Manufacturing Solar Photovoltaic Products in the United States

Status and Recommendations for Policy Makers

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I. Executive Summary

The objective of this White Paper is to articulate the necessity for U.S. economic development programs designed to retain, attract and increase manufacturing output and employment involved in the rapidly growing photovoltaic (PV) solar industry. Along with most informed economists, analysts and researchers in energy policy, the SEMI PV Group believes that solar PV is at the beginning of a long-term growth cycle and will be a major contributor to energy independence and break from our reliance on fossil fuels in the United States. Today's approximately $80 billion dollar global solar industry has the potential to grow to a trillion dollars in revenues and create as many as 10 million jobs worldwide in the coming years. How many of these jobs will reside in the United States will be dependent on responsible, sustained public policies and government programs that support manufacturing and technology development. In addition to policies designed to stimulate and support the growth of PV power demand and use, forward-thinking policies are also necessary to assure the U.S. economy derives long-term benefits from job creation, increased adoption and other economic benefits of manufacturing solar products on U.S. soil.

The PV industry is a major job creation engine in the U.S. that accounted for over 100,000 jobs in 2011.[1] However, only 24% of these jobs are in manufacturing as a majority of PV cells and modules are made overseas, including many of those manufactured overseas by U.S. companies. The U.S. PV manufacturing industry also includes a long supply chain of American equipment and materials suppliers, electrical and installation components, and balance of system products. A GTM Research report[2] (2010 data) estimated that overall the U.S. solar supply chain contributed a positive $2 billion to the nation's trade balance. However, in February 2012, a reversal in trade balance was reported which took the $2 billion surplus in solar products in 2010 to an over $1.5 billion deficit in 2011.[3] The deficit in cell and module manufacturing will over time lead to migration of some key material manufacturing plants and R&D centers to overseas locations, nearer to their direct customers. It is a rare American industry that has a trade *surplus* with China, as was the case for the solar industry in 2010 when estimated surpluses ranged between $247–540 million.

Some theories on globalization suggest that the United States could benefit from the growth of the solar energy industry through advanced technology and science while letting manufacturing investments and jobs migrate to low-cost labor countries in China and other Asian countries. SEMI PV Group believes that balancing PV energy supply and demand within each region will provide greater economic benefits and reduce the carbon emissions and dollars required to ship PV

1. National Solar Jobs Census 2011, The Solar Foundation
2. U.S. Solar Energy Trade Assessment 2011, GTM Research
3. International Trade in Environmental Goods 2012 Report, Senator Ron Wyden, February 2012

products made in one area of the world for deployment in another. In addition, a recent NREL study,[4] showed that shipping costs offset China's core cost advantage for c-Si module from 1% to -5% and from 10% to -3% for CIGS. While PV creates significant job creation in the installation of solar modules (over 50% of total solar jobs are in installation and sales), long-term job creation in manufacturing will create greater economic stability through a greater multiplier effect that will generate significant additional employment in adjacent industries. Reports from the National Association of Manufacturing (NAM) indicate that each dollar's worth of manufactured goods creates another $1.43 of activity in other sectors, twice the $.71 multiplier for services. And a chart from U.S. Department of Commerce, Bureau of Economic Analysis provides similar findings.

While the U.S. leads the world in venture capital funding and patent activity for solar technologies, many of these early-stage firms face financing, policy inconsistencies, and other barriers in attempting to scale volume production. It is important to identify and support ways to retain a sustainable regional manufacturing supply chain to serve the fast-growing regional market for solar power.

