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Competitiveness

American Energy & Manufacturing Competitiveness Partnership

The Power of Partnerships

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SECTION I

Introduction

In a letter released February 1, 2013, outgoing Secretary of Energy Steven Chu reviewed the accomplishments and aspirations of the Department of Energy (Department). One point he emphasized was the Department is, "forging stronger partnerships with industry to give America's innovators and entrepreneurs a competitive edge in the global marketplace…Numerous industry leaders have told me of a new-found appreciation of our convening role in many areas of energy innovation." [1] The Secretary detailed an array of activities and tangible progress that has emerged from convening leaders to grapple with clean energy issues—progress like new companies, better technologies, jobs, new forms of collaboration and steady strides toward a cleaner environment.

Secretary Chu also warned of the risk posed by climate change and extolled the economic promise of leading the clean energy revolution underway worldwide. Although the ability to find and extract fossil fuels is likely to keep pace with demand for decades, noted Chu, Americans still must act. "As the saying goes, the Stone Age did not end because we ran out of stones; we transitioned to better solutions. The same opportunity lies before us with energy efficiency and clean energy. The cost of renewable energy is rapidly becoming competitive with other sources of energy, and the Department has played a significant role in accelerating the transition." [2]

Partnerships between government, industry, academia and the national laboratories hold great promise for energy efficiency (EE) and renewable energy (RE). Through a variety of existing partnerships and programs, the Department is tackling the barriers to bringing EE and RE technologies into widespread use. If Americans are to capture the maximum benefit from increasing the use of EE and RE technologies, the Department recognizes that beyond inventing EE and RE technologies in the United States, American businesses should also be providing a significant share of the manufacturing of new EE and RE technologies for domestic consumption and export where they have intrinsic competitive advantages.

The global clean energy market is rapidly expanding—driven by global energy demand and concern for economic, environmental and national security. The United States must gain a competitive foothold in this growing market that offers hope for good jobs, new innovations and a higher standard of living. Clean energy technologies—combined heat and power, for example—must also be deployed in the United States to enable all manufacturing sectors to increase their competitiveness through increased energy productivity.

In this context, the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy (EERE) and the Council on Competitiveness (Council) have formed an "American Energy and Manufacturing Competitiveness Partnership." This report fulfills the objectives of Contract # DE-EE0006099.000, to examine:

- Links between energy efficiency efforts, renewable energy, and manufacturing competitiveness in the United States and internationally;
- Barriers to and opportunities for manufacturing competitiveness as they relate to energy in the United States and internationally; and
- Models for public-private partnerships (PPPs) to foster competitive industries in the United States or abroad.

Specifically, the Council's effort has centered around the most important barriers and opportunities in manufacturing clean energy products in the United States, and the most promising PPPs to overcome those barriers and develop those opportunities. We find that there is significant overlap with barriers, opportunities, and PPP models that are applicable to increasing the manufacturing of clean energy products in the United States with those that are applicable to increasing energy productivity in the manufacturing sector. Thus, this study focuses on barriers, opportunities and PPPs most directly applicable to enhancing competitiveness in manufacturing of clean energy products—that can also be applied to enhancing manufacturing competitiveness with energy productivity. Some PPPs focused uniquely on enhancing broader manufacturing competitiveness through enhanced energy productivity were not studied in detail, but should be considered and explored in forthcoming dialogues. In this effort the Council has:

- Undertaken an initial literature review and mapping of 184 reports, studies or initiatives. Of these, the Council has considered 28 to be particularly relevant for a more extensive side-by-side analysis of their policy recommendations.
- Drawn approximately 180 recommendations into a "policy side-by-side analysis" tool, split into 26 broad categories—22 of which relate either directly to PPPs or have an indirect effect on them.
- Developed a "domestic and international PPP side-by-side analysis" tool. After an initial review of over 30 PPPs, the Council has focused on 19 that are most relevant for clean energy manufacturing competitiveness.
- Linked barriers, opportunities and this universe of policy recommendations to the PPPs—that either directly address or are indirectly supported by these policy recommendations—via an infographic companion report, *A Summary of Public-Private Partnerships.*

To supplement further its review of policy studies, key recommendations and PPPs—adding another layer of intelligence to the effort—the Council has interviewed key leaders across the country involved in the development of PPPs. This interview process has enriched the Council's overall analysis and understanding of policies and partnerships. Appendices specific to this report include: (A) summaries of examined PPPs, including their locations, missions, governance structure and financing; (B) the leadership interview template and list of interviewees; (C) an overview of examined policy recommendations; and (D) a full list of sources reviewed and compiled by the Council in preparation of this report.

The Council also has drawn on its deep, 27-year, non-partisan, institutional knowledge of innovation, manufacturing and regional cluster development issues to inform the report[3]—as well as leveraging its long standing commitment to the nation's efforts to optimize America's energy portfolio and manufacturing capacity for long-term productivity and prosperity, having launched significant, public-private efforts to those ends, such as:

- The 2007-2009 Energy Security, Innovation and Sustainability (ESIS) Initiative to enhance U.S. competitiveness, energy security and sustainability by creating an energy action plan focused on identifying opportunities to inspire private sector demand for sustainable energy solutions, and support the creation of new industries, markets and jobs.

- The ongoing U.S. Manufacturing Competitiveness Initiative (USMCI) to create a private sector-driven agenda addressing five key challenges to optimize the nation's manufacturing competitiveness.

In the context of focusing on the barriers to EE and RE manufacturing in the United States, the Council offers a few, overarching insights about the larger competitiveness environment, particularly for EE and RE technologies (Figure 1).

The review of EE, RE and manufacturing literature reveals that barriers to wide-spread adoption and U.S. manufacturing exist across technology readiness levels (TRLs, Figure 2), from the early stage research and innovation phases through the later prototyping and production phases. The major production barriers to EE and RE technologies in the United States are, in many cases, the same barriers that inhibit other technologies. The Council observed that many of the barriers differentiating EE and RE technologies from other technologies tend to affect demand. Examples include clean energy market externalities, low demand due to low-cost incumbent energy sources, imperfect or incomplete information, and split incentives. These types of barriers generally require EE and RE technologies to meet challenging price, performance, and return-on-investment standards—as well as unique market information or incentive problems in addition to the manufacturing barriers that other technologies face.

Figure 1. Examples of Energy Efficiency and Renewable Energy Technologies in Three Sectors
Source: Department of Energy, Office of Energy Efficiency and Renewable Energy

Renewable Electricity Generation	Energy-Saving Homes, Buildings, and Manufacturing	Sustainable Transportation
Solar	**Homes & Buildings**	**Vehicles**
• Photovoltaic technology	• Appliances and their sensors and controls	• Lightweight structural and propulsion materials
• Concentrated solar power	• Building materials (windows, doors, walls, roof)	• Advanced lubricants
• Solar water heating	• Geothermal heat pumps	• Alternative fuel vehicles
Geothermal	• Advanced lighting	• Energy efficient traffic lights
• Heat pumps	• Weatherization	• Idle reduction technology and infrastructure
• Exploration technology	**Manufacturing**	**Bioenergy**
• Drilling technology	• Waste heat recovery	• Bioenergy feedstocks
Wind	• Combined heat and power systems	• Bioenergy processing and conversion
• Turbine technology	• Nano-manufacturing	• Integrated biorefineries
• Distributed and community wind systems	• Additive manufacturing	**Hydrogen & Fuel Cells**
• Utility-scale systems technology	**Government Energy Management**	• Fuel cells
Water	• Weatherization assistance	• Hydrogen production
• Hydrokinetic flow turbines	• Green urban planning technologies	• Hydrogen storage
• Hydropower generators and turbines		

Figure 2. Technology Readiness Levels

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

Figure 3 displays a schematic of barriers to EE and RE technology development and production uncovered in the Council's literature review. Once again, the Council observed significant overlap between barriers to manufacturing clean energy products and barriers to improved manufacturing through increased energy productivity. Therefore this schematic represents the barriers to these two objectives together, grouped by three pillars laid out by the Advanced Manufacturing Partnership (AMP) Steering Committee to drive U.S. manufacturing competitiveness—enabling innovation, securing the talent pipeline, and improving the business climate.[4] The Council has added a fourth pillar to address particular barriers faced by EE and RE technologies addressing clean energy market risks. The market risks listed under the fourth pillar reflect barriers to EE and RE adoption that, in turn, result in low domestic manufacturing investment.[5]

The Department administers several programs aimed at reducing or mitigating barriers in these four pillars. This report focuses predominantly on barriers in enabling innovation, securing the talent pipeline, and improving the business climate. While the fourth pillar of addressing clean energy market risks is included in the analysis of existing public-private partnerships, it is not a focus of the Manufacturing Barriers section of this report. The report also explores the role and barriers to the development of advanced manufacturing technologies that could enable EE and RE technologies—as well as all manufactured products—to be produced competitively in the United States. Some of these technologies remain at early Technology Readiness Levels (TRL) and require continued research to mature and diffuse.

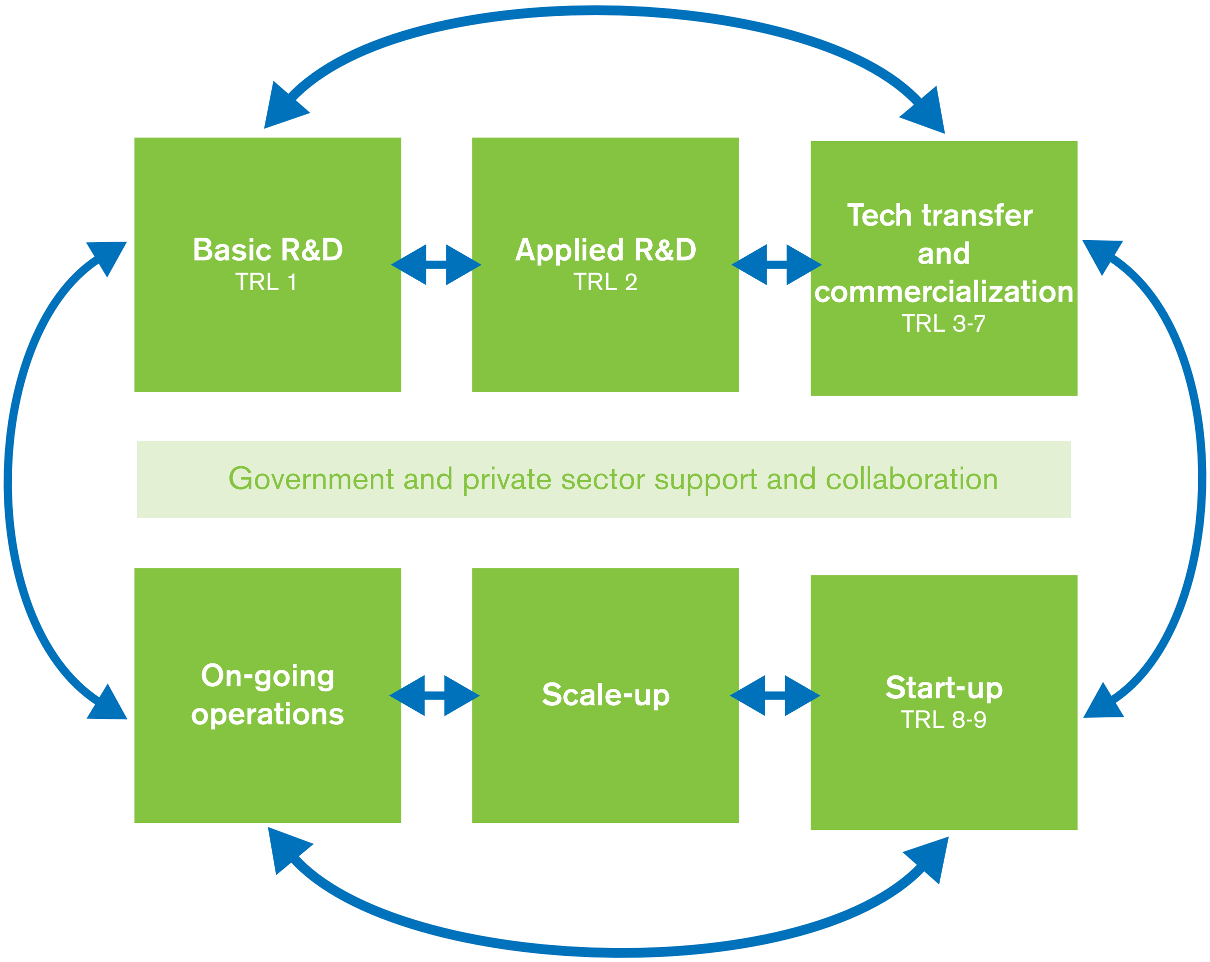
A final caveat worth noting: production considerations should be integrated more with early-stage technology development. Companies succeeding in bringing new technologies to market and manufacturing at scale typically face intense competition and rapid technology lifecycles. To survive in this space, companies strive to build cultures of continual product and production innovation.[6]

In these cases, the Council's research and relevant initiatives over the past two decades argue a linear process of research to production—that may characterize the introduction of a truly novel technology—is not optimal for subsequent innovation cycles to improve or replace that technology. In many cases, there is a virtuous relationship between the research lab and production floor that nourish each other's efforts. (Figure 4) Many firms co-locate their labs and manufacturing facilities to enable this interaction.[7]

Figure 3. Barriers to the Manufacturing of EE and RE Technologies

Enabling Innovation	**Capital Requirements**—(1) underinvestment in basic research due to private sector inability to assume risk/reward ratio,[8] (2) the "valley of death" at the development & demonstration stage[9] and (3) a second "valley of death" for new SMEs at the point of scaling production.[10] **Innovation Infrastructure**—a lack of shared infrastructure and expertise on which companies and entrepreneurs can rely to develop and produce products more quickly and less expensively—often at universities or national labs. **Low Investment in Advanced Manufacturing Technologies**—low investment in technologies that lend advantage to manufacturers, e.g. additive manufacturing, sensors, robotics, artificial intelligence.[11]
Securing the Talent Pipeline	**Talent: STEM**—scarcity of people with science, technology, engineering and mathematics skills (spans K-12 through graduate education).[12] **Talent: Middle Skills**—scarcity of people to fill—at current wages—jobs that require more than high school but not 4-year degree, e.g. welders, technicians, computer support, HVAC installers.[13]
Improving the Business Climate	**Pre-Production Costs**—high up-front costs of development, infrastructure, and meeting price/performance of incumbent energy sources and producers.[14,15] **Structural Costs**—expense of corporate taxes, employee benefits, tort litigation, regulatory compliance, and energy.[16] **Fiscal, Regulatory and Statutory Uncertainty**—inconsistent or unpredictable treatment by tax, regulatory or standards bodies that distort market behavior or investment decisions.[17] **Public & Cyber Infrastructure**—quality of roads, rail, waterways, dams, transport, energy systems, communication networks, etc.[18] **Trade Policy**—cost for manufacturers to source and export globally versus competitors, export controls, and distortions from foreign subsidies.[19,20,21]
Addressing Clean Energy Market Risks	**Externalities / Public Goods**—The true cost of a product or behavior is not captured in its market price.[22,23] **High Costs**—high up-front cost associated with demonstration, production, and purchase of EE or RE technologies keeping them from being cost-competitive with incumbent energy technologies.[24, 25, 26] **Technical Risks / Uncertainty**—market incentives that encourage firms to focus on low-risk incremental improvements to existing technologies.[27] **Low Demand**—a lack of demand for low-carbon or carbon-free energy because it is often indistinguishable to consumers at the point of consumption[28] (e.g. a residential or commercial consumer using electricity from the power grid) and because it is more expensive in some cases. **Imperfect or Incomplete information**—consumers of electricity from the power grid lacking adequate information to make informed decisions about EE or RE technology use.[20, 30] **Hidden Costs / Transaction Costs**—unaccounted costs (e.g. overhead, training, disruptions) that can skew EE or RE benefit analysis.[31] **Access to Capital**—EE investments are inhibited by strict payback periods as well as organizational rules and procedures that place lower priorities on EE through capital budgeting procedures and investment appraisals.[32,33,34] **Split Incentives**—cases where the benefits of EE or RE adoption do not accrue to the person or organization seeking to adopt them.[35] **Imperfect Competition / Gold Plating**—markets with limited producers or sellers, leading to higher prices or inflexible bundling of products & services.[36] **Bounded Rationality / Behavioral Factors**—constraints on consumers' time, attention and ability to process information that skew decision-making.[37]

Figure 4. U.S. Innovation and Manufacturing Require Full Life-Cycle Support to Maximize Return on Innovation
Source: Council on Competitiveness



For illustrative purposes.

For example, Harvard Business School professors Gary Pisano and Willy Shih assert that in many high tech industries, product and process innovation is intertwined. “Once manufacturing is outsourced, process-engineering expertise can’t be maintained, since it depends on daily interactions with manufacturing.”[38]

The professors attribute part of the long-term decline in U.S. competitiveness in technologies like solar panels and lithium-ion batteries to this trend. “Most innovation in batteries in recent decades has been driven by the increasing demands of consumer electronics products for more and more power in smaller and smaller packages. When U.S. companies largely abandoned the mature consumer electronics business, the locus of R&D and manufacturing—not just for laptops, cell phones, and such but also for the batteries that power them—shifted to Asia.”[39]

By examining key barriers in, opportunities for and case studies of PPP models, this report provides a resource 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.

SECTION II

Manufacturing Barriers

The global outlook for U.S. manufacturing competitiveness evolves continually. At times, macro forces drive change—like the end of the Cold War that opened vast new areas for trade, investment and manufacturing in large, low-cost labor markets. In some instances, technology revolutions—like those in information technology and automation—change the landscape. And at other times, the policy choices of competitors to lower taxes, invest in education, and build infrastructure can shift comparative advantage.

Several such changes are underway today:

- Wages have risen steadily in competing nations like China decreasing a prior disadvantage in U.S. competitiveness.
- Technologies like additive manufacturing, sensors, robotics, and high performance computing are opening new opportunities to compete.
- A boom in natural gas supply is lending America a major cost advantage for the entire manufacturing sector.
  - Domestic gas production has a dramatic impact on the competitiveness of steel and chemical producers.
  - Natural gas serves as a feedstock for products such as plastics, fertilizers and pharmaceuticals.[40]
  - Lower natural gas prices reduce electricity costs for all manufacturers, including producers of EE and RE technologies.

Industry executives and analysts are sorting out what these changes mean for their firms and the United States more broadly. New ways of calculating the total cost of production and the potential reach of the "reshoring" phenomenon are common topics of manufacturing articles and literature today.[41] Because of evolving factors like these, the decision-making of many manufacturing firms is in flux and the United States is receiving greater consideration as a site for production.[42, 43, 44]

Additionally, President Barack Obama established and called on the AMP Steering Committee to issue recommendations that would help strengthen America's manufacturing competitiveness. The recommendations were issued under three pillars: enabling innovation, securing the talent pipeline and improving the business climate.

It is timely, therefore, for the Department, as a key actor in implementing the president's national manufacturing strategy and AMP recommendations, and the Council to review the barriers to U.S. manufacturing and the partnership efforts underway to overcome those barriers, with a keen eye toward those partnerships most promising for addressing AMP recommendations with respect to the production of EE and RE technologies and to enhancing manufacturing competitiveness with energy productivity measures. To that end, the barriers are grouped under the same pillars put forward by the AMP Steering Committee. These barriers are gathered from an extensive literature review and are listed here to form the basis of discussion and exploration of effective PPP models, rather than statements of policy perspective in themselves.

