration PPPs Although the other PPP models in this study may include testing and demonstration components, the Test Bed / Demonstration PPPs have testing and demonstration as their primary function. These PPPs often work to establish the market for emerging technologies and are local by nature, even if their user community is national or global in scope.

Innovation Network PPPs are generally national or international networks of applied research and demonstration organizations, often focused on a particular technology or set of technologies at each node in the network. The network nodes sometimes are linked by a broad theme, such as advanced manufacturing technologies under the NNMI or nanotechnology applications under the Interuniversity Microelectronics Centre.

It is important to note that, rather than a strict categorization, the Council suggests considering the predominant characterization of each public-private partnership. For example, a PPP may have the primary function of a Mature Market PPP, but also have attributes of a Test Bed/Demonstration PPP. With this in mind, Figure 4 reveals the PPPs analyzed by the Council and their respective characterization.

Figure 4. Public-Private Partnerships Characterized by Model
Source: Council on Competitiveness, *The Power of Partnerships*, 2013.

PPP Model	PPPs Analyzed by Council
Early Market E	Joint Center for Energy Storage Research (JCESR)
Mature Market M	Commonwealth Center for Advanced Manufacturing (CCAM) Fraunhofer Center for Sustainable Energy Systems (CSE) SEMATECH Smart Grid Interoperability Panel (SGIP) Photovoltaic Manufacturing Consortium (PVMC) PDES, Inc.
Test Bed / Demonstration T	Energy Efficient Buildings (EEB) Hub NextEnergy Oak Ridge National Laboratory—Manufacturing Demonstration Facility (ORNL-MDF) Solar Technology Acceleration Center (SolarTAC)
Innovation Network I	National Additive Manufacturing Innovation Institute (NAMII) National Network of Manufacturing Innovation (NNMI) National Digital Engineering and Manufacturing Consortium (NDEMC) Catapult Centres (Catapult) Industrial Technology Research Institute (ITRI) Fraunhofer-Gasellschaft (Fraunhofer) Interuniversity Microelectronics Centre (IMEC) GTS Advanced Technology Group (GTS)

Insights

After analyzing the data on each PPP and reviewing the relevant literature, the Council developed insights to help understand: (1) how to match PPP models to clean energy technology challenges, (2) the optimal scope of PPP activities across Technology Readiness Levels, (3) which manufacturing barriers PPPs are well-suited to address, (4) the government role in PPP funding and formation, and (5) critical success factors for PPPs.

Key Highlights from the PPPs Analysis

- Technology readiness (Figure 5) is essential to structuring a PPP—the first step toward matching a PPP to a particular EE or RE manufacturing challenge is to assess the market readiness and availability of test bed facilities for a particular technology or basket of technologies.
- To take advantage of the virtuous feedback loop between production and innovation, a PPP is more likely to be effective if it extends across the Technology Readiness Scale.
- Not all barriers to clean energy product manufacturing and energy efficient manufacturing are most effectively addressed by PPPs; capital requirements, innovation infrastructure, low investment in advanced manufacturing technologies, talent, and clean energy market risks are commonly addressed by PPPs, while structural costs, public and cyber infrastructure, and trade policy are largely addressed using policy.
- Federal and state governments play critical roles in the formation of PPPs as both a key funder (seed and long-term) and neutral convener—bringing stakeholders together to tackle problems they would not pursue on their own.
- PPP Success Factors:
  - Strong leadership
  - Clear, compelling mission
  - Early funding stream to establish a PPP, usually from the public sector
  - Intellectual property practices that draw corporate participation
  - Participation across industry value chains
  - Engagement by multiple large companies
  - Affordable membership terms for small companies
  - Regional organization or other mechanism to engage entrepreneurs and risk capital community
  - Talent development
  - Universities and institutions with a culture of applied research
  - Demonstrably positive community impact
  - Acceptance of high failure rates for new firms and products
  - Establishment or enhancement of standards, as needed
- Literature Review “White Space”: Most of the PPPs reviewed expressed the importance of success metrics and measurements systems, however, few PPPs actually have precise measurement systems and metrics. A similar conclusion was drawn regarding intellectual property (IP)—all PPPs promote the importance of IP protection, but there are few insights on best practices.

Figure 5. Technology Readiness Levels (TRLs)
Source: Department of Energy, Office of Energy Efficiency and Renewable Energy

	Reserach & Development							Technology Deployment
TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	TRL 9
Basic Research	Applied Research	Proof of Concept	Testing Components or Processes	Testing Systems	Prototype System Verified	Pilot System Demonstrated	System in Commercial Design	Ready for Full Commercial Deployment
Innovation			Emerging Technologies			Systems Integration		Market Penetration

SECTION V

Key Questions for the Inaugural Dialogue

What barriers to the U.S. manufacturing of clean energy products and increased energy productivity in the manufacturing sector can a public-private partnership effectively address—and what public policies can complement this effort?

What are the common and unique barriers and roles of public-private partnerships in the manufacturing of clean energy products, and increasing energy productivity in the manufacturing sector?

Of the PPP models described in *The Power of Partnerships* report produced for the AEMC Partnership Inaugural Dialogue, what models would be optimal for existing and/or emerging clean energy, increased energy productivity and foundational manufacturing technologies?

What steps or actions would most improve the U.S. current clean energy manufacturing landscape and generate the greatest return on investment?

What priority areas (technologies, barriers, infrastructures, stakeholders, etc.) should the AEMC Partnership and the eventual PPP model target?

What aspects of a PPP would incentive your organization's involvement or keep it from participating (i.e. what are the must-haves and deal breakers)?

As a stakeholder, what do you see as the benefit of participating in a PPP, and what are you willing to trade for that participation?

Is one of the four models more attractive than another?

SECTION VI

Looking Forward

A range of major studies, initiatives and efforts across the nation during the past quarter century have made the case that manufacturing remains a core driver of U.S. competitiveness, innovation and job creation—even as automation and technology make manufacturing more efficient. Creating the conditions that foster the promotion of EE, the adoption of clean energy technologies, and the deepening of clean technology manufacturing investment in the 21st century, while propelling private sector innovation and elevating EE and management to a more strategic level, will help to improve dramatically the U.S. economy, U.S. job growth, the environment, national security and U.S. living standards–in essence, America's competitiveness. It will also lead the United States to the forefront of a remarkable new era of technological advances, market and industrial transformation, and innovation of all kinds on every scale.

As innovators, investors and adopters, the private sector is the pivotal actor at the nexus of clean energy technology manufacturing. Nonetheless, the government has the power to strengthen the business case for investment and innovation in clean technology manufacturing solutions. Together, the public and private sectors must set the enabling conditions on a number of interdependent fronts to have an impact on EE, technological innovation, investment, infrastructure modernization and workforce readiness to unleash the inherent investment and innovative capacity of American enterprises and create a U.S. clean energy manufacturing revolution.

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The Council on Competitiveness is the only group of corporate CEOs, university presidents and labor leaders committed to ensuring the future prosperity of all Americans and enhanced U.S. competitiveness in the global economy through the creation of high-value economic activity in the United States.

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The key to U.S. prosperity in a global economy is to develop the most innovative workforce, educational system and businesses that will maintain the United States' position as the global economic leader.

The Council achieves its mission by:

- Identifying and understanding emerging challenges to competitiveness
- Generating new policy ideas and concepts to shape the competitiveness debate
- Forging public and private partnerships to drive consensus
- Galvanizing stakeholders to translate policy into action and change

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