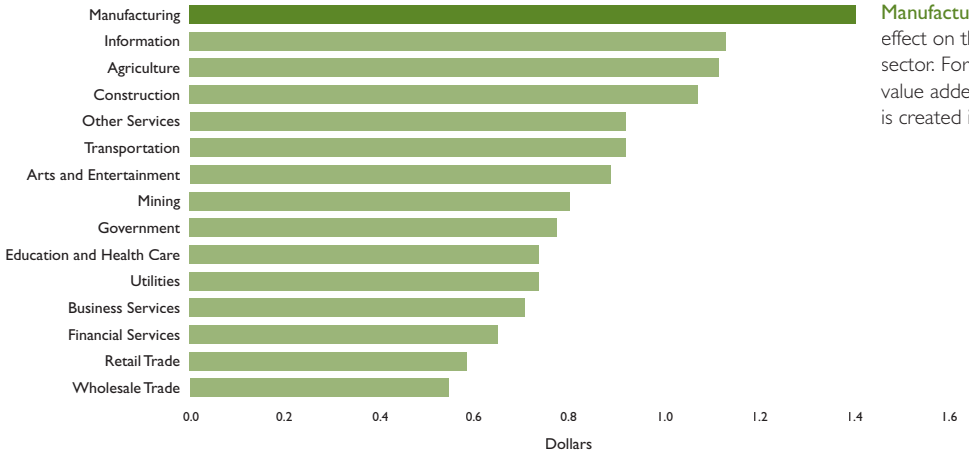
This White Paper will conclude with recommendations on key federal public policy issues that have emerged with the globalization of the solar energy supply chain. U.S. state and federal public policies that have fueled the demand for PV solar power have not kept pace with the policy requirements necessary to sustain and grow the supply of PV products and services. The gap between U.S. PV supply and demand needs to be addressed with public policies that enable U.S. manufacturers of solar energy and other renewable energy products to compete more effectively in both U.S. and global markets.

In support of a balanced demand and supply relationship in the solar PV industry, the SEMI PV Group recommends the following policy positions for federal and state policy makers:

- Large, long-term, stable, market-side support policies, including: a national Renewable Clean Energy Standard (RES), state Renewable Portfolio Standards, buyer incentive programs, sales and property tax credits, and so on.
- Maintain the Investment Tax Credit (ITC) through 2016
- Extend the Section 1603 Treasury Grant Program that has provided a grant in lieu of the advanced energy investment tax credit (ITC).
- Increase Department of Energy funding for both R&D and manufacturing infrastructure development of the U.S. solar industry
- Establish the R&D tax credit on a long-term basis to assure solar manufacturers greater consistency in tax and investment planning
- Revive the Advanced Energy Manufacturing Tax Credit (MTC), and creation of a federal Green Bank to supplement PV and other green energy projects, particularly for manufacturing.
- Work with foreign counterparts and the WTO to develop a strong, effective and enforceable rules-based international trading system that promotes free and open trade.

4. Solar PV Manufacturing Cost Analysis: U.S. Competitiveness in a Global Industry, NREL, 2011

MANUFACTURING JOBS ARE MORE VALUABLE



Manufacturing has a higher multiplier effect on the economy than any other sector. For every $1 in manufacturing value added, $1.4 in additional value is created in other sectors.

Source: U.S. Department of Commerce, Bureau of Economic Analysis

II. Solar Energy: A Trillion Dollar Industry

Prices for gasoline and home heating oil will continue to rise. The Middle East will continue to be a region of political, social and economic instability. China, India and other nations are rapidly increasing their demand for fossil fuels. Power plants that burn coal, oil and natural gas, as well as vehicles everywhere, continue to pour millions of tons of pollutants and greenhouse gases into the atmosphere annually, threatening the planet.

Scientists, engineers, investors, economists and policy-makers around the world are responding to these challenges by improving the performance and affordability of solar PV technology to meet an increasing share of new energy demands around the world. Solar PV is in the beginning stages of a 50-year growth cycle that may reach over 1 trillion dollars in revenues by 2030 globally.

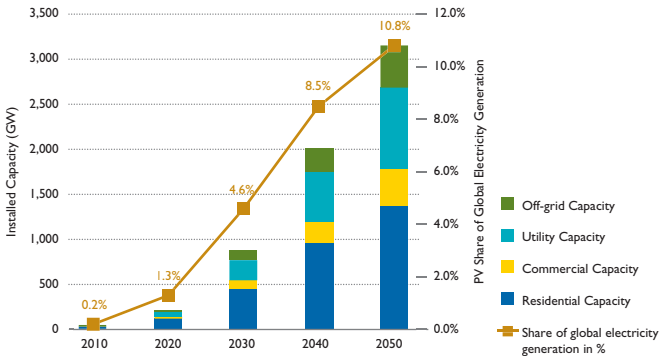
Today the solar PV industry contributes less than 0.5% of the world's electricity, but is already an $80 billion industry. The International Energy Agency (IEA) estimates that with the right support from government policies that PV power will grow its contribution to world's electricity capacity over 5X by 2020, reaching nearly 5% by 2030 and nearly 11% by 2050.[5]

We are entering the rapid growth phase of the PV industry that will create financial opportunity, economic growth and jobs.