Manufacturing Barriers

Enabling Innovation

- **Capital Requirements—**This barrier refers to two "valley of death" zones where start-up companies struggle to meet their capital requirements. The traditional valley referred to in most literature occurs at the development, demonstration and prototyping stages. Often overlooked, however, is a second valley of death that typically emerges at the point of scale-up production beyond approximately $100 million—$150 million in revenue.[45]
- **Innovation Infrastructure—**This barrier refers to a lack of shared infrastructure and expertise on which industry scientists and engineers can draw to increase speed and lower costs on the path to production and commercialization. Typically innovation infrastructure refers not only to shared research and testing equipment, but also to university or lab personnel with specialized knowledge and skill.
- **Low Investment in Advanced Manufacturing Technology—**This barrier refers to the low investment in advanced manufacturing technologies and processes that would convey an advantage to the United States if leveraged here first. Such technologies include additive manufacturing, sensors, robotics, artificial intelligence and high performance computing.

Securing the Talent Pipeline

- **Talent—**Consistently ranked by CEOs as the top driver of manufacturing competitiveness,[46] talent barriers to manufacturing include the low quality and availability of (1) researchers, scientists and engineers; and (2) skilled labor like welders, technicians and plumbers.

Improving the Business Climate

- **Structural Costs—**This barrier is a compilation of costs in the United States, including corporate taxes, employee benefits, tort litigation, regulatory compliance, and energy costs[47] as defined by the Manufacturing Institute and the Manufacturers Alliance for Productivity and Innovation (MAPI). These costs are often compared to the costs of operating a facility in America's largest trading partners to determine relative barriers to competitiveness.
- **Public and Cyber Infrastructure—**This barrier refers to the 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.
- **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.

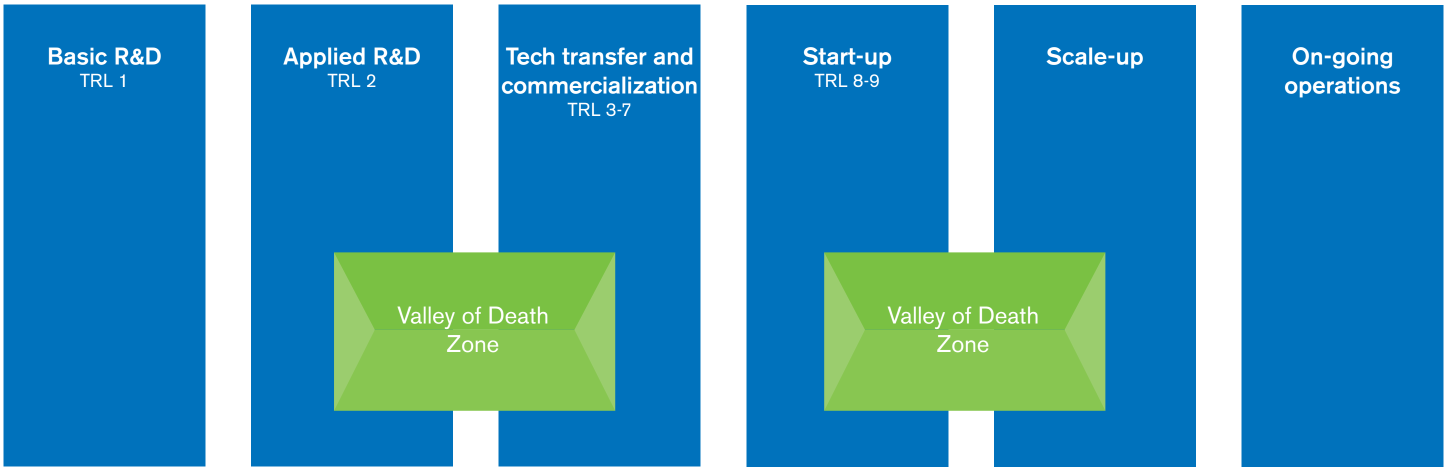
The Council's review of policy literature and public-private partnerships finds that some barriers are primarily policy problems, while other barriers are coordination problems that require or are greatly aided by well-functioning partnerships. Barriers classified as "addressing clean energy market risks," while important, are not a primary focus of the Manufacturing Barriers section.

Capital Requirements

Two investment gaps exist in the process of developing technology for commercialization. Most reports about barriers to U.S. innovation and manufacturing describe a "valley of death" that occurs at the development, prototyping, and demonstration phases of technology commercialization (Figure 5). The innovation literature has defined thoroughly the institutional and behavioral barriers between invention and a viable business.[48] Two barriers to bridging this gap include the difficulty of obtaining risk capital and insufficient enabling innovation infrastructure—the latter is discussed in the subsequent section.[49, 50]

At the early stages of technology development, efficient markets do not exist for allocating risk capital. Early-stage technologies and new markets

Figure 5. Manufacturing Innovation Investment Gaps
Source: Council on Competitiveness



carry higher levels of risk and uncertainty, creating a market failure where the private sector foregoes investment.[51] The science and technology policy community has long advocated increasing the availability and reducing the cost of risk financing through targeted subsidies, incentives for private investors, grants, and loan programs.[52, 53, 54, 55]

Five of the 19 PPPs the Council examined help provide capital through grants or loans to emerging companies. Most PPPs focus less on supplying capital than on lowering capital requirements through innovation infrastructure.

Less frequently cited in manufacturing literature is a second valley of death beyond Technology Readiness Level 9 between start-up and scale-up, when a new company is ready to scale-up production in the United States beyond approximately $100 million—$150 million in revenue, according to Council members.[56] Venture firms often will condition scale-up capital on a business plan that moves production at scale overseas.[57] Such investment stipulations reflect factors such as U.S. structural costs, talent availability, speed of permitting, depth of supporting supply chain firms, and projections of a product's margin and lifecycle. The scale-up valley of death is very much linked to solving the other manufacturing barriers examined in this report.

Innovation Infrastructure

One way to reduce the high capital requirements of crossing the first valley of death and to strengthen competitiveness in ways to avoid the second valley is to build a more robust innovation infrastructure, mainly by developing and leveraging the physical assets and expertise of America's universities and national laboratories.

The concept of innovation infrastructure centers on linkages between the actors in an innovation ecosystem. Although such linkages exist in the United States between industry, academia and government through partnerships and technology transfer offices, the nation can improve them. The President's Council of Advisors on Science and Technology (PCAST) and the National Science and Technology Council (NSTC) suggest advancing these linkages through shared infrastructure.[58, 59, 60] Shared infrastructure includes facilities often developed through PPPs that help small and medium-sized manufacturers improve their products and compete globally.

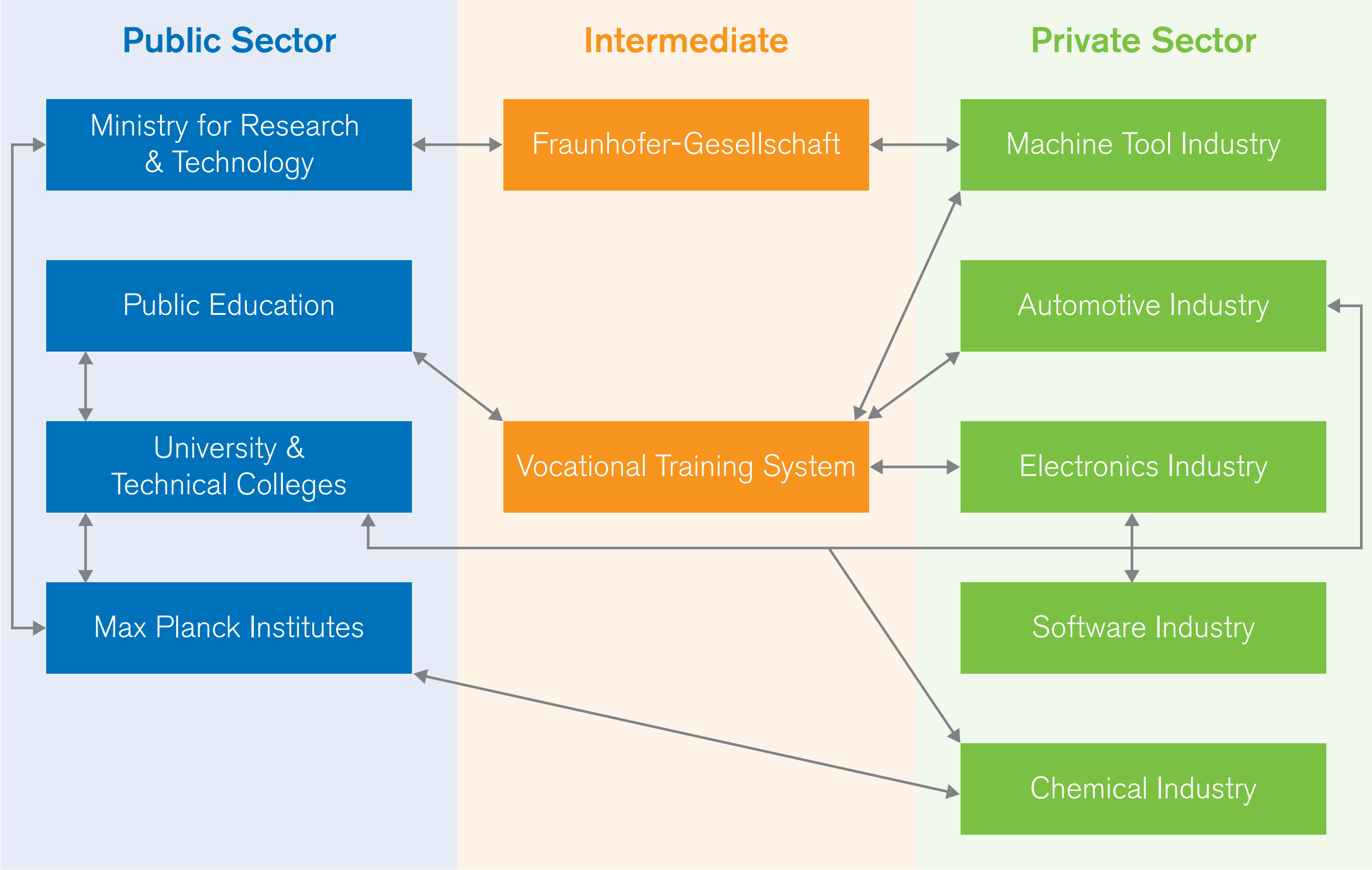
According to the PCAST:

"There are many tools and technologies that can improve the ability of existing firms to prototype rapidly and virtually, produce small batches, customize products to individual consumers and clients, reduce inventories, and expand the range of products that they can manufacture. Many firms, however, cannot gain access to such technologies. The minimum investment required are too large to be cost-effective for an individual firm, and there is often no effective way to buy shared services." [61]

This quote highlights the importance of innovation infrastructure to small and medium-sized enterprises (SMEs), that rely more heavily than their global counterparts on the industrial commons to achieve economies of scale during commercialization and scale-up. [62] The benefits of building innovation infrastructure, however, accrue to more than companies. The co-location of scientists and engineers creates synergies between public and private researchers from multiple fields that spur new innovation and lower barriers to market entry. [63] Moreover, PCAST notes that shared innovation infrastructure creates geographically specific assets that help anchor manufacturing facilities and manufacturing jobs in the United States.

Other countries historically have been more deliberate in their actions to link the public and private sectors, which may be a contributing factor in the success of certain high-wage countries, like Germany, in maintaining a robust, medium- and high-technology manufacturing sector (Figure 6). This physical, public-private linkage is sometimes called the intermediate sector in innovation literature, but this report refers to it as innovation infrastructure. In foreign countries, the innovation infrastructure is positioned between academia, industry, and government. Institutions such as the public-private

Figure 6. Visualization of Germany's Intermediate Sector
Source: Nelson, R.R., "National Innovation Systems: A Comparative Analysis," 1993.



partnerships Fraunhofer Society in Germany and Industrial Technology Research Institute (ITRI) in Taiwan aim to develop new technology and increase commercialization.[64] These institutions typically partner with government as a component of the nation's economic strategy in these cases. Outside of maintaining the defense industrial base, the United States has historically taken a more cautious approach to these kinds of collaborations, but other national interests might be served by using this model to facilitate pre-competitive activities and to establish shared facilities that serve multiple companies.

In fact, initiatives such as the National Network for Manufacturing Innovation (NNMI) and the Department's Manufacturing Demonstration Facilities (MDF) are attempting to do just that. They are the building blocks of a physical, national network of shared innovation infrastructure—such as labs, pilot plants, capital-intensive technological tools, and expertise—for manufacturers to leverage to scale production in the United States.

Establishing and leveraging innovation infrastructure is one of the most common barriers addressed by the PPPs examined, with 15 of the 19 PPPs serving this function in some way.

Low Investment in Advanced Manufacturing Technologies

PCAST consulted with key stakeholder groups to identify pivotal technologies that would lend advantage to U.S. manufacturers. These include:

- Advanced Sensing, Measurement and Process Control
- Advanced Materials Design, Synthesis, and Processing
- Visualization, Informatics, and Digital Manufacturing Technologies
- Sustainable Manufacturing
- Nanomanufacturing
- Flexible Electronics Manufacturing
- Biomanufacturing and Bioinformatics
- Additive Manufacturing
- Advanced Manufacturing and Testing Equipment
- Industrial Robotics
- Advanced Forming and Joining Technologies

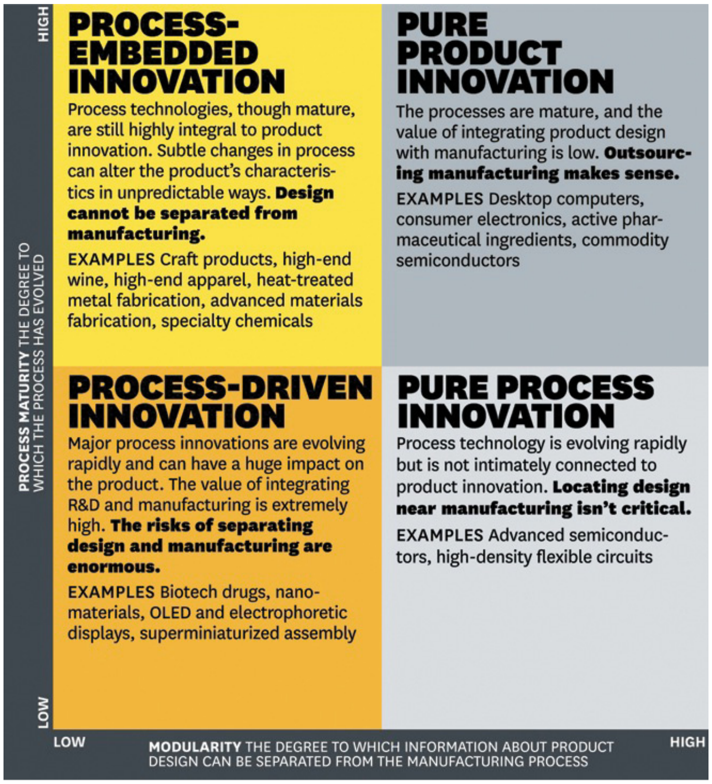
PCAST concluded that, "universities, national labs, intermediate technology institutes, independent research institutions, and community colleges will need to work together with industry to support research, development, and deployment of these manufacturing technologies, and to develop the talent pipeline for industry."[65]

Increasing American investment to mature these technologies for commercial consumption and diffuse them into society would lend the United States a manufacturing advantage. Many of the technologies, such as those related to sensors, advanced materials, sustainable manufacturing, and flexible electronics have implications for EE and RE technologies. Another noteworthy enabling technology is the use of high performance computing for modeling and simulation that speeds the path to production.[66] Over the long term, part of the strategy to ensure U.S. competitiveness must be a steady investment in basic and applied research into novel production technologies and processes.

Harvard Business School Professors Gary Pisano and Willy Shih take these ideas a step further. To understand which products might be most suitable to be produced where they are researched and developed, they suggest examining the modularity and maturity of both the product and the manufacturing process (Figure 7). In this scenario, modularity relates to the ability of R&D and manufacturing to operate independently of the other.[67]

Of the PPPs examined, 13 of the 19 PPPs examined seek in part or in whole to increase investment to mature or diffuse advanced technologies. PPPs are an important tool that should be leveraged in order for the United States to lead in maturing advanced manufacturing technologies.

Figure 7. Modularity-Maturity Index
Source: Gary Pisano and Willy Shih, Harvard



Talent

Talent barriers to manufacturing come in several forms, but most of the literature discusses shortages of (1) workers with science, technology, engineering and math (STEM) degrees; and (2) individuals with "middle skills" such as technicians, welders, machinists, programmers, and electricians.

Meeting the manufacturing demand for these skill sets requires attention across a pipeline from K-12 education through graduate school and adult education and training programs. Employers and educators also have to overcome cultural beliefs in the United States that manufacturing offers little job security and no long-term career development.[68]

The shortage of STEM professionals in the United States is well documented. The problem has many facets, including issues of retention, immigration, and recruitment of women and minorities. The bottom line, however, is that the number of graduates is not keeping pace with current or projected job openings, and a large share of the STEM workforce is approaching retirement age. In 2008, the United States ranked 23rd among 30 OECD countries surveyed in STEM graduates per employed 24- to 30-year-olds.[69]

A report by Deloitte and the Manufacturing Institute finds that despite persistently high U.S. unemployment, up to five percent of U.S. manufacturing jobs go unfilled because people with the skills to fill them are not available. That translates into roughly 600,000 jobs.[70] This is a phenomenon observed by manufacturers in many sectors, ranging from automotive to telecommunications (Figure 8).

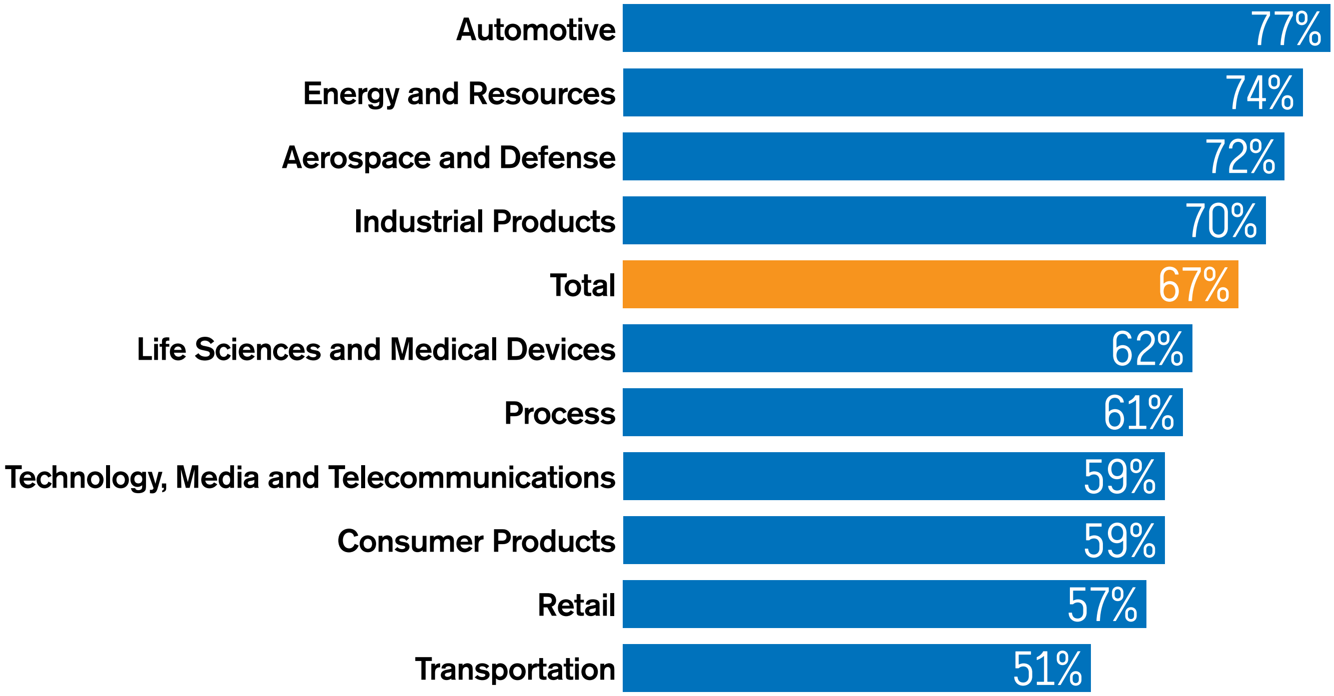
Most of those jobs fall into the category of middle skills "that require postsecondary technical education and training and, in some cases, college math courses or degrees. Currently in the United States about 69 million people work in middle-skills jobs, representing roughly 48 percent of the labor force."[71] Several organizations suggest that an expanded role for community colleges, unions, and industry partnerships will be required to meet these needs.[72, 73, 74, 75]

Talent barriers are a focal point of 17 of the 19 PPPs examined by the Council. The evidence suggests PPPs are an essential tool to address both workers with "middle" skills and STEM degrees and a deeper examination to determine best practices would be an important part of future Department and Council dialogues.