The conservative IEA solar energy estimates are one of many predictions that see a positive, long term growth for the solar PV industry. The European Photovoltaic Industry Association (EPIA) estimated that compound annual growth of the PV industry will exceed 12%.[6] The U.S. Department of Energy says that the PV industry can grow 10-fold and provide up to 14% of the nation's electricity by 2030 and 18% by 2050.[7] Industry researchers Navigant Consulting, IMS Research, Solarbuzz, Gartner, Greentech Media, EuPD all see strong, double-digit growth throughout the decade. Financial analysts such as Bank of America, Bank Sarazin, Bloomberg New Energy Finance, and Deutsche Bank are all bullish on the long term growth of the solar power industry. Bank of America (Merrill Lynch) sees Clean Technology and PV to be the sixth revolution, on par with the Industrial and Agricultural Revolutions.[8]

The growth of the industry over the past decade was driven by strong regional governmental policies and incentives, reflecting policymakers' recognition of the long-term growth potential for clean solar energy, and the substantial contribution that solar energy can play in addressing global environmental challenges. Virtually every developed country in Europe, Asia and North America has public policies that encourage the use of renewable energies such as solar and wind. The goals of these policies are primarily to reduce the dependence on fossil fuels, reduce greenhouse gas emissions and to improve energy security. The primary policy mechanism in the world to promote solar energy has been feed-in-tariffs

ESTIMATED ANNUAL COMPOUND GROWTH OF PV INDUSTRY



Source: International Energy Agency

where energy producers are rewarded at a prescribed level for renewable electricity fed into the grid. Today, approximately 40 countries employ some form of feed-in-tariff to offset the higher price of solar energy and encourage PV deployments. In the United States, tax credits and grants from federal, state and or municipal governments are used to support the purchase of solar power by homeowners, businesses, and utilities. Government mandates and targets for renewable energy production, including solar power, have also been used in the United States. Approximately 30 states have implemented Renewable Portfolio Standards (RPS) mandating the use of a specified percentage of electricity generated by renewable sources. Several of those states include a specific portion to be supplied by solar power, supported by performance-based incentives and procurement programs that reimburse owners for the generation and environmental value of solar production.

The result of these various government incentives and policies has been to jump-start and accelerate the emergence of a truly global PV industry; this in turn has led to technology innovation, capacity expansion and steadily reduced costs to produce and install solar energy systems.

The price of solar power today is approximately 65% less than 2005. Last year alone, the price of solar declined by 30%.[9] As the solar industry continues to realize the benefits of economies of scale production, learning curve efficiencies, and increased PV device efficiency, the price of solar power will continue to decline, reducing the need for government subsidies and achieving the critical inflection point for solar power growth called grid parity.

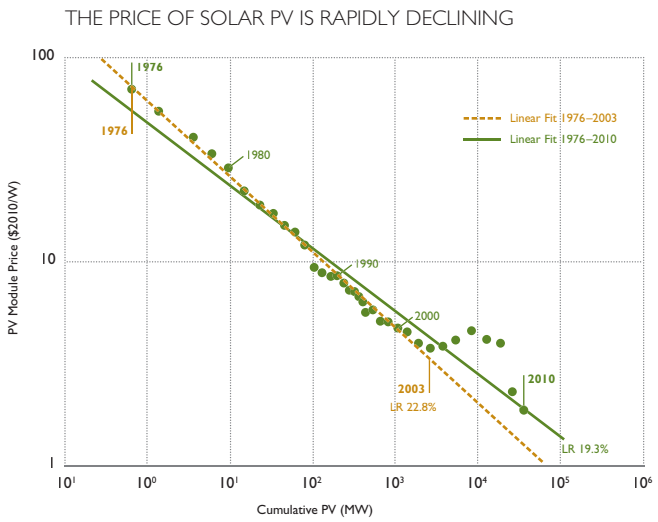
Grid parity for solar power is the point at which the levelized cost of electricity (LCOE) produced or delivered by solar panels is equal to or cheaper than electricity produced by traditional fossil fuels. Once grid parity is reached, demand for photovoltaic products will dramatically expand without price

5. International Energy Agency, World Energy Outlook, 2010
6. EPIA and Greenpeace, Solar Generation 6, 2011
7. U.S. Department of Energy, Solar Energy Technologies Program, SunShot Program Goal, 05/17/2011
8. Bank of America, Merrill Lynch, The Sixth Revolution: The Coming of Cleantech, November 2008
9. Solar Energy Industries Association, Solar Energy Facts: Q2 20119

subsidies. Grid parity will be achieved first in those areas that have a combination of abundant sunshine and comparatively high grid electricity prices, places like California and Texas.