Structural Costs

Structural costs are a barrier to manufacturing because they guide decisions on where to locate manufacturing processes. The Manufacturing Institute calculates structural costs (corporate taxes, employee benefits, torts, regulation, and energy costs) to be 20 percent higher in the United States than the average structural cost over America's nine largest trading partners in 2011.[76] The biggest contributors to the 20 percent U.S. structural cost disadvantage are corporate tax rates and employee benefits, which account for 85 percent of the difference (Figure 9). Methods of calculating structured costs, however, can differ.

Figure 8. U.S. Companies Facing (Talent) Shortages by Sector
Source: *The Future of Manufacturing: Opportunities to Drive Economic Growth*, A World Economic Forum report

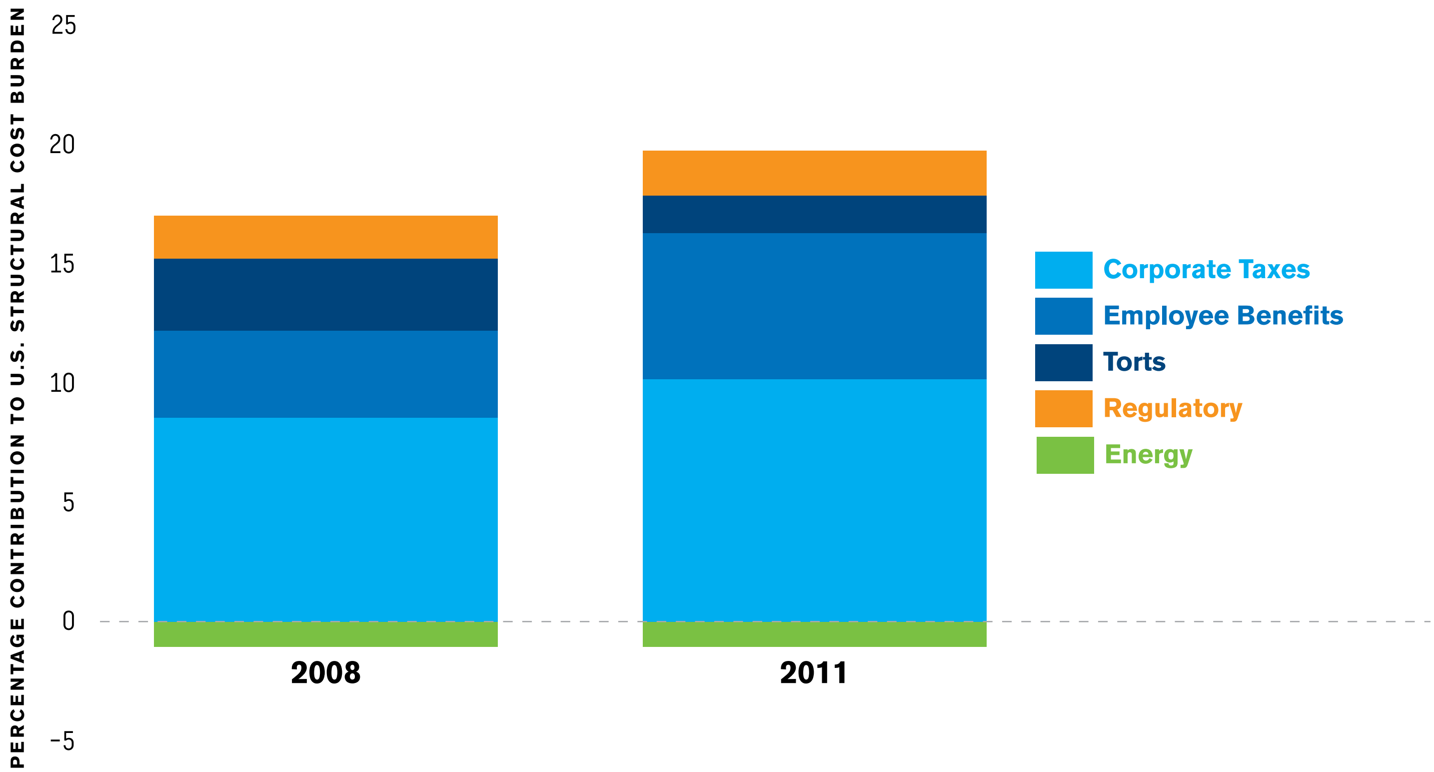


Deloitte Analysis of 2011 Skills Gap Survey, Deloitte Development LLC and The Manufacturing Institute

For example, estimates of the U.S. federal corporate tax rate range from 12 percent to 35 percent, depending on the use of the effective or statutory tax rate.[a, 77, 78, 79, 80] Regardless of the rate, a key conclusion of a recent Congressional Research Service meta-analysis revealed that U.S. effective corporate rates are roughly the same as those of international competitors. Nonetheless, the reduction of the U.S. statutory corporate tax rate receives bipartisan support. Many groups, including the Council and the Innovation and Information Technology Foundation (ITIF), have called for U.S. statutory corporate tax rate to be lowered more in line with competing OECD nations. "This would… make investing in the United States more attractive while at the same time increasing the competitive position of U.S. establishments vis-à-vis their foreign competitors," asserts ITIF.[81]

a. According to the Organization for Economic Cooperation and Development (OECD), federal statutory U.S. corporate tax rates are the highest in the industrialized world at 35 percent. When combined with state and local levies, the U.S. rate stands at 39.1 percent, trailing only Japan.[77] Statutory tax rates, as used to calculate structural costs by the Manufacturing Institute, are not the only way to understand corporate taxes. Peter R. Orszag, previous director of the Congressional Budget Office, explains that the effective U.S. corporate tax rate—the share of corporate profits actually paid in taxes—averaged 19 percent over the past three decades.[78] As reported in the Wall Street Journal, in years with temporary tax breaks corporate taxes can fall even lower. In 2011, for example, bonus depreciation is credited with lowering the total U.S. corporate federal taxes paid to 12.1 percent.[79] In a December 2012 report, the Congressional Research Service (CRS) reviewed three different studies of average effective tax rates using three different methodologies. The effective tax rates in these studies ranged from 23 to 29.5 percent.[80]

Figure 9. Factors Contributing to U.S. Structural Cost Disadvantage
Source: Manufacturers Alliance for Productivity and Innovation



The Manufacturing Institute report also notes U.S. advantages over other nations—namely, a highly productive labor force. Taking this into account, the average total production cost disadvantage relative to our international competitors falls from 20 percent to 9.3 percent.

Employee benefits include paid leave, insurance, overtime pay, savings plans, and legally required benefits like Medicare, Social Security, and unemployment insurance. The largest single cost component of these benefits for U.S. manufacturers is employer provided health insurance, which accounts for 27 percent of the total.[82] From 2001 to 2011, the employer costs for employee health care increased 83 percent.[83]

The structural cost (and delay) of torts and regulation remain significant for U.S. manufacturers,[84, 85] but the disadvantage they pose relative to America's largest trading partners is far less compared to corporate tax rates and employee benefit costs driven by health insurance expenses.

American manufacturers continue to enjoy a modest structural cost advantage related to energy costs, which may increase over the next few years due to the boom in U.S. natural gas production.[86, 87] Leading the world in energy efficient industrial buildings would enhance this advantage and help compensate for other structural costs that hinder U.S. manufacturing competitiveness.[81] Conversely, falling behind on energy efficiency would erode this advantage.

When discussing structural costs and total production cost, it is important to note that this data varies by sector and region. It is also important to note that several other comparative advantages may be taken into account with structural costs, such as U.S. investments in early stage, possibly disruptive technologies for PV innovation, knowledge in complimentary industries, and access to private capital.

Due to these added factors, many firms are reevaluating how they calculate the total cost of production in ways that partially offset the large U.S. structural cost disadvantage. For many products, proximity to the customer is important. Rising shipping, rail and road costs are damaging for companies that make goods with relatively low "value-density," such as consumer goods, appliances and furniture.[89] In addition, manufacturers may have concerns about overseas intellectual property protection, long supply lines, workforce reliability, and access to cutting-edge automation and robotic technology. These factors increase America's attractiveness as a location for a manufacturing facility.

The second concept related to structural costs is where a firm will locate the "second plant." Even if an EE or RE firm were to surmount all of the U.S. manufacturing barriers—perhaps through novel production techniques, government incentives, and strong partnerships—the question remains as where that firm might build and operate a second manufacturing facility. Would the new technologies and production know-how be replicated in a nation with lower structural costs? Sometimes that will happen naturally to take advantage of proximity to new markets, but for products that might otherwise be suitable to export from the United States, structural costs make America a significantly less attractive platform.[90]

PPPs can help offset structural costs, but few address them directly. This barrier is predominantly a policy problem. The one exception is energy. As noted above, PPPs like the Energy Efficient Buildings Hub (EEB Hub) based in Philadelphia, NextEnergy in Michigan, or the Oak Ridge National Laboratory Manufacturing Demonstration Facility (ORNL-MDF) can advance energy efficiency for manufacturers and help reduce their structural disadvantage.

Decreased structural costs have been demonstrated by incorportating EE and RE technologies. Industry case studies reveal firms have achieved overall operating cost reductions up to 12 percent as a result of energy-saving efforts.[91, 92, 93] Moreover, a report co-authored by the Department and the Environmental Protection Agency show that investment in energy efficiency technologies such as combined heat and power (CHP) can save industrial and commercial energy users $10 billion a year compared to current (2012) energy use.[94] These data have motived the numerous federal agencies and the current administration to view increased energy productivity in manufacturing as essential to improvement U.S. competitiveness.[95, 96, 97, 98]

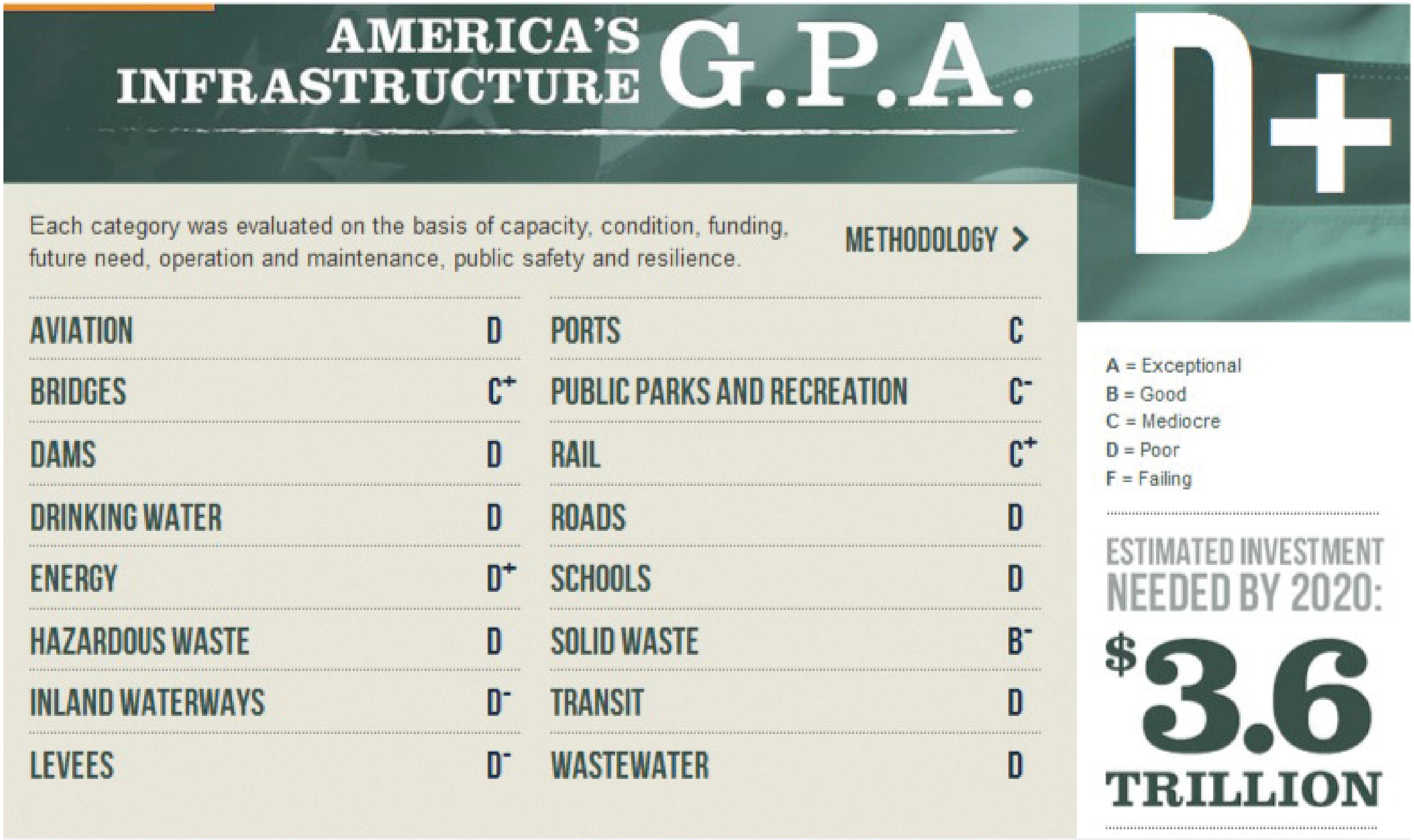
Physical and Cyber Infrastructure

The American Society of Civil Engineers (ASCE) "has a sober message for elected officials, policy makers, businesses, and general public: unless the United States invests an additional $1.57 billion per year in infrastructure—drinking water and waste water, electricity, airports, seaports and waterways, and surface transportation—between now and 2020, the nation will lose $3.1 trillion in GNP (gross national product), $1.1 trillion in trade, a $3,100 per year drop in personal disposable income, $2.4 trillion in lost consumer spending, and a little over 3.1 million jobs."[99] ASCE released this grim new infrastructure report card in March 2013 giving the United States a grade point average of D+ (Figure 10).[100] Manufacturers rely heavily on such infrastructure for their plant operations, supply chain logistics, and product distribution.

That public infrastructure, as well as the private infrastructure of manufacturers, is vulnerable to disruption from cyber-attacks. America relies on vast networks to communicate, power buildings, manage transportation systems, and provide government services. Cyber intrusions and attacks pose an urgent danger to the nation's critical infrastructure, notes the Department of Homeland Security, threatening sensitive personal and business information and potentially disrupting the infrastructure on which manufacturers rely.[101]

Like structural costs, infrastructure barriers to manufacturing competitiveness are predominantly a policy and budget problem. Of the 19 PPPs examined, only the Smart Grid Interoperability Panel (SGIP) appears to directly address a broad-based manufacturing infrastructure need.

Figure 10. Report Card for America's Infrastructure
Source: American Society of Civil Engineers, 2013



Trade Policy

Trade policy presents several barriers to domestic manufacturing, including the cost to source and export versus competitors, restrictions imposed by U.S. export controls, and non-tariff barriers and market distortions that arise from foreign government subsidies to their producers.

Although the United States remains one of the more open countries for trade and investment, it has declined since 2010 from 19th to 23rd in the World Economic Forum's Enabling Trade Index (ETI) of 132 countries (Figure 11). The ETI measures the extent to which individual economies have developed institutions, policies, and services facilitating the free flow of goods over borders and to their destination.[102]

Recent steps by the administration toward a trade and investment pact with Europe would strengthen America's position. Two-way goods trade between the United States and the European Union (E.U.) now totals more than $600 billion annually. More significant is the investment relationship. U.S. companies have invested around $1.9 trillion in production, distribution and other operations in the E.U., far more than in China or anywhere else in the world. E.U. companies have invested about $1.6 trillion in the United States.[103] Globally, the United States and Europe account for 57 percent of the inward stock of foreign direct investment (FDI) and 71 percent of the outward stock of FDI.[104] Lowering the cost for U.S. manufacturers to trade, invest and source in the E.U.—a region with similar wage structures and regulatory standards as the United States—would make many U.S. manufacturers more price competitive than they are today both in Europe and across the globe.

Figure 11. Enabling Trade Index
Source: World Economic Forum

Country/Economy	ETI 2012		ETI 2010 Rank
	Rank	Score	
Singapore	1	6.14	1
Hong Kong SAR	2	5.67	2
Denmark	3	5.41	3
Sweden	4	5.39	4
New Zealand	5	5.34	6
Finland	6	5.34	12
Netherlands	7	5.32	10
Switzerland	8	5.29	5
Canada	9	5.22	8
Luxembourg	10	5.20	9
United Kingdom	11	5.18	17
Norway	12	5.17	7
Germany	13	5.13	13
Chile	14	5.12	18
Austria	15	5.12	14
Iceland	16	5.08	11
Australia	17	5.08	15
Japan	18	5.08	25
United Arab Emirates	19	5.07	16
France	20	5.03	20
Belgium	21	4.96	24
Ireland	22	4.96	21
United States	23	4.90	19

The administration signed an Executive Order on March 8, 2013, that advances its modernization plan to streamline export authorization processes, thereby improving national security and U.S. competitiveness. [105] This represents a major step toward addressing a long-standing barrier whereby U.S. international trade in arms regulations lag behind the pace of global technology diffusion, blocking American firms from selling leading-edge technologies worldwide even when such technologies are available from other nations.

Significant manufacturing trade barriers to EE and RE technologies are subsidies, benefits or rules that foreign governments convey to manufacturers within their borders.[106] This kind of "green mercantilism" includes lax IP enforcement, forced technology transfer, export subsidies, discriminatory standards, barriers to imports and preferential treatment of domestic firms by their parent governments.[107]

U.S. manufacturers also struggle against currency manipulation that can function as a trade barrier, with few tools for recourse.

The International Monetary Fund (IMF) has jurisdiction for exchange rate questions while the World Trade Organization (WTO) oversees rules governing international trade. According to a Congressional Research Service report, "the two organizations approach the issue of currency manipulation differently. The IMF Articles of Agreement prohibit countries from manipulating their currency for the purpose of gaining unfair trade advantage, but the IMF cannot force a country to change its exchange rate policies. The WTO has rules against subsidies, but these are very narrow and specific and do not seem to encompass currency manipulation." [108]

Solving trade barriers also are predominantly a matter for policy rather than partnerships. The exception is the role that partnerships play in standards setting, often an international exercise that helps level markets and make them more efficient. Two of the 19 PPPs examined work on international standards—Smart Grid Interoperability Panel (SGIP) and PDES, Inc., which focus on power grid and aeronautics standards, respectively.

Addressing Clean Energy Market Risks

While the adoption of EE and RE technologies typically involves proven and established technologies, various barriers inhibit their adoption as described in Figure 3. Barriers to the adoption of these EE and RE technologies are diverse, vary based on the end-users, and are often specific to individual technologies. For the purpose of this report, the barriers selected are based on factors widely cited within EE and RE literature that broadly inhibit the adoption of EE and RE technologies in residential, commercial and industrial sectors.