As solar PV power costs continue to decline, solar power will reach grid parity based on a levelized cost of energy (LCOE) beginning now and throughout the decade, depending on local electricity rates and received sunlight. Hawaii is already there; large portions of Southern California are at wholesale grid parity and residential and commercial solar markets and at retail grid parity in much of Northern California.

"Grid parity is not that far away," said Navigant managing director Lisa Frantzis. "It's only about two rate cases away. It's not 20 years out. It's right around the corner, and a lot of these utilities are becoming more and more aware of that."[11]



Cost reduction in PV modules from 1976 to 2010. Like other electronics industries, the cost to produce PV rapidly decline as volumes increase. As volumes double, PV module has consistently declined by about 20% with variations due to materials shortages, market dynamics and other short term factors.[10]

Virtually every expert agrees: solar power will make a significant, long-term contribution to the United States energy future. The current era of subsidies and state RPS mandates—essential to accelerating the industry and establishing the financing and installation infrastructure—will ultimately transition to unsubsidized market-based economics, where solar is directly competitive with conventional grid electricity based on its inherent energy value alone. The solar energy industry will continue to grow and become a major economic force in the world economy, potentially larger than computers, semiconductors and pharmaceuticals.

Over the past decade, policymakers have mostly been focused on encouraging and supporting the demand and development of solar power. In the coming decades, policymakers in the U.S. need to focus on leveraging the economic developments of solar power, particularly the industry's long-term need to expand manufacturing capacity and manufacturing employment. The solar industry is a global industry serving customers around the world. Companies that manufacture products for the solar PV industry have many options on where to locate manufacturing facilities. With the large volume of solar demand expected in the United States, there are strong economic advantages to locating manufacturing resources next to U.S.-based customers and markets. These economic advantages can be leveraged to increase economic growth and employment, but only if we develop effective public policies that understand the global competitive environment for plant and facility locations.

10. N. Tanaka (ed.), Energy Technology Perspectives 2008—Scenarios and Strategies to 2050, International Energy Agency (IEA), Paris, 2008

11. As reported by Andrew Nusca, Smart Planet, July 1, 2010, "U.S. States can reach grid parity by 2014, energy experts says"

III. The Economic Development Opportunity

The solar industry is comprised of a diverse set of technologies, products, manufacturing equipment, materials, subsystems and ancillary components that collectively constitute a complex and valuable supply chain. According to a Greentech Media report, there are more than 5,000 companies in the U.S. solar value chain with at least 39 active facilities manufacturing PV components (polysilicon, wafers, cells, modules, inverters) spread across 17 states.[12] While some solar manufacturing operation have closed due to obsolete equipment, uncompetitive technology and other reasons, according to SEIA, in 2010 and 2011, 27 new U.S. solar manufacturing facilities have begun or will begin operations across America, including in Arizona, Ohio, Michigan, Mississippi, Pennsylvania and Tennessee.

Solar PV technology is generally comprised of two types: crystalline silicon and thin film PV. Crystalline silicon PV from such firms as Sunpower, SolarWorld and many Chinese suppliers utilizes many of the same materials and processes as semiconductor technology to optimize electrical performance. Like other semiconductor devices, the PV crystalline cell manufacturing process begins with raw material silicon that is processed into ingots with specific dopant (type and resistivity) characteristics and then cut into wafers which are then processed in a "fab" to obtain the semiconducting properties desired. The majority of PV power today is supplied by crystalline silicon PV.

Thin film PV technology from First Solar, Sharp Solar, Oerlikon Solar and Stion use similar manufacturing methods as flat panel displays used in today's computer monitors, mobile phone displays and flat screen TVs. Thin film solar

12. Greentech Media, SEIA, U.S. Solar Market Insight™, 2010 Year in Review

panels are constructed by depositing extremely thin layers of photosensitive material on to a low-cost backing such as glass, stainless steel or plastic. Once the material is deposited it is typically patterned using laser scribing into thin electrically-interconnected strips (glass panels) or in the case of roll-to-roll sheets, mechanically cut into module-sized sections.