These barriers include:

- Externalities/Public Goods; [109, 110, 111, 112, 113, 114]
- High Costs [24, 25, 26]
- Technical Risks /Uncertainty; [115]
- Low Demand; [116, 117, 118, 119, 120, 121, 122, 123]
- Imperfect or Incomplete Information; [124, 125, 126, 127, 128, 129, 130]
- Hidden Costs/Transaction Costs; [131, 132]
- Access to Capital [32, 33, 34]
- Split Incentives; [133, 134, 135, 136, 137, 138, 139]
- Imperfect Competition/Gold Plating; [140, 141, 142, 143] and
- Bounded Rationality/Cognitive and Behavioral Factors. [144, 145, 146, 147, 148, 149, 150]

As these barriers have been described widely in the literature, they are not expanded upon in this report.

SECTION III

Linkage Between Policy, Partnerships and Manufacturing Barriers

Of the 184 reports reviewed by the Council, 28 were found to align most closely with the topics of EE, RE and manufacturing. They make policy recommendations, identify barriers, or both. The Council also examined over 30 public-private partnerships and gathered detailed information on their characteristics. Of the PPPs examined, 19 were identified as most relevant based on their organizational model and mission. For both policies and PPPs, the Council identified linkages to manufacturing barriers. Companions to this report are three analytical tools, which can be found at www.compete.org.

a. The Policy-Side-By-Side Analysis offers detailed information about the 28 reports, including an overview of the source and a breakdown of the 180 total recommendations. In this analysis, the Council classified the recommendations into 26 distinct categories within the three AMP pillars, and the fourth pillar—Clean Energy Market Risks—was added by the Council for the purpose of this analysis. Some of the most commonly targeted subjects across the reports are tax policy, improving institutions, procurement, talent, and research. Several of the reports also advocate the creation of public-private partnerships.

Policy Recommendation Categories

Enabling Innovation

1. Demonstration Facilities
2. Development/Commercialization—General
3. Innovation Standards
4. Innovation Tax Incentives
5. Public Funding of Pre-Competitive R&D
6. PPPs
7. Technology Development Financing

Securing the Talent Pipeline

8. Immigration Reform
9. K-12
10. On the Job
11. PPPs
12. Tertiary Education
13. Vocational/Credentialing/Community Colleges
14. Workforce Development (including programs targeted at veterans)

Improving the Business Climate

15. Alternative Energy and Transmission
16. Infrastructure
17. Tax Policy
18. Trade Policy

Clean Energy Market Risks

19. Demand Pull Regulations
20. Finance (Adoption—Deployment)
21. Government Procurement
22. Public Outreach
23. Regulatory Reform
24. Standards
25. Tax Credits to Spur Demand
26. Technical Assistance

b. The Public-Private Partnerships Side-By-Side Analysis offers detailed information about the 19 PPPs, breaking them down on 23 characteristics like mission, technology focus, geographic scope, leadership, funding streams, talent development efforts and organizational structure.

The Council used a subset of this information to define four PPP models: (1) Early Market, (2) Mature Market, (3) Test Bed/Demonstration and (4) Innovation Network. The models are similar to the types of consortia put forward in a study by the National Renewable Energy Laboratory (NREL) of PV research and manufacturing PPPs: university-led, industry-led, and manufacturing and testing facilities. [151]

The PPPs included in the side-by-side analysis do not all have a core mission associated with EE, RE, or manufacturing processes. Nonetheless, these PPPs were studied because the organizational model could be applied to such missions.

c. A Summary of Public-Private Partnerships offers deeper insights into the linkages between PPPs, barriers and policy. For each PPP, the summary (1) describes the PPP, (2) categorizes the PPP into one of four models, (3) indicates whether the PPP could be applicable to EE, RE, or advanced manufacturing processes, (4) identifies which recommendations from the 28 reports are directly addressed by the PPP, and (5) which policy recommendations indirectly support the PPP (e.g. through a national funding stream, standard setting process, tax incentive, or procurement policy).

Public-Private Partnership Characteristics

1. Model Type
2. Technology Areas
3. Mission
4. Mission Type (sector specific, regional specific, national, international)
5. Focus Areas (production, standards, demonstration, enabling technology, etc.)
6. Governance
7. Organization Model (501C3, LLC, 501C6, etc.)
8. Partners Involved (industry, academic institutions, government agencies, labs, etc.)
9. Level of Government Involvement (levels of government involved and their involvement, seed funding, etc.)
10. Funding Stream (membership fees, fee-for-service, state, federal, etc.)
11. Original Funders (total scale of investment and public-private ratio)
12. Motivation and Key Actors in Standing-Up Partnership
13. IP Management
14. Metrics of Success
15. Location
16. Number of Years the PPP Has Operated
17. Key Factors that Drive Success
18. Cost (will this partnership reduce technology and/or structural costs)
19. Innovation (how does this partnership encourage innovation)
20. People/Workforce (will we have a better trained workforce because of this partnership)
21. Demand (does this partnership increase demand for products)
22. Leveling the Playing Field (does this partnership level the playing field for clean energy products)
23. Leadership (does this partnership create leadership that will attract manufacturing)

SECTION IV

Public-Private Partnership Models

The Council analyzed PPPs through many lenses, as reflected in the PPP Side-By-Side Analysis. The analysis demonstrated the diversity of PPPs in their missions, geographic scope, funding streams, technology focus, and leadership.

The Council characterized the PPPs by four models. Rather than a strict categorization, the Council suggests PPPs should be characterized by the predominant focus of each public-private partnership. The Council notes that while any one public-private partnership may be predominantly characterized by one model, it may also have characteristics of fit within multiple models:

- **Early Market**
- **Mature Market**
- **Test Bed / Demonstration**
- **Innovation Network**

Models

- **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.

  Structure: Early Market PPPs are typically governed by a board that includes university, industry and government representatives. Lab or university personnel are usually responsible for the day-to-day operations rather than an employee of an independent organization.

  Finance: Early Market PPPs usually rely on federal seed funding to start and some rely in part on annual government funding. Some procure matching funds from industry or fulfill fee-for-service contracts.

- **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 development. The technologies addressed by theses PPPs can be early-stage or more mature, but are characterized as Mature Market if mature companies exist in the marketplace and engage heavily in the leadership.

Structure: Mature Market PPPs usually establish an independent entity governed by a board of mainly corporate representatives. These PPPs often have a scientific advisory board staffed by member companies and tend to include representatives across supply chains.

Finance: Government typically, but not always, supplies seed money and research grants. Four of the six Mature Market PPPs examined receive state funding on an annual basis. As the PPP becomes established, companies tend to contribute most of the funding through a system of membership dues.

- **Test Bed / Demonstration PPPs** focus predominantly on testing and demonstration—often working to establish the market for an emerging technology or group of technologies. 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 tend to be local by nature—utilizing the local community for testing purposes—even if their user community is national or global in scope. For example, the Solar Technology Acceleration Center (SolarTAC) conducts testing of solar devices on the local community's power grid, and the EEB Hub works closely with the city of Philadelphia both to develop new building codes and test energy efficiency building technologies in order to achieve a goal of reducing energy use in the regional-Philadelphia commercial buildings sector by 20 percent by 2020.

  Structure: Test Bed / Demonstration PPPs are usually administered either by organizations contracted by government to operate them or by nonprofits established by members participating in the PPP. The leadership of the PPPs in the Council study varied between industry, academia, laboratories and nonprofits. They also tend to have close working relationships with local governments and economic development authorities.

  Finance: Government typically provides seed funding for Test Bed / Demonstration PPPs, often including resources to purchase equipment. Federal, state and local government sometimes continue annual financial support after establishment. Fees for services make up the other primary revenue stream.

- **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 National Network for Manufacturing Innovation or nanotechnology applications under the Interuniversity Microelectronics Centre.

  Structure: A nonprofit organization, overseen by a board of industry and academic representatives, typically governs the day-to-day activities. The nonprofit is often a research institute or a network of institutes. Because of the network characteristic, these PPPs are often decentralized and sometimes the nodes of the network are autonomous, though related.

  Finance: Governments typically provide a significant share of the seed money—often 50 percent or more. Governments also supply research grants. Of 5 European Innovation Network PPPs all receive regular annual funding from the government and are commonly considered to be strategic national innovation infrastructure for applied research. Innovation Network PPPs also supplement their budgets through contracted research and development with industry or fee-for-service contracts for industry researchers to use lab infrastructure.

Figure 12. PPPs Grouped by Model

PPP Model	PPPs Analyzed by the Council on Competitiveness
Mature Market	CCAM, CSE, SEMATECH, SGIP, PVMC, PDES
Early Market	JCESR
Test Bed / Demonstration	EEB Hub, NextEnergy, ORNL-MDF, SolarTAC
Innovation Network	NAMII, NNMI, NDEMC, Catapult, ITRI, Fraunhofer, IMEC, GTS

Insights

To pull together insights about how the PPP models relate to manufacturing barriers, public policy, and EE and RE technologies, the Council conducted detailed cross-cut examinations described in Section III of this report—a Policy Side-by-Side Analysis, a Public-Private Partnership Side-by-Side Analysis, and a *A Summary of Public-Private Partnerships* that are companion pieces to this report. The Council also interviewed key leaders across the country involved in the development of PPPs and mapped the activities of each PPP across the Technology Readiness Levels.

The following sections will present insights from these reviews, helping to understand (1) how to match PPP models to EE and RE 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.

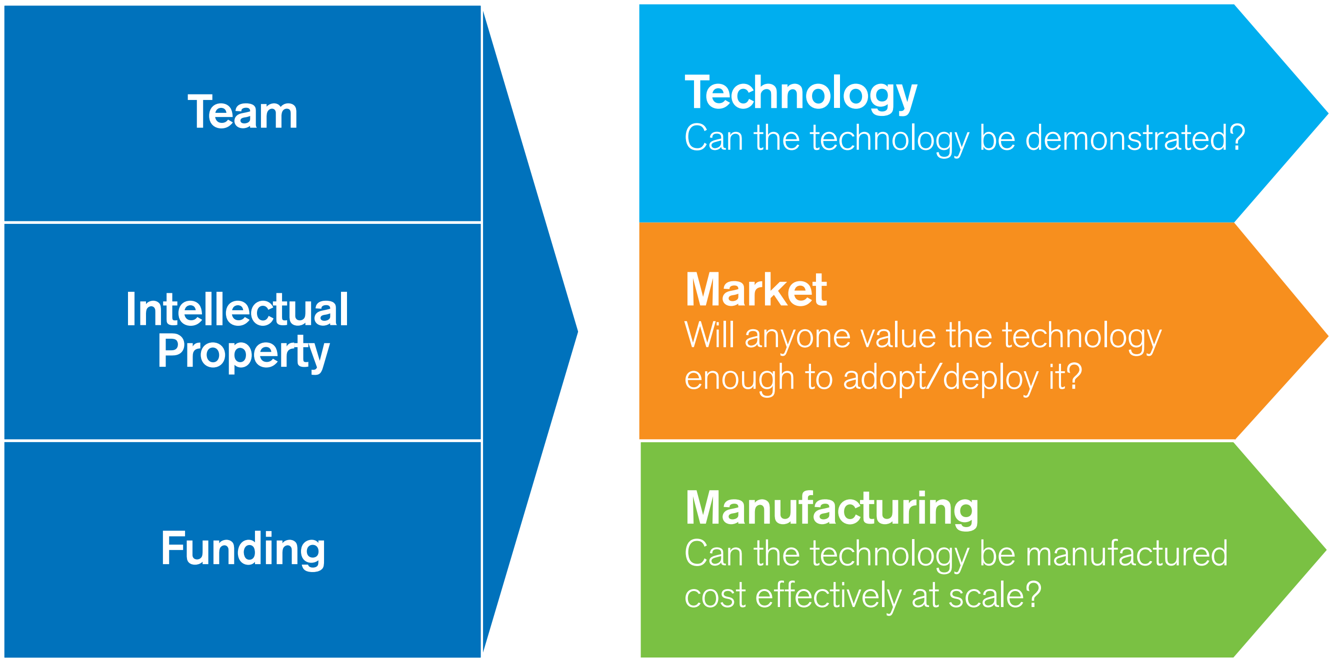
1. Matching PPP models to EE and RE Challenges: Based on the Council's PPP review, this report suggests that the first step toward matching a PPP to a particular EE or RE manufacturing challenge is to assess the market readiness and availability of test bed facilities for a particular technology or basket of technologies. This would be similar to the market assessments made by the Advanced Research Projects Agency-Energy (ARPA-E) of a technology's readiness on a performance and cost basis to scale without subsidy.[152]

ARPA-E's mission centers on cooperative agreements to support strategic medium maturity or near market-ready energy technologies and help move them to market. Part of that process is prospective grantees working with ARPA-E to submit plans with specific technical performance and technology-to-market milestones (Figure 13).[153] The Office of Energy Efficiency and Renewable Energy (EERE) has slightly different dynamics. EERE's portfolio of technologies varies from early market to more mature market, and EERE has authority to pursue its mission through a wider range of activities, including the establishment of PPPs.

More mature EE and RE technologies would be candidates for a Mature Market PPP. The parameters for a Mature Market PPP could be determined by a dialogue with industry leaders in those fields. If there is an adequate body of pre-competitive research, common advanced manufacturing processes/technologies, or standards issues that entice private sector time and investment—then government efforts to seed or convene such a PPP could bear fruit. SEMATECH is a good example of a Mature Market PPP.

Sometimes industry interest and engagement also can be generated by a PPP that focuses on an industry supply line or value chain. In response to the Council's interview questions, SEMATECH's Director of Corporate Relations and Resources, Anne Englander, wrote, "SEMATECH engages the whole supply chain, including manufacturers, universities, national labs, research institutes, equipment/materi-

Figure 13. Elements of ARPA-E Technology-To-Market Plans
Source: Advance Research Projects Agency–Energy



als manufacturers and other suppliers. This engagement allows each entity to improve its understanding of its customers' needs, and helps drive alignment and consensus across the broader industry…Collaboration with, and alignment of, a U.S. supply chain is needed to provide insight and guidance on the strategic investments required to achieve consortia goals…and accelerate progress toward commercialization." Another example was provided by Paul Hallacher, Director of Research Program Development at Penn State University and a leader of the EEB Hub—a Test Bed / Demonstration PPP. Hallacher told the Council that supply chain integration drew more corporate participation into hub activities.

Early Market PPPs tend to work on early-stage technologies that hold great promise but require significant price and performance improvements before they would be ready for commercialization. If a critical mass of companies is unwilling or unavailable to devote resources to lead a PPP for an early stage EE or RE technology, then establishing an Early Market PPP led by a national lab or university is probably the best route to advance the technology. If the challenge is less about the maturity of the market that would utilize the EE or RE technology, but more about a lack of testing and demonstration infrastructure, then establishing a Test Bed / Demonstration PPP is an option to consider. The Council observes that some PPPs are established with a strong focus on performing testing and demonstration activities—because that is what the market is missing or the challenge demands. The leadership and location of a Test-Bed / Demonstration PPP may rely more on locating in a region with a strong concentration of talent and infrastructure than on a region's market maturity.

If the EE or RE barrier is related to a lack of applied research in broad technology fields (e.g. advanced manufacturing or materials science) that apply to multiple EE and RE technologies, then an Innovation Network PPP might be the best model. The network of institutions or networked sub-PPPs consist of individual nodes with a specific technology component focus or specialization that contributes to the advancement of the broad technology. Each node on the network might be categorized as one of the other three PPP models or a smaller scale Innovation Network itself. The Innovation Networks facilitate the sharing of expertise and resources among individual network nodes—through shared IP, convening stakeholders or other means—which in turn accelerates the development of new technologies. For example, the NNMI is focused on advanced manufacturing broadly and will consist of linked Institutes for Manufacturing Innovation (IMIs) with common goals, but unique concentrations such as NAMII which is focused on additive manufacturing—a component of advanced manufacturing.

2. Scope of PPP Activities across Technology Readiness Levels: Regardless of which model is best suited to a particular EE or RE challenge, the activities undertaken by the PPP should most likely extend across Technology Readiness Levels. As seen in Figure 14, most of the 19 PPPs examined stretch across several Technology Readiness Levels (most commonly TRLs 2-8). This functional reality validates the Council's assertion that research and production considerations form a virtuous feedback loop and that competitiveness relies on strategies for continual innovation. [154] It also reflects the desire by many PPPs of all four characterizations to transition ideas into production. The Joint Center for Energy Storage Research, for example, is not only researching material properties, but also building and testing prototypes. [155] The Fuel from Sunlight Hub is working to create a prototype device that can produce fuel from the sun 10 times more efficiently than plants and has an objective to "provide system integration and scale-up so that laboratory experiments can be transitioned into prototypes for commercial development." [156]

The Council mapping of PPPs across the TRLs shows that most of the PPPs engage in activities that range from applied research to early stage production, even if their primary focus is on a smaller portion of the TRL spectrum. The greatest variability appears to be for Mature Market PPPs, where some, like SEMATECH, focus primarily on pre-competitive research and others, like PDES, Inc. and SGIP, focus on developing standards.

Regardless of which model is best suited to a particular EE or RE challenge, the activities undertaken by the PPP should most likely extend across the technology readiness scale.

One PPP, the National Digital Engineering and Manufacturing Consortium (NDEMC), can be viewed as tackling two TRL needs. NDEMC serves as a model on how bringing several actors together enables a strategic technology to penetrate a broader market. NDEMC's mission, additionally, centers on helping multiple industries move more effectively from the proof-of-concept stage to prototyping through modeling and simulation.

3. Applying PPP Models to Lowering EE and RE Manufacturing Barriers: The Council examination finds that four of the manufacturing barriers identified in this report—capital requirements, innovation infrastructure, the low investment in advanced manufacturing technologies, and talent—are commonly addressed by PPPs. The other three manufacturing barriers—structural costs, public and cyber infrastructure, and trade policy—are largely policy problems that few PPPs address (Figure 15).

Almost all of the PPPs (17 of 19) addressed talent barriers in some way as part of their mission. *A Summary of Public-Private Partnerships* breaks down in significant detail which talent issues are addressed by each PPP, such as K-12, vocational credentialing, on-the-job training, tertiary education, partnerships with community colleges and employers, or workforce development. The most common talent development efforts center on tertiary education (12 PPPs) and workforce development (10 PPPs). The least commonly addressed were K-12 (2 PPPs) and vocational credentialing (3 PPPs).