U.S. companies are represented in every step of the value chain in both technologies:

- **Manufacturing Equipment:** According to NPD Solarbuzz, in 2011 approximately $13.1 billion globally was spent on equipment to manufacture and process polysilicon, ingots, and wafers, cell and modules in the solar industry. Many of the leading semiconductor companies that provide manufacturing equipment to the PV industry also serve the semiconductor and flat panel display industries. Companies such as GT Advanced Technologies, Applied Materials, KLA-Tencor, Amtech, and others are key global suppliers to the crystalline silicon PV technology. In thin film, some of the equipment is built by the module manufacturers is customized, but utilizes critical subsystems and components manufactured in the U.S.
- **Materials:** Polysilicon is the largest cost contributor to crystalline silicon PV solar cells, representing approximately 25% of the total cost of a solar module. In the U.S., three leading polysilicon manufacturers have manufacturing plants: MEMC, Hemlock Semiconductor and REC. In addition, both Wacker Chemie and Hemlock Semiconductor have announced billion dollar projects to expand U.S.-based production. Other materials used in the manufacturing process are glass, wet chemicals, gases, dopants, inks and pastes, encapsulation/backsheets and slurries.
- **Solar Cells and Modules:** According to Photon International, the U.S. produces 4.8% of the world's PV solar cells.[13] China's contribution to global cell production has risen rapidly to account for approximately 48% of the world's capacity. Rapid price declines of PV modules initiated plant closure announcements at several U.S.-based PV manufacturing facilities: BP Solar's wafer-cell plant in Maryland, Spectrawatt's cell plant in New York, Solyndra's thin film plant in Fremont, California, Energy Conversion Devices plant in Auburn Hill, Michigan and Evergreen Solar's wafer-cell-module plant in Massachusetts.

  New U.S. PV manufacturing plants announced in 2011 include Stion's CIGS (Copper Indium Gallium Selenide) facility in Mississippi, a 250MW manufacturing site for First Solar in Arizona, Flextronics module assembly plant in California (SunPower partner), and a 400 MW plant by General Electric for producing cadmium-telluride thin film panels in Colorado. Several other companies have announced plants for new PV manufacturing plants, financed in part by DOE Loan Guarantees, including SoloPower (Oregon). Abound Solar (Colorado/Indiana) has already shut down one of its production lines and plans to upgrade their equipment to produce a more efficient solar panel design. These manufacturing plants represent a cross-section of all technologies. Many of these new facilities are start-ups (thin-film) and are not yet at full mass production.
- **Balance of Systems:** Manufactured products used in conjunction with solar power include inverters, junction boxes and connectors, transformers, racking, trackers, sensors and controls, anchors and ballasts, and optical components.
- **CPV (Concentrated Photovoltaics):** CPV uses highest efficiency solar cells originally developed for space applications by leading space companies like Boeing/Spectralab, who manufactures these cells in Southern California. These cells are incorporated into large modules using concentrating technologies. CPV requires high direct normal irradiation (DNI) in order to be competitive. The U.S. Southwest is one of the best DNI areas in the world. As CPV modules are bulky and heavy, assembly plants are located close to end-user installation areas. A new assembly plant was opened by U.S. company Amonix in Las Vegas in 2011, however, in January 2012, it laid off 2/3 of the workforce as it retools production. Soitec Solar of France/Germany is currently setting up a 200MW assembly plant in San Diego. Soitec and Amonix are the two CPV players with the largest publicly declared project pipelines.

In a widely reported meeting between President Barack Obama and Silicon Valley high tech executives (*New York Times,* January 21, 2012), President Obama asked the late Steve Jobs, "what would it take to make iPhones in the United States?" Mr. Jobs's, in reference to highly developed electronics assembly supply chain in China, replied, "Those jobs aren't coming back."

Unlike the electronics assembly supply chain, the U.S. solar supply chain is healthy and among the leaders in the world. But without effective policies, the U.S. risks losing not only solar cells and module manufacturing, but the entire supply chain of high tech and cleantech equipment, components, software and materials suppliers.The necessary manufacturing infrastructure of suppliers and service firms is in place; our policy choice is whether to support this source of jobs and competitive advantage or watch it gravitate to offshore locations.