Figure 14. Mapping Public-Private Partnerships Across Technology Readiness Levels

Source: Council on Competitiveness

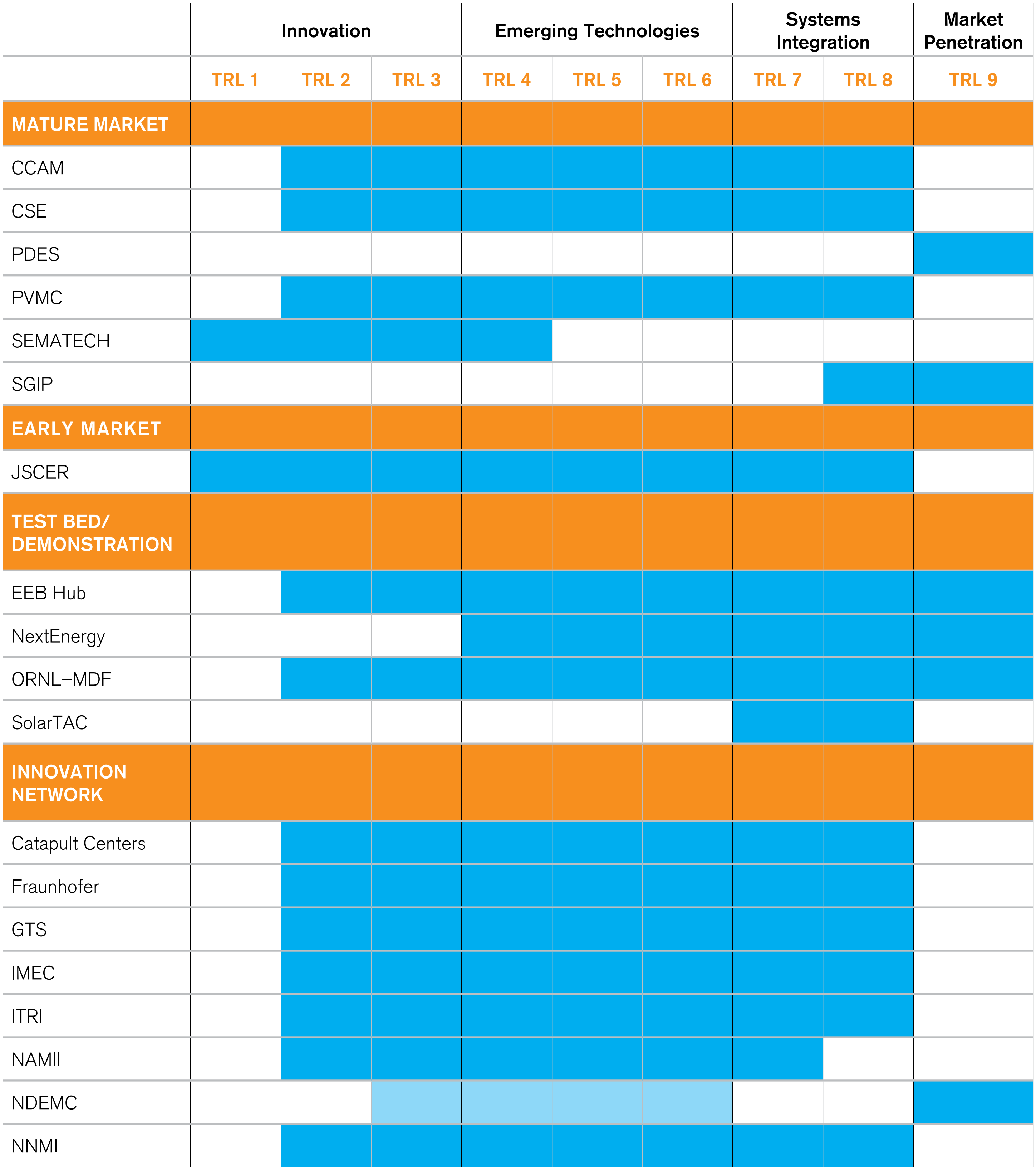


Figure 15. Barriers Addressed by PPPs

Source: Council on Competitiveness

Manufacturing Barrier	PPPs that Help Address the Barrier
Capital Requirements	CSE, EEB Hub, NextEnergy, Fraunhofer, ITRI
Innovation Infrastructure	CCAM, CSE, SEMATECH, PVMC, JCESR, EEB Hub, NextEnergy, ORNL-MDF, SolarTAC, Catapult, Fraunhofer, GTS, IMEC, ITRI, NAMII/NNMI, NDEMC
Maturity of Manufacturing Technology	CCAM, NAMII/NNMI, NDEMC, SEMATECH, ORNL-MDF, PVMC, Catapult, ITRI, Fraunhofer, IMEC, GTS, PDES
Talent	CCAM, CSE, EEB Hub, NAMII/NNMI, JCESR, NDEMC, NextEnergy, SEMATECH, ORNL-MDF, PVMC, SolarTAC, Catapult, ITRI, Fraunhofer, IMEC, GTS
Structural Costs	EEB Hub, NextEnergy, ORNL-MDF
Public & Cyber Infrastructure	SGIP
Trade Policy	SGIP, PDES
Addressing Clean Energy Market Risks	EEB Hub, CSE, JCESR, NDEMC, NextEnergy, ORNL-MDF, PVMC, SolarTAC, Catapult, Fraunhofer, GTS, ITRI, IMEC, PDES

Almost all of the PPPs (17 of 19) also address strengthening innovation infrastructure, spanning the four models. Although only five PPPs address capital requirements directly through loans or grants, the 17 PPPs offering innovation infrastructure do more than provide shared facilities and a climate for innovation—they also reduce the capital requirements that firms otherwise would have to meet if those facilities were not available.

Thirteen of the 19 PPPs examined address low investment in advanced manufacturing technologies. The high number partly reflects the Council's selection bias to examine manufacturing-related PPPs, but it also demonstrates that partnerships are a common way to pursue leadership in such enabling technologies. Most of the 13 that address this barrier are either Mature Market PPPs or Innovation Network PPPs.

The three manufacturing barriers that need to be addressed primarily by policy actions—structural costs, public and cyber infrastructure, and trade policy—are only marginally addressed by the PPPs examined. Exceptions include (1) efforts by the EEB Hub, NextEnergy and ORNL-MDF that could lower structural costs via energy efficiency, (2) work by SGIP to improve the performance of the electric grid, and (3) international standards collaborations by SGIP and PDES that reduce the risk of non-tariff trade barriers. One element of the AEMC Partnership dialogues could be to examine whether and how PPPs might be leveraged more effectively to address these three manufacturing barriers.

4. Government Role in PPP Funding and Formation: Council analysis and interviews found that government plays a critical formation role for PPPs across all four models. Ten PPPs were started with federal funding, three PPPs were started with state funding, and four PPPs were jointly funded.

Depending on the scope of activities, seed funding to start the PPPs ranged from $3 million to $100 million, with significant variation between each model. For example, three Mature Market PPPs received less than $10 million in seed money, while SEMATECH ($100 million) and the Photovoltaic Manufacturing Consortium (PVMC, $62.5 million) received substantially more. Of the Test Bed/Demonstration PPPs, SolarTAC received no government funding while the other three with more extensive partner networks like the EEB Hub did.

The Council observes that American PPPs that are established by the federal government—whether the intent is to transition the PPP to a private entity (such as SGIP) or to establish a partnership through a competitive process (such as JCESR, EEB Hub, NAMII and ORNL-MDF)—typically receive government seed funding on an annual basis for the first 1-7 years. This federal funding typically accounts for 40 percent or more of the PPPs revenue stream for the first few years of operation.

Some model specific observations about seed funding:

- Early Market PPPs rely more heavily on federal seed funding with less matching funds from industry and universities.
- Mature Market PPPs tend not to rely on continual federal government funding, but several receive federal grants at the time of establishing the partnership (e.g. CCAM, PVMC). Federal seed funding was 50 percent or less of total seed funding for three of the six Mature Market PPPs examined. In one case, SGIP, the federal government provided all of the seed funding. For CSE and PDES the federal government provided no seed funding. Many Mature Market PPPs become self-sustaining over time through funding streams such as member dues or user fees.
- Test Bed / Demonstration PPPs can be for-profit enterprises, but typically they rely on government seed funding (e.g. ORNL-MDF, EEB Hub). Those commissioned by states rely primarily on state seed funding, such as NextEnergy. Because of their local nature, many Test Bed / Demonstration PPPs (e.g. SolarTAC, EEB Hub, NextEnergy) also receive seed funding or economic development benefits from local government.
- Innovation Network PPPs tend to get seed funding from the federal government that is matched by industry and university members (NDEMC, NAMII) and require a 1:1 funding ratio. European Innovation Network PPPs tend to be established with a majority of seed funding coming from the federal governments (IMEC, ITRI, Catapult). State and local governments sometimes provide a small amount of seed funding to establish individual nodes of the networks.

Perhaps equally important to the government's funding role in founding new PPPs is the public sector's role as a neutral convener. Government leaders can bring together corporate or university competitors to tackle common problems that none of the individual partners could reasonably be expected to host or fund on their own initiative.

Once a PPP is established, government financial support in the United States typically continues in the form of competitively awarded federal or state research grants.

In many cases, government agencies continue active engagement with PPPs. They typically do not become members of the PPP but maintain an advisor, observer or oversight role. In some cases, however, government agencies do become PPP members, such as the National Institute of Standards and Technology participating in SEMATECH and PDES.[157, 158] Government-owned laboratories also can play a leadership or partner role in PPPs, such as the Argonne National Laboratory's lead role in the JCESR.

5. PPP Success Factors: The Council uncovered several success factors in our conversations with PPP leaders that apply to multiple models. Common success factors include:

- strong leadership
- clear, compelling mission
- early funding stream to establish the PPP, usually from the public sector
- intellectual property practices that attract corporate participation
- participation across industry value chains
- engagement by multiple large companies
- affordable membership terms for small companies

- regional organization or other mechanisms to engage entrepreneurs and the 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

As the Department and the Council host dialogues on PPP models, these topics are likely to be raised in significant detail. For example, even if an EE or RE challenge is determined to be best met by a Mature Market PPP where leadership is often a member of industry, the initial leadership typically must come from the public sector. A deeper understanding of success factors by the public sector will increase the chance that a productive PPP will emerge.

Two fairly undefined "whitespace" areas are worthy of mention. First, the Council notes that few of the examined PPPs have clearly defined success metrics and measurement systems to assess and manage their effectiveness. The Department and the Council may want to consider including this topic into the dialogues and ultimately recommend transparent measurement systems as a condition for establishing new PPPs.

Second, an important change is underway across the United States. Many universities are experimenting with new ways to manage intellectual property, favoring flexibility and industry engagement over strictly maximizing license revenue. Labs, too, are pursuing more flexible engagements using tools like the newly-developed Agreements for Commercializing Technology (Figure 16). Several leaders interviewed by the Council emphasized that upfront clarity on IP practices is one of the most critical success factors. An examination of best practices in intellectual property for each model would be a valuable dialogue component, particularly for Early Market PPPs.

Figure 16. Agreements for Commercializing Technology (ACTs)

Source: Council on Competitiveness

ACTs offer more flexibility in negotiating intellectual property rights for technologies created at participating national laboratories. More flexible terms also are available under ACTs on issues like payment arrangements, project structures, and indemnification. ACTs seek to ease the creation of multi-party research and development partnerships so companies, universities, and other entities can come together with a laboratory to address complex technological challenges of mutual interest.

Participating National Laboratories

Ames	NREL
Brookhaven	Oak Ridge
Idaho	Pacific Northwest
Lawrence Livermore	Savannah River

SECTION V

Conclusion and Next Steps

Future dialogues centered on the four PPP models could be used to learn more about which kinds of partnerships would be most appropriate to facilitate manufacturing of EE and RE technologies in the United States, and to enhance manufacturing competitiveness across the board with energy productivity measures. The Council's research and conversations with partnership leaders suggest that further dialogue on PPPs models, success factors, success metrics, and goals for success would contribute significantly toward this objective.

This report and supporting and companion materials offer rich detail about the policies, partnerships and barriers that are relevant to technology commercialization and manufacturing. A continued dialogue that explores EE and RE technologies through the prisms presented here could lay the groundwork for important advances in U.S. energy and manufacturing competitiveness.

- What kinds of partnerships are optimal or existent for various technologies?
- What steps would most improve the current landscape and have the greatest chance of generating a return on public investment of resources and effort?
- What barriers can be addressed and how can complimentary policy and partnership efforts be effective?

The Council looks forward to a continued partnership with the Department of Energy's Office of Energy Efficiency and Renewable Energy and an even deeper examination of these issues with our membership and extended network of experts.

This report is intended to be an overview of PPPs and their method to lower barriers to the wide-spread adoption of EE, RE and manufacturing advanced technologies and to U.S. manufacturing processes. Other PPPs exist that are not included in this report may address barriers described in this report, but were considered outside of the scope of work.

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APPENDIX A

Public-Private Partnership Summaries

NATIONAL

Commonwealth Center for Advanced Manufacturing (CCAM)

http://www.ccam-va.com/about-us/
Disputanta, VA

Overview

The Commonwealth Center for Advanced Manufacturing (CCAM) is a nonprofit, membership-based, scientific, research and educational corporation located in Virginia. CCAM brings together universities and multiple companies to collaborate in a research consortium focused on developing surface engineering technologies and intelligent manufacturing processes and systems. CCAM provides shared facilities, equipment and personnel to its members. Research is directed by industry and executed by university members, and takes place at the CCAM facility as well as each of the universities.

Mission

The mission of CCAM is to bridge the gap between fundamental research and commercialization; foster collaboration among diverse industry sectors; lower R&D costs for member companies; and train next generation technology leaders. CCAM focuses on accelerating technology into markets and demonstrating it on real problems. CCAM conducts generic, directed, and guided research. Generic research is funded and guided by the members, and members have rights to non-exclusive, royalty-free licenses to all intellectual property developed. Members can also individually fund and direct the work of CCAM research staff in directed research projects and own the intellectual property that results. CCAM core research focus areas are:

- Surface characterization
- Coating application methods
- Material handling
- Digital manufacturing
- Modeling and simulation
- Inspection, testing and validation techniques
- Surface preparation
- Material development
- Design for manufacturing
- Manufacturing process control
- Data collection and management
- Human factors and knowledge capture

Organization

CCAM is comprised of 15 industry members (OEMs and SMEs) from around the world and 3 Virginia-based university members (University of Virginia, Virginia Tech, Virginia State University). University members provide faculty and students, who will work exclusively at CCAM to conduct research. Industry membership is divided into four tiers:

- Organizing Industry Members (OIM): join during CCAM's formative stage and agree to a long-term commitment. They have influence over initial organization, management, vision and research plans. They appoint one voting member to the CCAM Board of Directors, and CCAM's Industry Operations Board and the Technical Advisory Council. They are permitted to sponsor directed research.
- Tier 1 Industry Members: appoint one voting member to the Industry Operations Board and the Technical Advisory Council to lead activities. They are permitted to sponsor directed research.
- Tier 2 Industry Members: participate in generic research and will have non-exclusive, perpetual, royalty-free rights to its results while a company is a member. Tier 2 members will appoint one member from their ranks to the CCAM's Technical Advisory Council.
- Tier 3 Industry Members: Tier 3 members commit manufacturing equipment, tools and research instruments to CCAM and serve on its Technical Advisory Council.

Funding

Organizing Industry Members and Tier 1 Industry Members each pay $400,000 per year in membership fees. Tier 2 Industry Members each pay $100,000 per year in membership fees. All Members commit to a minimum of five years of membership.

Energy Efficient Buildings Hub (EEB Hub)

http://www.eebhub.org/about-eebhub
Philadelphia, PA

Overview

The Energy Efficient Buildings Hub (EEB Hub) was established by the U.S. Department of Energy (DOE) as an Energy-Regional Innovation Cluster located at the Navy Yard in Philadelphia, PA. The Navy Yard serves as both the headquarters and a living laboratory for the hub. While DOE is the sponsor of the hub, Pennsylvania State University manages the hub as the primary contractor, earned through a competitive proposal and selection process. The EEB Hub is an open consortium focused on accelerating the adoption of advanced energy retrofits in commercial buildings by working on the design, demonstration and deployment of market proven solutions in the Greater Philadelphia region so that the buildings sector accomplishes its full potential for ongoing energy efficiency.

Mission

The EEB Hub has a dual mission of improving energy efficiency in buildings and promoting regional economic growth and job creation from its headquarters in Philadelphia's Navy Yard. The overall goal of the EEB Hub is to reduce annual energy use in the U.S. commercial buildings sector by 20 percent by 2020. The mission is to accomplish the goal through informed people, validated information, and proven technologies.

The objectives of the EEB Hub are as follows:

- Develop and deploy to the building industry a state-of-the-art modeling platform to integrate design, construction, commissioning, and operation
- Demonstrate the market viability of integrating energy saving technologies for whole building solutions at the Navy Yard and elsewhere in the region.
- Identify policies that accelerate market adoption of energy efficient retrofits of commercial buildings and support policy makers in the development of such policies in the Greater Philadelphia region.
- Inform, train, and educate people who design, own, construct, maintain, or occupy buildings about proven energy saving strategies and technologies
- Help launch ventures with new and existing companies that will exploit market opportunities for providing whole building energy saving solutions.

The Hub is focused on the following:

- Performing research needed to integrate disparate technologies into a building to optimize energy performance
- Researching and developing the technologies, models and analytical tools needed to do this better (where technical solutions do not currently exist or are not optimized)
- Demonstrating the results in buildings, measuring results, and cycling back to continue to optimize this whole building approach
- Scale solutions which involves cost considerations, job training, marketing, and policies among other issues

Organization

The EEB Hub is comprised of both members and charter partners. The EEB Hub members include 22 organizations made up of 11 academic institutions (research universities and community colleges), 2 DOE laboratories, 6 industrial firms, and economic development agencies. Charter partners consist of 60 partners who provided letters of support for the EEB Hub drawn from stakeholder groups including government, industry, education and workforce development, banking and finance, labor, and philanthropic foundations.

The Executive Board is the ultimate decision making authority within the Hub. It is comprised of various leaders from Hub members and the Executive Director. The EEB Hub is managed by Pennsylvania State University, which is responsible for hierarchical control with decentralization, promoting day-today teamwork but also providing authoritative decision-making when needed. The Operating Committee is made up of the Task Team Leaders, the Director for Technology and Operations, and the Director for Management and Administration.The Advisory Board advises the Executive Director and the Operating Committee and serves two primary functions: 1) strategic review and assessment of Hub research and deployment activities and 2) assistance with the diffusion of cluster discoveries and practices to the region and beyond.

Funding

The EEB Hub is funded through a combination of government funding (federal and state) and membership contributions. Federal funding for the EEB Hub's first five years of operation comes primarily from the DOE ($122 million), with additional contributions from EDA ($5 million), NIST ($1.5 million), and SBA ($1.3 million). The Commonwealth of Pennsylvania is providing separate funding for EEB Hub facilities ($30 million). EEB Hub participants make cost-sharing contributions.

Fraunhofer Center for Sustainable Energy Systems (CSE)

http://cse.fraunhofer.org/
Cambridge, MA

Overview

The Fraunhofer Center for Sustainable Energy Systems (CSE) is a nonprofit, applied R&D laboratory dedicated to the commercialization of clean energy technology. CSE was established in 2008 through a partnership between Fraunhofer USA, Massachusetts Institute of Technology (MIT) and the State of Massachusetts. CSE focuses on solar photovoltaic modules, building efficiency, and materials. CSE partners with private companies, government entities, and academic institutions, to conduct collaborative research and development through confidential co-development programs and joint applications for grant programs; third-party validation to evaluate system and materials performance; and technology commercialization assistance for early-stage clean technology companies.

Mission

The mission of CSE is to foster economic development through the commercialization of clean energy technologies for the benefit of society. CSE's work is divided into three major focuses areas: 1) photovoltaic (PV) modules, 2) building energy efficiency, and 3) technology commercialization. The PV modules group focuses on applied research for reducing cost, increasing efficiency and improved durability of PV modules through the development of innovative PV module designs and materials, proof of concept, pilot production, certification and full production. CSE is a joint owner of the CFV Solar Test Laboratory. The building energy efficiency research group focuses on applied R&D in the areas of building enclosures and residential energy management in order to develop, commercialize, and deploy energy-saving building technologies and practices. CSE has also developed a "living laboratory" for testing and demonstrating new building technologies with its Building Technology Showcase. CSE also focuses its work on assisting clean technology start-ups through its TechBridge program that offers start-up companies access to its applied resources and provides assistance in obtaining capital and channels to markets.

CSE also provides various forms of talent and workforce development through its fellowship program and various partnerships. The Fraunhofer-MIT Alliance provides faculty and students of MIT opportunities to collaborate on CSE projects and gain valuable experience. CSE's Massachusetts Partnership focuses on job creation and workforce development by working with the Massachusetts Clean Energy Center to create and support jobs through fostering early-stage clean energy companies and providing training and education.