13. Photon International, Earth Policy Institute, Wiley Rein. Graphic: Tobey/ *The Washington Post.* Published on December 16, 2011

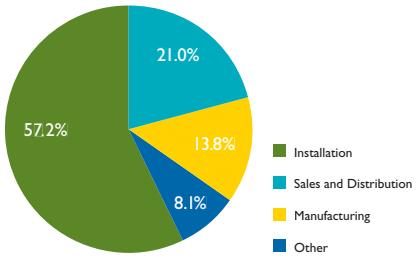
IV. The Importance of Solar Products Manufacturing to U.S. Economic Development

Throughout U.S. history, state and federal governments have embraced the responsibility to support economic development by promoting innovation and competitiveness, and preparing American regions for growth and success in the worldwide economy. Economic development policies typically have job creation and retention as a primary goal and often involve specific efforts in business finance (grants, loans and tax incentives), infrastructure development, technology transfer, workforce development, business retention and expansion. Policies that support solar products manufacturing in the United States would be consistent with these long-held goals of economic development: job creation and retention.

Many researchers have claimed that solar energy is the most effective and efficient job creator among all traditional and renewable energy sources. As much as 33 jobs are supported per megawatt (MW) of solar power, in comparison to less than 10 jobs supported for every MW in coal, natural, nuclear and wind power generation. A study by M. Wei et al. also confirms solar PV creates more jobs per unit of electricity output than other alternatives.[14] By 2030, an estimated 10 million full-time jobs will be created thanks to the development of solar energy around the world.[15] Where these jobs locate will be subject to a variety of economic, social, geographic, and historical factors—working in concert with government-supported economic development policies. Nearly all developed countries in the world have policies designed to encourage the development of renewable and solar energy for the express goal of job creation and retention.

In the U.S., The Solar Foundation provides the most thorough overview of the U.S. solar employment outlook. As of August 2011, the National Solar Jobs Census 2011 identified more than 17,198 solar employment sites and 100,237 solar jobs in all 50 states. The solar workforce grew 6.8% from 2010 to 2011—nearly 10 times the overall national employment growth rate—and is expected to grow an amazing 24% in 2012. Of the total jobs in 2011, 24% are involved in manufacturing.[16]

PERCENTAGE OF RESPONDENTS, BY SUBSECTOR



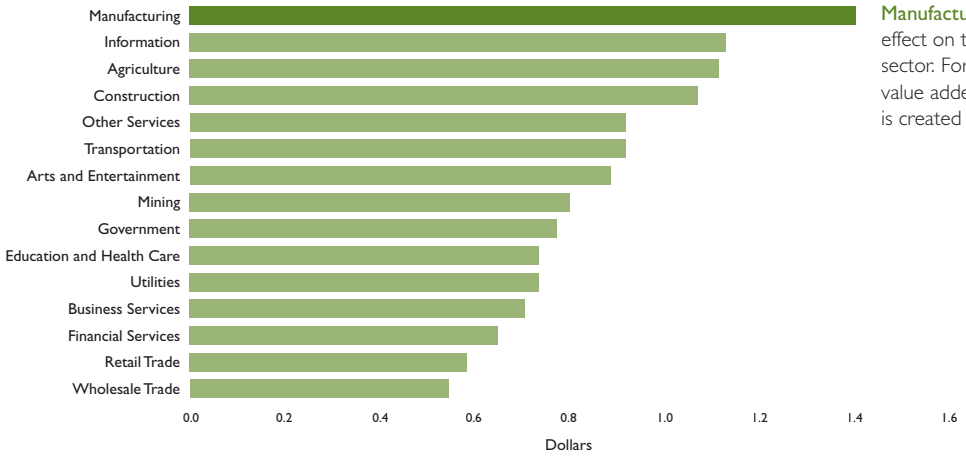
While the majority of jobs related to the solar industry have been in the sales and installation of solar products, the full value of manufacturing employment should not be underestimated. Employment multipliers measure how job creation or destruction in a particular industry translates into wider employment changes throughout the economy. Several empirical studies have shown that closing of an auto factory, for example, that employs 1,000 people will have a greater impact on the overall economy than the closing of a retail shopping mall that employs 1,000 people. The direct impacts (1,000 jobs lost) are the same; but employment multipliers

14. M. Wei, Shana, patadia and Daniel Kammen, Putting renewables and energy efficiency to work: How many jobs can the clean energy industry create. Emergy Policy, 38 (2010 919-931

15. Solar Generation V- 2008, EPIA and Green Peace

16. The Solar Foundation, 2011 National Solar Jobs Census, October 2011

MANUFACTURING JOBS ARE MORE VALUABLE



Manufacturing has a higher multiplier effect on the economy than any other sector. For every $1 in manufacturing value added, $1.4 in additional value is created in other sectors.

Source: U.S. Department of Commerce, Bureau of Economic Analysis

indicate that manufacturing jobs—due to their relation with other suppliers and service firms—have a greater positive impact on the surrounding economy. The Economic Policy Institute estimates that every 100 jobs in manufacturing support 2.91 jobs elsewhere in the economy, compared to 1.54 jobs in business services.[17] Another study by the National Association of Manufacturing (NAM) indicates that each dollar's worth of manufactured goods creates another $1.43 of activity in other sectors, twice the $.71 multiplier for services.[18]

The U.S. Bureau of Economic Analysis (USBOA) estimates that about one in six U.S. private sector jobs depend on the U.S. manufacturing base. USBOA estimates that manufacturing supported an estimated 18.6 million jobs in the United States in 2009: 11.8 million jobs directly within manufacturing and more than 6.8 million jobs in sectors outside of manufacturing such as professional services, transportation, retail and agriculture.[19] The economic benefits of manufacturing solar power products are significant and profound.

17. Josh Bivens, PhD, Updated Employment Multipliers for the U.S. Economy, Economic Policy Institute, 2003

18. National Association of Manufacturers, *The Facts About Modern Manufacturing,* 8th Edition, 2009

19. U.S. Bureau of Economic Analysis, 2007 Annual Input-Output Tables

V. The Link Between U.S. Innovation and U.S. Manufacturing

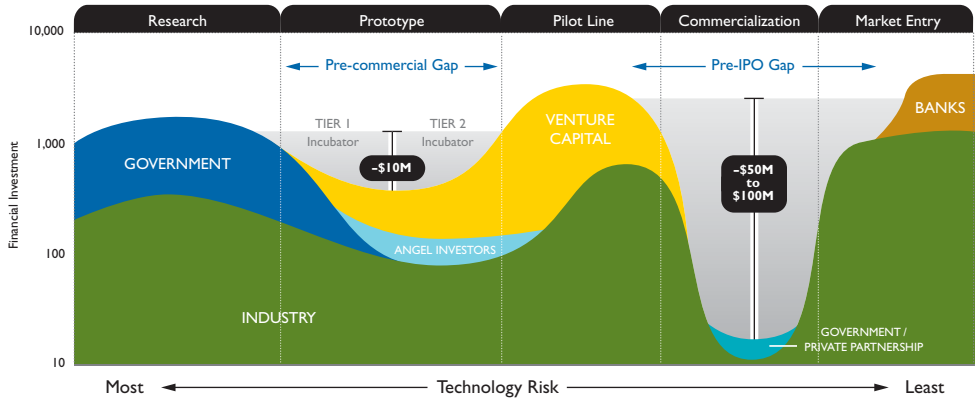
A major competitive strength of the United States is the collective research and development ecosystem that has propelled American high technology companies to world leadership positions. In the key sectors of information technology, life sciences, electronics, aerospace and defense, and energy, a strong synergy between private and public R&D funding has been widely recognized as an essential component of U.S. global competitiveness. Over one-third of global R&D funds are spent in the U.S.; 25% of the global R&D spending on energy is in the U.S.; over 20% of the world's R&D investment in chemicals and advanced materials is in America. Basic research funded by the National Science Foundation, the National Institute for Science and Technology, the National Institutes of Health, the Department of Defense, and the Department of Commerce enjoy bipartisan support to advance the national health, prosperity and welfare, to help secure the national defense.

It is essential that effective public policy work to link this global leadership in R&D and innovation with employment. The best way to ensure that solar PV innovations developed in government-supported labs benefit the most Americans is to ensure a high percentage of these innovations are manufactured in the United States. As many new technologies reach volume production levels, they often move to non-U.S. manufacturing locations. Effective public policy and the State and Federal level must seek to retain positive manufacturing and employment outcomes as these firms scale to volume production.

As in other sectors, the United States currently leads the world in solar PV innovation, but has not leveraged this position into manufacturing job creation. More venture capital in solar energy, more patents and the world's leading academic R&D efforts are all occurring in the United States than in any other country. According to the Cleantech Group, a San Francisco-based global research organization, venture fund investments in clean technologies reached $8.99 billion in 2011, a 13% increase over 2010.