Organization

A managing director, scientific director and several advisors from the Fraunhofer network lead CSE. The CSE also has board of advisors that includes an administrative board, buildings board, and solar board comprised of energy experts from the Fraunhofer network, MIT faculty, industry entrepreneurs and researchers, and members of the Massachusetts state government.

CSE is part of Fraunhofer USA, a wholly owned subsidiary of German-based Fraunhofer-Gesellschaft.

Funding

CSE was originally funded by a group of founding sponsors which provided $21.5 million in seed funding. The CSE funding model requires that 2/3 of operating revenue to be competitively earned through contract research for commercial clients and research funding agencies. The founding sponsors of CSE include Fraunhofer- Gesellschaft, the State of Massachusetts, Fraunhofer Institute for Solar Energy Systems, four major U.S. foundations, and National Grid. Fraunhofer Institute of Building Physics is a project sponsor, and Weil, Gotshal, and Manges LLP provides legal counsel in areas such as contract law and intellectual property is an in-kind sponsor.

Joint Center for Energy Storage Research (JCESR)

http://www.jcesr.org/
Lemont, IL

Overview

The Joint Center for Energy Storage Research (JCESR) is a research partnership established in 2012 to overcome critical scientific and technical barriers and create new breakthrough energy storage technology. The U.S. Department of Energy established JCESR. While DOE is the main sponsor, Argonne National Laboratory manages the center as the primary contractor, earned through a competitive proposal and selection process. JCESR consists of partners from five research universities, five national laboratories, and four industry members with expertise along the whole innovation pipeline.

Mission

The mission of JCESR is to develop and commercialize new energy storage technologies that go beyond today's best Li-ion systems to provide five times the energy storage at one-fifth the cost in five years. The partnership will focus on end-to-end integration across all aspects of the full RDD&D pipeline- from basic research to prototype development and product engineering to market delivery. JCESR provides partners with the tools and institutional backing they need to discover new materials, accelerate technology development, and commercialize revolutionary new energy storage technologies.

Funding

The partnership is funded by an initial $120 million investment by DOE and $5 million from the State of Illinois for the construction of facilities with another $30 million promised over time. Partners will also make contributions to the center as well.

National Additive Manufacturing Innovation Institute (NAMII)

http://namii.org/
Youngstown, OH

Overview

The National Additive Manufacturing Innovation Institute (NAMII) is an applied research consortium focused on additive manufacturing innovation located in Youngstown, Ohio. In 2012, the National Center for Defense Manufacturing and Machining (NCDMM)—a nonprofit focused on identifying and implementing innovative manufacturing systems and technologies for U.S.-based producers of Department of Defense systems—established NAMII. The federal government selected NCDMM through a competitive process to operate the program. NAMII is a member-based consortium comprised of industry, academia, and other nonprofit organizations. NAMII's goal is to transition additive manufacturing technology to the mainstream U.S. manufacturing sector and create an adaptive workforce capable of not only meeting industry needs but also increasing domestic manufacturing competitiveness.

Mission

The mission of NAMII is to accelerate additive manufacturing technologies to the U.S. manufacturing sector and increase domestic manufacturing competitiveness. NAMII will accomplish the mission by:

- Fostering a highly collaborative infrastructure for the open exchange of additive manufacturing information and research.
- Facilitating the development, evaluation, and deployment of efficient and flexible additive manufacturing technologies.
- Educating students and training workers in additive manufacturing technologies to create an adaptive, leading workforce.

NAMII provides a company access to cutting-edge capabilities and equipment as well as training for using the equipment. NAMII competitively seeks to undertake projects that adhere to the gaps and needs within the National Additive Roadmap. Projects selected will be based on their applied research, high sustainability, digital data, viability of educational outreach and workforce training. NAMII conducts both generic collaborative research as well as member-guided and funded research. IP generated from projects funded by federal or membership funds will be provided to NAMII members with royalty free, non-exclusive rights. Certain membership level members also have the opportunity to self-fund applied research projects for which they will have exclusive rights to IP developed.

Organization

Membership for NAMII is open to all U.S. industrial organizations, academic institutions, non-profit agencies, federally-funded research and development centers (FFRDCs), and governmental agencies interested in furthering additive manufacturing (AM) technology and education. There are three tiers of membership that have varying costs and benefits: Lead Membership, Full Membership, and Supporting Membership. Currently NAMII is comprised of 40 industry members, 9 research universities, five community colleges, and 11 nonprofit organizations.

NAMII employs a shared leadership model between industry and government, which includes a technical advisory committee, governance board, and executive committee. The Technical Advisory Board is a multi-agency government group that advises on technical direction, including strategic visioning; project selection and project review; education and workforce development; industry partnering; and other technical activities within the institute. The Governance Board is comprised of representatives from Lead and Full member organizations; directors from member Manufacturing Extension Partnerships (MEPs); and small business members. The Governance Board provides collective input to the NAMII Executive Committee. The Executive Committee is consists of representatives from industry, academic, and government members and are elected by the NAMII Governance Board. A director and four deputy directors run day-to-day operations.

Funding

A $30 million grant from government, matched by $40 million from members helped establish NAMII. Moving forward, funding will rely on membership fees, research grants and fee-for-service activities. Additionally, all research projects require a 50-50 cost share between members and NAMII.

National Digital Engineering and Manufacturing Consortium (NDEMC)

http://ndemc.org/
National/Washington, D.C.

Overview

The National Digital Engineering and Manufacturing Consortium (NDEMC) is a partnership established in 2011 to demonstrate the impact that high performance computing and modeling and simulation can have on small and medium-sized manufacturers competitiveness.

Mission

The mission of NDEMC stems from the Council on Competitiveness' longstanding efforts in driving high performance computing capabilities, and focuses on developing pilot programs that promote the adoption and advancement of modeling and simulation and high performance computing among small and medium-sized manufacturers (SMEs) in the U.S. Midwest. NDEMC provides SMEs access to high performance computing hardware, software, and technical resources through partnerships with state high performance computing centers, national laboratories and universities. By providing SMEs with expertise, consulting, education and training on the use of advanced modeling and simulation resources, the SMEs are able to innovate new products, solve technical problems, and improve production capabilities. NDEMC also supports and promotes the development of shared infrastructures such as web-based application software gateways, pay-per-use cost models, and online training and certification.

Organization

The Council on Competitiveness is responsible for managing the day-to-day operations as the secretariat and fiduciary agent for the project. The Executive Board is comprised of representatives from each OEM and solution provider partners. The board sets the strategic direction of NDEMC and identifies and selects SMEs to participate.

Funding

The Council on Competitiveness—which brought nearly $3 million in private sector and state funds to the table—developed the consortium through a public-private partnership, with nearly $2 million in matching funds from the Department of Commerce Economic Development Administration (EDA). The Council on Competitiveness manages NDEMC, and the consortium is comprised of five federal agencies, one national laboratory, four OEMs, three academic institutions, and three nonprofit organizations.

National Network for Manufacturing Innovation (NNMI)

http://manufacturing.gov/nnmi.html
National/Washington, DC

Overview

In 2012, President Obama announced a $1 billion proposal to create a National Network for Manufacturing Innovation (NNMI). The NNMI is an interagency initiative to create a network of up to 15 Institutes for Manufacturing Innovation (IMIs) each with distinct manufacturing topic or technology focus areas. The NNMI will bridge the gap between research and development activities and the deployment of technological innovations in the domestic production of goods.

Mission

The mission of NNMI is to create an effective manufacturing research infrastructure for U.S. industry and academia to solve industry-relevant problems. The Advanced Manufacturing National Program Office (AMNPO) is responsible for managing and coordinating the development of the NNMI. AMNPO is comprised of representatives from federal agencies with manufacturing-related missions as well as fellows from manufacturing companies and universities. The AMNPO is responsible for selecting the individual IMIs through a competitive proposal and review process.

Organization

IMIs can be led by independent U.S. not-for-profit institutions as well as other lead organizations such as universities. Partners in each IMI should include national, state, and local stakeholders from manufacturing enterprises; higher education; research organizations; national laboratories or government agencies; career and technical institutions; state, regional, and local public and private entities that support industrial clusters and associated economic development partnerships; unions; professional and industry associations; other not-for-profit organizations; and the general public.

The focus area for each IMI will be defined by the proposing team and will need to demonstrate that their focus area has potential to deliver regional and national improvements in advanced-manufacturing capabilities, and to meet national needs. IMIs differ in activities, but in general, provide shared facilities infrastructure for conducting applied R&D and demonstration projects, education and training, and engagement of SMEs. Federal funding to launch an IMI is expected to range from $70-$120 million over a 5-7 year timeframe. Institutes must plan on becoming self-sustaining within 5-7 years of opening. Each Institute should have substantial autonomy from its partner organizations and institutions and should have an independent fiduciary Board of Directors predominantly composed of industry representatives. The three key stakeholders of NNMI (industry, academia, and government) will need to have their interests preserved in a joint governance model.

The NNMI is responsible for ensuring that the individual IMIs collaborate amongst each other—sharing resources such as research results, best practices, funding and membership models. The NNMI will support and expand the impacts of IMIs, develop cross-cutting metrics and methods for evaluating impact, and develop best practices and standards.

NextEnergy

http://www.nextenergy.org/
Detroit, MI

Overview

NextEnergy is a nonprofit organization established in 2002 through a grant from the State of Michigan and the Michigan Economic Development Corporation to accelerate the development and growth of advanced energy industries in Michigan. NextEnergy partners with industry, academia, national laboratories, nonprofits and government to implement projects and initiatives to catalyze the development and deployment of advanced energy technologies through consulting, value chain analyses, venture development, and collaborative research and development.

Mission

NextEnergy's mission is to accelerate energy security, economic competitiveness, and environmental responsibility through the growth of advanced energy technologies, businesses, and industries. In order to accomplish its mission, NextEnergy's work focuses on technology demonstration and commercialization; industry and venture development; and, public sector leadership. NextEnergy partners with private and publicly-funded programs to provide laboratory space, along with demonstration and validation services for research in vehicle electrification, energy efficiency, and advanced grid technologies. NextEnergy also provides comprehensive program management and commercialization services to its partners.

In regards to industry and venture development, NextEnergy conducts value chain mapping to identify opportunities and gaps in energy industry; uses market, product and technology intelligence to assist energy ventures with business growth and technology commercialization; and conducts venture development by providing direct assistance to start-up companies in the commercialization of products and intellectual property by facilitating matchmaking between early-stage companies and partners that can support the research, product development, fundraising, product manufacturing, and approach to markets adoption including first customers.

NextEnergy also provides an authoritative voice in the public sector by partnering with local government, the State of Michigan and federal agencies to design future energy strategies, advise on funding priorities, and administer and evaluate programs. NextEnergy also develops curriculum and workforce development programs.

Organization

NextEnergy's management team sets its agenda with input and oversight from the Board of Directors, and significant input from economic development and philanthropic stakeholders. The management team regularly engages industry through working group and cluster activities, technical advisory relationships and market research and technology assessment activities in order to shape its agenda.

Funding

The State of Michigan Economic Development Corporation established NextEnergy in 2002 with initial seed funding. NextEnergy continues to receive funding from the State on an annual basis. Additional funding streams come from federal grants, philanthropic grants, and industry fee-for-service.

Oak Ridge Manufacturing Demonstration Facility (ORNL-MDF)

http://www.ornl.gov/sci/manufacturing/mdf.shtml
Oak Ridge, TN

Overview

The Department of Energy established the first Manufacturing Demonstration Facility (MDF) at Oak Ridge National Laboratory (ORNL). ORNL was selected through a competitive process to manage the MDF with the technological focus of additive manufacturing and carbon fiber and composites. ORNL-MDF offers a collaborative, shared infrastructure to facilitate the development and use of energy efficient, rapid, flexible manufacturing technologies and promotes rapid technology dissemination.

Mission

The mission of ORNL-MDF is to give industries access to unique research facilities and reduce their risk for adopting cutting-edge manufacturing technologies. ORNL-MDF provides physical and virtual tools from design to evaluation for rapidly prototyping new technologies and optimizing essential manufacturing processes. ORNL-MDF provides access to facilities for industry, universities, nonprofits, and other non-federal entities seeking technology solutions or research and development partnerships with ORNL-MDF to access its technologies, expertise and facilities. Additionally, ORNL-MDF collaborates with industry in technology assessments on the path to commercial implementation of advanced manufacturing and materials technologies in order to help industry adopt new manufacturing technologies to reduce life-cycle energy and greenhouse gas emissions, lower production cost, and create new products and opportunities.

Funding

ORNL-MDF, established through a federal grant, will receive federal support for its first five years of operation- at the end of which, it is expected to be self-sustaining. Other funding streams may include cost-share for projects, fee-for-service, and additional grants.

PDES Inc. (PDES)

http://www.pdesinc.org/
Charleston, SC

Overview
PDES Inc. is an international, industry-government-university, member-based consortium founded in 1988 to accelerate the development and implementation of information standards for data exchange that enable enterprise integration and product lifecycle management.

Mission
The mission is to support the Digital Enterprise through the development, testing and implementation of information standards to support model-based engineering, model-based manufacturing, and model-based sustainment.

Organization
The PDES Executive Board approves and oversees all activities of the consortium and is comprised of one senior representative from each PDES member organization. The General Manager oversees day-to-day operations and ensures that the technical teams perform the activities in accordance with the Board-approved Technical Development Plan. Senior technical managers from each of the PDES member organizations make up the Technical Advisory Committee. This committee serves as advisors to the Executive Board and general manager. The Technical Teams are each managed by a Team Leader. Team Leaders also work as a group on the Systems Integration Board, where they discuss progress and resolve project-related issues.

Funding
As a member-based consortium, the primary sources of PDES revenue are membership fees that vary by organization type, size, and annual revenue. Currently, PDES has 26 members from industry, universities, government, and other standards-setting organizations from around the world.

Photovoltaic Manufacturing Consortium (PVMC)

http://www.uspvmc.org/
Albany, NY

Overview
The Photovoltaic Manufacturing Consortium (PVMC) was founded in 2011 to conduct cooperative R&D among industry, university, and government partners to accelerate the development, commercialization, and manufacturing of next generation solar photovoltaic (PV) systems. PVMC, chartered as part of the Department of Energy's SunShot initiative, shares the goals of reducing the cost of solar energy and driving to grid parity by 2020. PVMC received an initial grant of $62.5 million from the Department of Energy.

PVMC is led by SEMATECH and its major partners are the College of Nanoscale Science and Engineering (CNSE) of the University at Albany and the University of Central Florida. PVMC is modeled after SEMATECH's collaborative, industry consortium experience and

CNSE's public-private partnerships and co-location experience to create an advanced research hub infrastructure. Emulating SEMATECH and CNSE, PVMC will pool resources, select the R&D and manufacturing program portfolio they wish to fund cooperatively, guide and evaluate the progress of those programs, and collectively share in the program results. Members will benefit from leveraged funding, shared cost and risk, and faster and better solutions to common pre-competitive infrastructure needs and requirements.

Mission

The mission of PVMC is to facilitate road mapping and standards initiatives, conduct collaborative R&D programs to address common, pre-competitive infrastructure needs in CIGS technology and manufacturing, and create advanced manufacturing development facilities (primarily at CNSE) to speed development and scale-up of materials, processes, equipment, and products. PVMC's goal is to increase the performance and speed the implementation of PV technologies (especially CIGS thin film technologies) while improving manufacturing processes and driving down costs. Key components of PVMC include:

- Collaborative R&D programs to address common, pre-competitive infrastructure needs in CIGS technology and manufacturing
- Advanced Manufacturing Development Facilities to speed development and scale-up of CIGS materials, processes, equipment, facilities, and products
- CIGS roadmap and standards to align and streamline industry research, development, and manufacturing
- Metrology and new wafering methodologies
- Support to the industry in testing and reliability, balance of system, technology commercialization, and workforce development

To achieve its mission, PVMC developed the following high-level strategic objectives:

- Coordinating the technical agenda of the U.S. PV manufacturing industry by developing and disseminating technology roadmaps and standards
- Establishing and supporting manufacturing development facilities to increase U.S. PV manufacturing market share, jobs, and technology innovation
- Increasing PV manufacturing productivity
- Linking research labs, universities, and industry to establish an effective PV commercialization support structure
- Developing a highly trained PV workforce

Organization

PVMC is a member-based organization comprised of over 40 companies and organizations representing the R&D community (universities, national and industry labs), equipment, materials and metrology suppliers, module producers and integrators, and end users. Membership is offered in three tiers and limited to U.S. based organizations except for special circumstances:

1. Core members: U.S. PV manufacturing and supply chain companies that participate in the full program set and the operations of the consortium, and have access to all common/pre-competitive program results
2. Associate and Sub-Program Members: PV manufacturing and supply chain companies that participate in select cell and module development, tool infrastructure, benchmarking, manufacturing productivity, or other consortium programs
3. Multi-User/Incubation Participants: Industry partners, start-up companies, national labs, and universities (collectively “users”) that access PVMC facilities as part of a proprietary program or on an individual, fee-for-service basis

The Board of Directors sets high-level strategy, policies and the budget and is made up of representatives from SEMATECH and CNSE as well as one industry member. The Executive Technical Advisory Board sets program policies, reviews performance, and provides industry perspective. It is comprised of representatives from industry as well as the University of Central Florida. Technical Working Groups set high level strategy, policy and budget and is comprised of members with high levels of engagement. The PVMC management team is comprised of executives from SEMATECH and CNSE.

SEMATECH

http://www.sematech.org/
Albany, NY/Austin, TX

Overview

SEMATECH emerged in 1987 to respond to a challenge to national security and national competitiveness by pooling together resources to solve technology and manufacturing problems when the U.S. semiconductor industry was losing market share to Japan and other countries. SEMATECH has since expanded its focus to advancing technology development and manufacturing solutions in both the semiconductor industry and other emerging technologies. As U.S. firms began to rely more on global suppliers and operate abroad and many international firms began to make significant contributions to the development of U.S. innovation and manufacturing, SEMATECH expanded its collaboration efforts to include international partners in order to engage with the global supply chain. Its membership is now comprised of half of the global chip market. As a consortium, members are brought together to pool resources for solving technology and manufacturing problems.

Mission

SEMATECH’s focus is to address critical challenges in advanced technology and manufacturing effectiveness, and to find ways to speed development, reduce costs, share risks, and increase productivity. The foundation of SEMATECH’s work is its clear pre-competitive mission to accelerate commercialization by addressing common challenges, which are enumerated by the industry roadmap focused on building technology infrastructure and strengthening the manufacturing base. SEMATECH R&D focuses on lithography, new materials and device structures, metrology, and 3D interconnects. The International SEMATECH Manufacturing Initiative (ISMI) focuses on integrating technology innovations with manufacturing best practices that enable productivity, cost and cycle time improvements in factories and equipment.

Organization

SEMATECH is a member-driven organization where members are engaged at all levels of decision-making. The Board of Directors make the strategic decisions; high-level technology decisions are made by the Executive Steering Council; and tactical/operational decisions are made by Program Advisory and Technical Working Groups. Membership includes broad representation of the whole supply chain, including manufacturers, universities, national labs, research institutes, equipment/materials manufacturers and other suppliers. This engagement allows each entity to improve its understanding of its customers' needs, and helps drive alignment and consensus across the broader industry. Members provide both financial contributions and technical personnel. Through SEMATECH, members can actively partner with equipment and material suppliers, universities, research institutes, other consortia, start-ups, and governments.

Funding

SEMATECH was initially funded by a federal grant of $100 million per year matched by industry. In the years that followed, the industry increased its share and SEMATECH became self-sufficient. Currently SEMATECH is primarily funded through membership fees and regional government grants.

Smart Grid Interoperability Panel 2.0 (SGIP)

http://sgip.org/
National

Overview

The Smart Grid Interoperability Panel (SGIP) was initially created in 2009 as public-private partnership by The National Institute of Standards and Technology (NIST) to support NIST in fulfilling its responsibility, under the Energy Independence and Security Act of 2007 (Title XIII, Section 1305), to coordinate standards development for the smart grid. The Smart Grid Interoperability Panel does not develop standards directly, but it provides an open process for stakeholders, including NIST, to interact and drive progress in the ongoing coordination, acceleration, and harmonization of new and emerging standards for the Smart Grid. SGIP was originally launched and completely funded by NIST as an unincorporated association with free and open membership with the intent to eventually transition into a self-sustaining entity. In 2012, Smart Grid Interoperability Panel 2.0 (SGIP) was established as an independent nonprofit membership organization.

Mission

SGIP's mission is to provide a framework for coordinating all smart grid stakeholders in an effort to accelerate standards harmonization and advance the interoperability of smart grid device systems. SGIP fulfills its mission by:

- Facilitating standards development for smart grid interoperability
- Identifying necessary testing and certification requirements
- Overseeing the performance of these activities and continuing momentum
- Informing and educating smart grid industry stakeholders on interoperability
- Conducting outreach to establish global interoperability alignment

SGIP produces and maintains the Catalog of Standards. The Catalog of Standards serves as a compendium of standards, practices, and guidelines considered relevant for the development and deployment of a robust and interoperable smart grid.

Organization

SGIP consists of 85 members represented by 22 different stakeholder categories from the seven integrated domains of the power system: customers, markets, service providers, operations, bulk generation, transmission, and distribution.

SGIP is guided by a Board of Directors consisting of representatives elected by participating member organizations. SGIP will also have management team that will be hired to run the organization on a day-to-day basis. Representatives from NIST will continue to serve as advisors.

Funding

As a nonprofit membership organization, SGIP is funded through membership fees as well as a $1 million annual grant from NIST through 2014. Membership fees depend on the organization type, annual revenue and membership tier. Members can be either Participating Members (have certain privileges such as voting and the ability to stand on a committee/board) or Observing Members.

Solar Technology Acceleration Center (SolarTAC)

http://www.solartac.org/
Aurora, CO

Overview

The Solar Technology Acceleration Center (SolarTAC) is a nonprofit, member-based solar research and testing facility in Aurora, Colorado and the largest outdoor solar testing facility in the United States. SolarTAC was founded in 2009 by Xcel Energy, SunEdison, and Abengoa Solar, with the City of Aurora providing land and an expedited permitting process to make it easier for testing and connection to the power grid serving the city.

Mission

SolarTAC's mission is to increase the efficiency of solar energy products and rapidly deploy them to the commercial market. SolarTAC provides a facility where the solar industry can test, validate, and demonstrate near-market and advanced solar technologies. The facility has access to the local grid and hosts photovoltaic, concentrating photovoltaic and concentrating solar thermal technologies as well as battery storage and other grid management systems. SolarTAC employs a flexible business plan that allows its members to sponsor proprietary research, in which results are not shared; common research in which results are shared with other SolarTAC members; and the broadest level of research that can be shared with the public.

Organization

SolarTAC membership is comprised of electric utilities companies, solar technology developers and solar equipment suppliers. There are two levels of membership: 1) Founding Members and 2) Sponsoring Members. Founding members have a permanent seat on the Executive Board and Scientific Advisory Board, a full vote in planning the build-out of the test site, a five-acre tract of land for proprietary tests, and several other benefits (including those listed for sponsoring members). Sponsoring members have representation on the Executive Board and a permanent seat on the Scientific Advisory Board. In addition to having members, SolarTAC has partnered with the state of Colorado and the four major research institutions that make up the Colorado Renewable Energy Collaboratory (Colorado Collaboratory)—Colorado State University, Colorado School of Mines, University of Colorado, and the National Renewable Energy Laboratory. The Colorado Collaboratory institutions will complement the applied testing and demonstration work in Aurora with more fundamental facilities and scientific research and will respond to requests for research proposals.

SolarTAC is managed and operated by MRIGlobal, a not-for-profit contract research organization that reports to the Executive Board. The Executive Board is made up of Founding Members, a representative from the Colorado Collaboratory, an MRIGlobal representative, and one Sponsoring Member representing all Sponsoring Members. In governing SolarTAC, the Executive Board:

- Approves budget and decides shared resource allocation
- Establishes the by-laws, governance, and all policies for SolarTAC
- Establishes and oversees the M&O contract
- Approves all Sponsoring Members' R&D or equipment testing
- Approves all new members
- Coordinates between SolarTAC and the Colorado Collaboratory's Center for Revolutionary Solar Photoconversion
- Markets SolarTAC to attract new members
- Establishes technology transfer and IP policies for shared projects

SolarTAC also has a Scientific Advisory Board that is comprised of representatives from every member, one representative from each Colorado Collaboratory Institution, and is chaired by the SolarTAC Technical Directory. The Scientific Advisory Board is responsible for:

- Develops technical priorities and key focus areas
- Recommends the technical program to the Executive Board
- Advises Executive Board on resource allocation
- Coordinates Requests for Proposals
- Recommends shared R&D plan to Executive Board
- Advises Executive Board on technology transfer

Funding

SolarTAC is funded primarily through membership fees. Founding members pay a minimum investment of $500,000 annually for the first three years, and $100,000 a year for membership fees thereafter. Sponsoring members pay a $100,000 annual membership fee from the date of becoming a member and small businesses pay $25,000. SolarTAC also pursues additional funding support through state and federal channels.

INTERNATIONAL

Catapult Centres (Catapult)

https://catapult.innovateuk.org/
United Kingdom

Overview

Catapult Centres (Catapult) is a network of seven centers in the United Kingdom designed to advance innovation in specific fields and enable business to access the UK research base to accelerate commercialization. The creation of the Catapult network was announced in 2010 by the UK government with an initial investment of $300 million. The UK innovation agency, the Technology Strategy Board is responsible for the development and overseeing Catapult.

Mission

The Technology Strategy Board selected seven focus areas for the centers that were identified as strategically important in global terms and where there is genuine potential for the UK to gain competitive advantage. The seven areas are: high value manufacturing, cell therapy, offshore renewable energy, satellite applications, connected digital economy, future cities and transport systems. Following the selection of the focus areas, the Technology Strategy Board began a competitive process for selecting the organizations to host the centres and identifying partners for each center. Currently, only the High Value Manufacturing and Cell Therapy Catapults are open and operating while the remaining five are scheduled to begin operation sometime in 2013.

While the Catapults will have center-specific missions, the general mission is to create a network of centers of excellence that bridge the gap between business, academia, research and government. The centers will work to accelerate the translation of research into profitable products and services and help businesses of all sizes to adopt, develop and exploit innovative products and technologies. The Catapults will allow businesses to access equipment and expertise that would otherwise be out of reach, as well as conducting their own in-house R&D together to unlock opportunity, reduce innovation risk and speed new products and services towards commercial reality. Catapults will offer concentrated expertise in areas vital areas such as manufacturing processes, test facilities, type approval and accreditation or supply chain development. Catapults will also provide training and workforce development.

Organization

The Technology Strategy Board is responsible for the development, management and coordination the network of centers as part of the wider UK innovation landscape. In order to do this, a new directorate was established to handle internal management responsibilities for setting up and overseeing the centers. An oversight committee was created to advise both the Technology Strategy Board and the individual centers. The committee is comprised of senior leaders across industry, the research base including research councils, the Department for Business, Innovation and Skills, and the Technology Strategy board. The committee's functions include the following:

- Advising strategic direction
- Ensuring robust links between the centers and the wider innovation system
- Advising on future investment decisions and continuity of funding
- Working with technology strategy board to develop success metrics
- Measuring performance of the centers and the network as a whole

While the Technology Strategy Board is responsible for general oversight of the centers, each center will be an independent nonprofit entity separate from any host organization or other partners. The centers will establish an industry-led governance board composed of industry and technology experts in the technology field of the center. The governance board will steer the work of the center and oversee its program of activity.

Funding

Catapults will receive seed funding from the Technology Strategy Board. Once the Catapult is fully established, the funding stream will be a one-third model where one-third of the funding comes from each of the following sources:

- Business-funded R&D contracts (i.e. contract research) won competitively
- Collaboratively applied R&D projects funded jointly by the public and private sector won competitively
- Core public funding for long-term investment in infrastructure, expertise and skills development

Fraunhofer-Gesellschaft (Fraunhofer)

http://www.fraunhofer.de/en.html
Germany

Overview

Fraunhofer-Gesellschaft (Fraunhofer) is a nonprofit applied research organization consisting of a network of 80 research units and 60 institutes in Germany as well as subsidiaries and offices throughout Europe, North and South America, Asia and the MENA-Region. Fraunhofer was founded in 1949 with the original purpose to distribute grants and donations for research of direct relevance to industry and has since evolved into the largest applied research organization in Europe. Fraunhofer conducts research for the public and private sectors and collaborates with other research organizations and institutions in both Germany and throughout Europe in the areas of health, security, communication, transportation, energy and production.

Mission

Fraunhofer's mission statement is comprised of the following Guiding Principles of the Fraunhofer-Gesellschaft:

- The Fraunhofer-Gesellschaft promotes and undertakes applied research in an international context, of direct utility to private and public enterprise and of wide benefit to society as a whole.
- By developing technological innovations and novel systems solutions for their customers, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their region, throughout Germany and in Europe. Their research activities are aimed at promoting the economic development of our industrial society, with particular regard for social welfare and environmental compatibility.
- As an employer, the Fraunhofer-Gesellschaft offers a platform that enables its staff to develop the necessary professional and personal skills that will enable them to assume positions of responsibility within their institute, in industry and in other scientific domains.

Organization

Fraunhofer partners with industry through contract research to provide a wide variety of services for businesses of all sizes with particular emphases on SMEs that do not maintain their own R&D departments. Fraunhofer works with industry on developing and optimizing technologies, processes and products. Supporting the introduction of new technologies to businesses, Fraunhofer conducts trials and testing in demonstration centers; onsite training of staff; and, other usability and support services. Fraunhofer also provides technology assessment support prior to research cooperation in the form of feasibility studies, market surveys, trend analysis, environmental audits, and pre-investment analysis. To provide further training for industry, the Fraunhofer Academy in collaboration with selected universities offers vocational training and courses. Fraunhofer also partners with other entities including government, universities and other research institutions. One example of collaboration is Fraunhofer's work in conceiving and implementing regional innovation clusters in Germany to build on existing strengths in regions and bridge the gap between industry and scientific research.

Each individual institute has a governing board which serve as an external advisory body attached to the institutes, and consist of representatives of science, industry, business and public life. For each institute, approximately twelve members are appointed to the governing board by the Executive Board with the approval of the director(s) of the institute. All of the institutes are categorized in one of seven groups devoted to specific broad research areas. Each group has a chairman that participates on the Presidential Council along with members of the Executive Board. The Executive Board is made up of the President and three senior vice-presidents. Working with the Presidential Council, the Executive Board is responsible for the basic premise of science and research policy; business-development and financial plans; and, negotiating and distributing institutional funding. The Executive Board is appointed by the Senate, which is comprised of leaders from science, industry, public life, representatives from the national and regional government, and the Scientific and Technical Council. The Senate is also responsible for decisions concerning basic science and research policy and decisions concerning the establishment, incorporation, devolution, merger or dissolution of research entities belonging to the Fraunhofer. The General Assembly which is made up of the members of the Fraunhofer elects the members of the Senate, discharges the Executive Board of its responsibilities and makes decisions concerning amendments to the Statute. The Scientific and Technical Council is the organization's internal advisory body comprised of the directors and senior management of the institutes and an elected representative of the scientific and technical staff of each institute. The Scientific and Technical Council provides advice to the Executive Board and other constituent bodies; issues recommendations concerning research and human resources policy; issues statements of opinion concerning the creation of new institutes or the closure of existing institutes; and, participates in the appointment of the directors of the institutes.

Funding

Fraunhofer receives funding from both the public and private sectors. Fraunhofer adheres to a one-third funding model where funding comes from the following three sources:

- One-third comes from the public sector
- One-third comes from industry contracted research
- One-third comes from government sponsored research grants

GTS Advanced Technology Group (GTS)

http://www.teknologiportalen.dk/en
Denmark

Overview

The GTS Advanced Technology Group (GTS) is a network of nine independent Danish research and technology organizations called the GTS Institutes. The Ministry of Science, Innovation and Higher Education approves each institute for a period of three years on the basis of technological/professional performance, financial performance and organizational solidity. Danish law established the GTS system of institutes in 1973, and the formal GTS Advanced Technology Group—that now serves as the umbrella organization—started in1995. The GTS network develops competences, know-how, methods and technological services not available in the private sector and ensures that the newest knowledge is available to the Danish industries. The nine institutes are focused on the following broad range of areas: construction; energy; food and agriculture; health; information technology; innovation and society; production; security; transportation and logistics; and welfare technology.

Mission

The mission of the GTS network is to disseminate new knowledge and technology to companies and public institutions in order to support innovation and development. The role of the GTS institutes in the Danish knowledge infrastructure is to develop and offer application-oriented and state-of-the-art technological services on a commercial basis. A main function of the institutes is to create technological innovation and development within Danish industry. The GTS institutes are involved in research and development projects in cooperation with companies, universities and research institutions in Denmark and abroad. Through applied research contracts, GTS institutes develop and transform new and existing technologies to companies and institutions. Another primary function of the GTS institutes is to develop and maintain the basic technological infrastructure in Denmark. GTS institutes provide valuable technological infrastructure not readily available to industry such as experimental equipment, specialized laboratories, advanced test facilities and other assets. The technological expertise and infrastructure allow the institutes to provide the following services:

- Applied R&D on a contractual basis
- Education and training courses
- Measuring techniques and calibration
- Inspection, certification and approval
- Testing
- Organizational development, strategy, and management

Organization

GTS serves as the central body for the GTS institutes. The central body is comprised of a managing director and staff who handle common interests of the institutes in relation to outside parties and facilitates internal cooperation on technological, professional, administrative and managerial matters. The Advanced Technology Group Board of Directors is made up of the directors of all of the GTS institutes and responsible for electing a chairman and vice-chairman on an annual basis as well appointing the managing director for the central body.

Funding

Funding for the institutes comes primarily from fee-for-service, as well as from government-financed performance contracts. GTS institutes sell their services on commercial terms in Denmark and abroad which generate a majority of each institutes funding. Additionally, close to 50 percent of services are sold to international clients. Institutes all provide some non-commercial services such as newsletters and events that generate revenue through nominal membership fees.

Interuniversity Microelectronics Centre (IMEC)

http://www2.imec.be/be_en/home.html
Belgium

Overview

The Interuniversity Microelectronics Centre (IMEC) is a nonprofit independent research center founded in 1984 with $82 million from the government of Flanders. IMEC is headquartered in Leuven, Belgium with additional R&D teams in the Netherlands, China, Taiwan, and India, and offices in Japan and the USA. IMEC research is focused on nanoelectronics and nanotechnology applied to health care, information and communications technology (ICT), and energy.

Mission

IMEC's mission is to work with partners and lead the development of nano-enabled solutions that allow people to have a better life in a sustainable society. IMEC emphasizes pre-competitive research that is three to 10 years ahead of industry needs, and therefore takes on risky projects that partners cannot afford to do on their own. Therefore, IMEC partners with industry, universities and other research organizations to collaborate on research. Their research covers the following domains:

- Technology for future chips and systems: IMEC pioneers new processing technologies, materials, transistor types, and integration and design methods to create future chips and systems.
- Energy: research focuses on improving the efficiency, industrial manufacturability, and cost of a number of advanced technologies in the areas of PV, energy storage, smart grid and energy efficiency
- Health Care: IMEC develops cost-effective and reliable health care solutions and tools for the life sciences industry
- Sustainable wireless radios: IMEC engineers solutions for future wireless communication that increase the performance and possibilities while drastically decreasing the cost and power consumption
- Imaging and future 3D visualization: developing advanced systems by co-designing software and hardware into optimal imaging solutions.
- Sensor systems for industrial applications: IMEC works on ultra-small wireless and autonomous sensor systems for the future intelligent environment.

Organization

IMEC's partnerships take the form of bilateral collaboration and IMEC Industrial Affiliation Programs (IIAPs). IIAP is a partnership model based on the sharing of intellectual property, talent, risk, and cost among several partners. IIAP partners may send their researchers to work with IMEC researchers and residents from other IIAP partners. IMEC also offers various services such as technology transfers and licenses, design, reliability, metrology, technology targeting, prototyping, and small-volume production. IMEC also developed the IMEC Academy offering a wide-range of training courses, seminars, online classes, and classes at universities where IMEC employees hold teaching positions.

IMEC International has a Board of Directors comprised of representatives from universities, Flemish government, and industry. There is also a Scientific Advisory Board comprised of industry leaders from around the world.

Funding

The Flemish government funds IMEC in part. The majority of funding comes from industrial partners, as well as from EU and other government research grants.

Industrial Technology Research Institute (ITRI)

http://www.itri.org.tw/eng/
Taiwan

Overview

The Industrial Technology Research Institute (ITRI) is a nonprofit R&D organization engaged in applied research and technical services. The Taiwanese Ministry of Economic Affairs established ITRI in 1973 as an independent, nonprofit, applied research and services organization. It was originally created to facilitate the development of the semiconductor industry in Taiwan. ITRI, headquartered in Taiwan, has offices in the United States, Japan, Russia and Germany. ITRI has expanded its scope of research to include information and communications technologies; electronics and optoelectronics technologies; material, chemical and nanotechnology; mechanical and systems technologies; medical device and biomedical technologies; and green energy and environment technologies.

Mission

ITRI's mission is expedite the development of new industrial technologies; aid in the process of upgrading industrial technology techniques; and shape the future of industrial technologies for greater efficiency and sustainability. ITRI's mission is aimed at developing high-value industry and enhancing the global competitiveness of Taiwan. In order to accomplish this, ITRI conducts advanced technology research, provides industrial services, provides R&D resources and creates new ventures. ITRI's advanced research focuses on generating next-generation technologies through both its expertise and collaborative research partnerships around the world. ITRI provides industrial services to assist industry in enhancing their competitiveness through information and business consulting; education and training; and enabling new service industries. ITRI can be contracted to provide a range of various technical services for the application and integration of new technologies such as new product development, improved manufacturing processes, pilot production, and measurement and certification services. ITRI helps industry develop new business opportunities through licensing IP. Additionally, ITRI provides R&D resources to many start-up companies through its OpenLab/Incubator program.

Organization

ITRI is led by its executive team, comprised of the Chairman and President. The executive team runs the ITRI headquarters and oversees planning for future development directions and integration of core labs.

Funding

ITRI receives its funding from annual government investments as well as industry through contracted research and fee-for-services. ITRI employs a one-to-one policy that aims to earn equal amount of income from the private sector without sacrificing government sponsored budgets.

APPENDIX B

Public-Private Partnership Interviews

To supplement the literature review of policy studies, key recommendations, and public-private partnerships, the Council reached out to key leaders across the country that are currently involved with—or have previously engaged in—technology-based public-private partnerships. The intent of this exercise was to add a layer of intelligence on top of the fact-based data gathering undertaken during the literature review.

Developing and sustaining a successful clean energy manufacturing PPP is highly dependent on capturing the tacit and experiential knowledge held by private and public sector leaders that have successfully developed a PPP. These interviews—and the resulting insights summarized in the *Power of Partnerships*—have begun to capture and codify this valuable knowledge. The following section lists the interview participants and recreates the questionnaire administered during the interview sessions.

Public-Private Partnership Questionnaire:

1. What are the critical factors that have driven the success of the partnership?
2. Is there one person/organization/institution that took ownership and drove these success factors?
3. Why do you feel this organizational (industry-led, university-led, etc.) and/or business model (501(c) 3, (c) 6, LLC, etc.) is the best framework to achieve the mission of the partnership? In addition to reflecting on the advantages, are there any disadvantages—if any—of the chosen organization model?
4. Who has the authority to make decisions and who sets the agenda?
5. Are there organizational aspects of the partnership that are innovative or unique?
6. How is success measured? What are the metrics, frequency of evaluations, and who performs the evaluations?
7. What was the biggest challenge to establishing the partnership?
8. What is the long-term vision?
9. How applicable is this model to other objectives or fields of science and technology—specifically aspects related to the promotion of domestic manufacturing?
10. Have there been public policies—federal, state, or local—that you feel have been either instrumental in the formation of the partnership or critical to its success? Examples could be incentives, subsidies, local laws, regulations, standards, etc.
11. Do you feel there is an opportunity for additional public policies to improve the efficacy or support the long-term success of partnership?

Interview Schedule

January 15, 2013
Dr. Phillip Singerman
National Institute of Standards and Technology
Office of the Director
Associate Director for Innovation & Industry Services

January 16, 2013
Rich Overmoyer
Fourth Economy Consulting, President & CEO
University Economic Development Association,
Executive Director

Dr. Paul Hallacher
The Pennsylvania State University
Director of Research Program Development
Energy-Efficiency Building (EEB) Hub Director

Dr. Donald J. Leo
Virginia Polytechnic Institute and State University
Vice president and Executive Director of National
Capital Region Operations
Board of Directors, Commonwealth Center for
Advanced Manufacturing

January 17, 2013
Nish Acharya
U.S. Department of Commerce
Economic Development Administration
Office of Innovation and Entrepreneurship
Director

January 18, 2013
Anne Englander
SEMATECH
Director of Corporate Relations and Resources

January 25, 2013
Dr. George W. Arnold
National Institute of Standards and Technology
Cyber Physical Systems Program Office
National Coordinator, Smart Grid Interoperability
Panel

February 1, 2013
Dr. Walter Kirchner
Council on Competitiveness, Chief Technologist
Argonne National Laboratory, Advisor to the Director

February 11, 2013
Dr. Cynthia McIntyre
Council in Competitiveness
Senior Vice President
High Performance Computing Initiative
NDEMC

February 13, 2013
Jean Redfield
NextEnergy
President & CEO

APPENDIX C

Overview of Policy Side-by-Side Reports

RENEWABLE ENERGY REPORTS

1. American Enterprise Institute, Brookings Institution, Breakthrough Institute, "Post-Partisan Power." October 2010.

This report provides a bi-partisan framework to drive energy innovation. The recommendations are to focus on both "technology push" and "technology pull" recommendations, while ensuring that the funding of such programs/initiatives do not contribute to the national debt or federal deficit. This is achieved through new sources of revenue. The authors focus on programs that drive innovation, as opposed to programs that promote diffusion of current technologies.

http://thebreakthrough.org/blog/Post-Partisan%20Power.pdf

2. Laura Diaz Anadon, Matthew Bunn, Gabriel Chan, Charles Jones, Ruud Kempener, Audrey Lee, Nathaniel Logar, & Venkatesh Narayanamurti, Harvard Kennedy School, "Transforming U.S. Energy Innovation." 2011.

This book offers analysis and recommendations designed to accelerate the pace at which better energy technologies are discovered, developed and deployed, and is focused in four key areas:

- Designing an expanded portfolio of federal investments in energy research, development, demonstration, and complementary policies to catalyze the deployment of novel energy technologies;
- Increasing incentives for private-sector innovation and strengthening federal-private energy innovation partnerships
- Improving the management of energy innovation institutions to maximize the results of federal investments; and
- Expanding and coordinating international energy innovation cooperation to bring ideas and resources together across the globe to address these global challenges

To achieve these tasks, the researchers performed expert interviews and surveys, used a case-study approach, and analyzed existing literature. Broadly, the recommendations are more focused on the innovation ecosystem and are less focused on actions or recommendations to promote the domestic production of clean energy technologies.

http://belfercenter.ksg.harvard.edu/files/uploads/energy-report-january-2012.pdf

3. American Energy Innovation Council, "Catalyzing American Ingenuity: The Role of Government in Energy Innovation." (2011)

The American Energy Innovation Council (AEIC) is a consortium of business leaders hosted and staffed by the Bipartisan Policy Center. The mission of the AEIC is to foster strong economic growth, create jobs in new industries, and reestablish America's energy technology leadership through robust, public investments in the development of clean energy technologies. This report highlights the need for an active government role in energy innovation, recommends ways to improve the effectiveness of government innovation programs, and highlights options to pay for energy innovation investments.

http://americanenergyinnovation.org/wp-content/uploads/2012/04/AEIC_Catalyzing_Ingenuity_2011.pdf

4. Bloomberg New Energy Finance, "Crossing the Valley of Death: Solutions to the next generation clean energy project financing gap." 2010.

The challenge of traversing the so-called "Valley of Death" intrigued the nonprofit Clean Energy Group (CEG). With funding from The Annenberg Foundation, CEG commissioned Bloomberg New Energy Finance (BNEF) to join in an assessment of current gaps in clean energy financing and in soliciting recommendations to address them. In 2009, CEG and BNEF conducted more than five dozen interviews with industry players across the EU and North America, seeking their input on how to address the quandary.

http://www.cleanegroup.org/publications/resource/crossing-the-valley-of-death-solutions-to-the-next-generation-clean-energy-project-financing-gap

5. The Breakthrough Institute, "Bridging the Clean Energy Valleys of Death." November 2011.

This report centers around the the two major gaps in private sector fiancing of advancing energy technology development from early-stage laboratory research and proof-of-concept prototype to full commercial scale. These gaps are known as the "Technological Valley of Death" and the later-stage "Commercialization Valley of Death." The thesis of the report is that "the current lack of public policy to address this pair of barriers acts to protect today's well entrenched incumbent technologies from full market competition while hamstringing American entrepreneurs and innovative ventures seeking to develop and deploy advanced energy technologies." The report is divided into two sections by the two types of "Valleys". Each section provides policy responses to overcome the respective financing valley of death.

http://thebreakthrough.org/archive/bridging_the_clean_energy_vall

6. Breakthrough Institute, Brookings Institution, World Resource Institute, "Beyond Boom & Bust: Putting Clean Energy on a Path to Subsidy Independence." April 2012.

"As long as clean energy sectors remain dependent on public support, they will be continually imperiled by the threat of policy collapse. Continued innovation and cost reduction is thus the only real route beyond today's policy-induced cycle of boom and bust... Yet the immediate cessation of clean tech subsidies is also not in the national interest."

This report provided a portfolio of recommendations designed to:

a. Remove subsidies from mature energy sources/technologies
b. Support nascent clean energy technology in ways to promote not just development and deployment, but cost reduction/competitiveness and scale
c. Once achieved, subsidies should be removed

This report contains a valuable compilation of federal policies and programs supporting clean technology segments in the U.S. between 2009 and 2014 (inclusive). This effort revealed 92 distinct programs: 3 manufacturing programs ($12.4 billion), 21 R&D programs ($28.1 billion), and 68 Deployment/Market programs ($108.7 billion). Spending is also broken down by technology. Central to the thesis of the paper, 70% of these programs will expire by the end of 2014.

http://www.brookings.edu/~/media/Research/Files/Papers/2012/4/18%20clean%20investments%20muro/0418_clean_investments_final%20paper_PDF.PDF

7. Center for American Progress, Center for the Next Generation "Regional Energy, National Solutions: A Real Energy Vision for America." October 2012.

This report focuses on non-fossil-fuel-driven economic development strategies in six major regions of the country, taking into account each regions' natural resources, infrastructure, and energy consumption patterns. The diversity of U.S. regions requires a multifaceted energy strategy that leverages the best of what each area has to offer—one that puts the United States squarely on the path toward long-term competitiveness, energy security, and climate stability. The paper concludes with national and regional recommendations to achieve these goals.

*Note: Several of the states and regional recommendations, though valuable, are considered outside the scope of this work and have not been included.

http://www.americanprogress.org/wp-content/uploads/2012/10/RER_full.pdf

8. Council on Competitiveness, "Drive. Private Sector Demand for Sustainable Energy Solutions—A Comprehensive Roadmap to Achieve Energy Security, Sustainability, and Competitiveness," 2009.

Drive is a compendium of recommendations—the result of a Progressive Dialogue Series and a Regional Energy Summit Series—developed by the Council's network of CEOs, university presidents, national laboratory directors and labor leaders. The report has a total of 49 recommendations. However—as the Council takes an "all of the above" approach to energy—there are also recommendations related to fossil fuels and nuclear energy. These have been omitted for this analysis.

http://www.compete.org/images/uploads/File/PDF%20Files/DRIVE._Private_Sector_Demand_for_Sustainable_Energy_Solutions,_Sept09_.pdf

9. Securing America's Future Energy, "A National Strategy for Energy Security," January 2013.

The Energy Security Leadership Council's mission is energy security: safeguarding the physical, military, and economic security of the U.S. by significantly reducing our dependence on oil. The promotion of renewable energy technologies and energy efficiency is understood to be a means to this end. Moreover, manufacturing of cleantech is not directly addressed in this report. However, some policy recommendations will work towards creating a market demand to support domestic manufacturing of clean energy technologies.

*This report contains a total of 19 policy recommendations, which are not all presented in this side-by-side analysis as they are outside the scope of this effort. This includes policies such as the development of the Arctic National Wildlife Refuge using extended reach drilling.

http://www.secureenergy.org/sites/default/files/SAFE_National-Strategy-for-Energy-Security_0.pdf

10. The Information Technology & Innovation Foundation, "Lemons to Lemonade: Funding Clean Energy Innovation with Offshore Drilling Revenues," July 2011.

This report proposes a method to fund the energy innovation ecosystem through revenue generation.

http://www.itif.org/files/2011-lemons-to-lemonade.pdf

11. President's Council of Advisors for Science and Technology, "Report to the President on Accelerating the Pace of Change in Energy Technologies Through an Integrated Federal Energy Policy," November 2010.

The PCAST recommendations were informed by a working group consisting of PCAST members and prominent energy experts from the public and private sectors. It should be noted, since the publication of this world, the DOE has implemented the a Quadrennial Technology Review (QTR), which is a first step toward the multi-agency Quadrennial Energy Review recommended in this report. This report recommends an increase in the RDD&D budget well beyond—roughly triple—the typical DOE appropriation. The report signals that the majority of this funding would come from new revenue. However, there is no specific guidance on how to generate the revenue.

http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-energy-tech-report.pdf

12. The Information Technology & Innovation Foundation. "An Innovation Carbon Price: Spurring Clean Energy Innovation while Advancing U.S. Competitiveness." March 2011.

This report proposes a method to fund the energy innovation ecosystem through revenue generation.

http://www.itif.org/files/2011-innovation-carbon-price.pdf

13. Wereld Natuur Fonds, Roland Berger Strategy Consultants, "Clean Economy, Living Planet," 2012.

This report provides a global breakdown of the clean technology manufacturing value chain and ranks countries accordingly. Based on a survey of 60 clean technology companies worldwide, the report goes on to recommend public policies to improve nation clean technology sales (manufacturing) in the United States, China, and the EU.

http://www.rolandberger.com/media/pdf/Roland_Berger_WWF_Clean_Economy_20120606.pdf

ENERGY-EFFICIENCY REPORTS

14. Alliance to Save Energy, "Doubling U.S Energy Productivity by 2030," February 2013.

The report makes recommendations for federal, state, and local governments as well as private sector, with the intention of doubling energy productivity by 2030. Energy productivity is calculated as GDP/quadrillion BTUs (quad). In the 2011, the US generated $135B/quad. Thus, the 2030 goal is to generate $270B/quad.

http://assets.fiercemarkets.com/public/sites/energy/reports/energytwentythirty.pdf

15. Alliance to Save Energy, "Guiding the Invisible Hand: Policies to Address Market Barriers to Energy Efficiency." 2012.

This work is focused on residential and commercial building energy efficiency. Specifically, the work makes recommendations to lower the barriers to energy-efficiency through innovative policy solutions. The recommendations, however, are market-supporting policies that supplement traditional measures such as standards and incentives.

http://ase.org/sites/default/files/guiding_invisible_hand_summerstudy2012_0.pdf

16. American Council for an Energy Efficient Economy, "Encouraging Modernization of the Industrial Sector and Other Energy-Saving Capital Investments through Tax Reform," December 2012.

This report suggests that modernizing factories will allow them to better compete in world markets by improving product quality and reducing product costs, including savings through reduced energy use. This paper provides tax reforms that incentivize capital investment.

http://aceee.org/files/pdf/white-paper/encouraging-modernization.pdf

17. Oak Ridge National Laboratory, "Making Industry Part of the Climate Solution—Policy Options to Promote Energy Efficiency." May 2011.

This report reflects the findings of policy options workshop to engage experts from academia, national labs, corporations, trade associations, and government agencies to identify the barriers to industrial energy efficiency (IEE) and potential policy responses to these barriers. The report does not advocate for a particular basket of policies. Alternatively, it systematically evaluates seven potential policy responses.

http://info.ornl.gov/sites/publications/files/Pub23821.pdf

18. Ernest Orlando Lawrence Berkeley National Laboratory, “Building Energy-Efficiency: Best Practice Policies and Policy Packages,” October 2012.

This report, completed by a team of laboratory researchers, recommends measures to change the trajectory of energy use in building in a way that reduces CO_2 emissions. This paper is industry agnostic.

http://eaei.lbl.gov/sites/all/files/GBPN_Final.Oct_.2012.pdf

NATIONAL MANUFACTURING STRATEGIES

19. Alliance for American Manufacturing, “Our Plan—A National Manufacturing Strategy,” 2013.

The Alliance for American Manufacturing is a non-profit, non-partisan partnership formed in 2007 by some of America’s leading manufacturers and the United Steelworkers to explore common solutions to challenging public policy topics such as job creation, infrastructure investment, international trade, and global competitiveness. The reviewed document is their recommendations for a National Manufacturing Strategy.

http://americanmanufacturing.org/files/AAM%20plan_2.pdf

20. American Wind Energy Association, Blue Green Alliance, United Steelworkers, “Winds of Change—A Manufacturing Blueprint for the Wind Industry,” June 2010.

The American Wind Energy Association (AWEA) is an industry association promoting the wind’s manufacturing sector. This paper details a policy strategy aimed at creating a long-term, stable market for the domestic production of wind equipment.

http://www.awea.org/learnabout/publications/upload/BGA_Report_062510_FINA`L.pdf

21. Breakthrough Institute, Third Way, “Manufacturing Growth: Advanced Manufacturing and the Future of the American Economy,” October 2011.

This report represents the basket of polices the Breakthrough Institute and the Third Way believe should comprise a national manufacturing strategy.

http://thebreakthrough.org/blog/BTI_Third_Way_Idea_Brief_-_Manufacturing_Growth_.pdf

22. Brookings Institution—The Metropolitan Policy Program, “Remaking Federalism | Renewing the Economy,” November 2012.

At the core of this paper is the recognition that metropolitan areas and their states are increasing by acting like engines of prosperity and change. As such, “the Obama administration will have no alternative but to move beyond isolated federal initiatives to adopt policies that support and maximize the impact of regional and state action...Such a stance would begin the work of groping towards a more realistic, focused, and collaborative federalism—call it “bottom-up” federalism.”

Note: This work has a broader mission than manufacturing or clean energy technologies. As such, irrelevant recommendations have been omitted.

Framework:

- Cut to invest, meaning that it should—while moving to reduce the national debt—channel some of the savings from cuts of unnecessary or counter-productive programs into strategic investments that will establish a platform for metropolitan growth;
- Invest but reform, meaning that it should reform its activities to make them not only more efficient and effective but more catalytic and encouraging of local and state problem-solving; and
- Strengthen federalism, meaning that it should maximize the power of its dynamic partnership with the nation's localities and states to solve problems.

http://www.brookings.edu/about/programs/metro/remaking-federalism

23. Council on Competitiveness, "MAKE: An American Manufacturing Movement," December 2011.

This document is the Council's portfolio of policy recommendations comprising a national manufacturing strategy. It was informed by numerous Council initiatives including:

a. The Global Manufacturing Competitiveness Index
b. *Ignite 1.0* through *3.0*: A multi-part, interview-driven project collecting insights from CEOs, university presidents, national laboratory directors and labor leaders.
c. A series of provocative "Out of the Blue" strategic manufacturing dialogues, bringing together hundreds of experts and practitioners to confront conventional wisdom about U.S. manufacturing.
d. The Technology Leadership and Strategy Initiative (TLSI), which convenes more than 40 chief technology officers to understand technology investment drivers and strategies for the 21st century
e. The Economic Advisory Committee, which assembles more than 40 chief economists to suggest actions to spur U.S. economic growth
f. The High Performance Computing Initiative, which focuses on providing advanced modeling and simulation tools to manufacturing enterprises throughout the supply network
g. The Workforce Initiative to transform K-12 education, boost performance in science, technology, engineering and mathematics disciplines, improve workforce training and development, and tap the talents of mature workers

http://www.compete.org/images/uploads/File/PDF%20Files/USMCI_Make.pdf

24. Information Technology and Innovation Foundation, "A Charter for Revitalizing American Manufacturing," March 2012.

This piece of work is ITIF's set of policy recommendations to inform a national manufacturing strategy. ITIF's strategy is informed by what the paper describes as the "Four T's": Technology, Trade, Tax and Talent.

http://www.itif.org/files/2011-a-charter-for-revitalizing-manufacturing.pdf

25. National Science and Technology Council, "A National Strategic Plan for Advanced Manufacturing." February 2012.

The National Science and Technology Council (NSTC)—a group of cabinet-level advisers to the President—is the principal means by which the Executive Branch coordinates science and technology policy across the diverse entities that make up the Federal research and development enterprise. A primary objective of the NSTC is establishing clear national goals for Federal science and technology investments. Developed by the interagency working group on Advanced Manufacturing, this report sets out a strategic plan for a National Manufacturing Strategy.

"The strategy seeks to achieve five objectives. These objectives are interconnected; progress on any one will make progress on the others easier. A large number of Federal agencies, coordinated through the NSTC, have important roles to play in the implementation of the strategy."

It should also be noted that this report calls out both clean energy technology and energy efficiency as integral to a national manufacturing strategy.

http://www.whitehouse.gov/sites/default/files/microsites/ostp/iam_advancedmanufacturing_strategicplan_2012.pdf

26. President's Council of Advisors on Science and Technology, "Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing." July 2012.

The President's Council of Advisors on Science and Technology (PCAST) is an advisory group of the nation's leading scientists and engineers, appointed by the President to augment the science and technology advice available to him from inside the White House and from cabinet departments and other Federal agencies. Developed by the Advanced Manufacturing Partnership (AMP) Steering Committee—a group of university and private sector leaders in manufacturing—the report's is PCAST's policy recommendations for a National Manufacturing Strategy.

http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_amp_steering_committee_report_final_july_17_2012.pdf

27. Gregory Tassey, "Rationales and Mechanisms for Revitalizing U.S. Manufacturing R&D Strategies," June 2010.

Gregory Tassey is the Director of the Economic Analysis Office at the National Institute of Standards and Technology and an expert in manufacturing and manufacturing policy. This journal article reflects Tassey's core recommendations for a national manufacturing strategy.

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28. "The Future of National Manufacturing Policy" (Q4 2012).

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APPENDIX D

Full List of Sources

The full list of sources is comprised of all of the initial sources reviewed and compiled by the Council on Competitiveness in order to conduct the literature review to develop the policy and partnership side-by-side analyses.

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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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