North America led the world in venture investments with $6.8 billion, 76% of the world total, up 31% over 2010.

BRIDGING THE GAP BETWEEN R&D AND MANUFACTURING



Effective public policy can bridge the gap between U.S. leadership in R&D and innovation and job-creating manufacturing/commercialization.

Cleantech mergers and acquisitions reached record highs in 2011 with 391 deals and a dollar volume of $41.2 billion, a robust 153% growth over 2010. Solar was the leading sector by amount invested ($1.81 billion). According to Mercom Capital, over 90% of the VC funding activity in solar was in the U.S.

In North America, California led the way with $3.69 billion in investments (54% share), followed by Massachusetts ($542 million, 8%) and Colorado (358 million, 5%).

The granting of patents by the United States Patent and Trademark Office (PTO) is another strong indicator of U.S. leadership in solar innovation. Patent awards measure the effectiveness of research and development investments, because not only does it account for the efforts of inventors to develop new and non-obvious innovations, but also the legal and financial requirements needed to shepherd a patent application through the PTO.

Through the first three quarters of 2011, nearly 400 U.S. patents were granted in solar energy, more than all of 2010 and more than double the patents granted in all of 2009. California ranks first in the U.S. in green-tech patents by a wide margin. It had 450 between 2007 and 2009, outpacing New York, which had 300.

Leadership in patents and venture capital funding, however, has not led to significant manufacturing job creation. Experts from NREL, Sandia National Laboratories and others have commented on the gaps in U.S. public policy that fails to leverage the U.S.'s leading role in high technology development to high volume manufacturing. Start-up companies and new corporate initiatives born in the USA through venture funding, academia connections and national science funding enter a "valley of death" at the commercialization and market entry stage that yield major economic benefits of employment and economic scale.

The challenge for U.S. policy makers is how to retain the benefits of this U.S. innovation to U.S. workers and taxpayers. Throughout the 1980s, the United States was the world's leading producer of high-technology products, including solar products, responsible for more than one-third of total world production from 1980 to 1987 and for about 30% from 1988 to 1995. In 1998, the United States high-technology industry accounted for 36% of world high-technology production, a level last reached in the 1980s.[20]

The U.S. share of global high technology exports declined from 21% in 1995 to 14% in 2008. During this time, China's share of global high tech goods exports more than tripled, from 6% in 1995 to 20% in 2008. According to the National Science Foundation, The U.S. trade balance of high tech products shifted from surplus to deficit, starting in the late 1990s. In 2000, the deficit was $32 billion in current dollars; in 2008, increasing to $80 billion in 2008.[21] Solar now has over a $1.5 billion trade deficit and is threatened by the same forces and international competition for manufacturing jobs that affect other high technology industries.

Many economists believe there is a strong link between manufacturing and R&D: **lose manufacturing and you lose the high-paying jobs in R&D, design and other areas. Lose manufacturing and you lose the entire industry to foreign companies.** This is particularly true for process engineering dependent industries like solar PV where continuous improvements in manufacturing processes play a major role in cost reduction and product improvement

In the *Harvard Business Review*, Harvard professors Pisano and Shih wrote, "the decline of manufacturing in a region sets off a chain reaction. Once manufacturing is outsourced, process-engineering expertise can't be maintained, since it depends on daily interactions with manufacturing. Without process-engineering capabilities, companies find it increasingly difficult to conduct advanced research on next-generation process technologies. Without the ability to develop such new processes, they find they can no longer develop new products. In the long term, then, an economy that lacks an infrastructure for advanced process engineering and manufacturing will lose its ability to innovate."[22]

20. National Science Foundation. Science and Engineering Indicators, 2002

21. National Science Foundation, Science and Engineering Indicators, 2008

22. Gary P. Pisano and Willy C. Shih, Restoring American Competitiveness, *Harvard Business Review*, August–September 2009

VI. The U.S. Policy Landscape

In the United States, economic development responsibilities are widely dispersed among federal, state and local governments. Manufacturing companies that are looking to move, expand or locate new facilities in the U.S. have a mix of assistance and benefit programs available to them—from tax incentives, loan programs, and grant assistance from federal, local and state governments—plus a variety of other benefit programs such as job training, R&D collaborations, utility agreements, permitting assistance and other programs that may be custom-designed to fit the needs of a company. In general, state and local economic development programs are designed to compete for manufacturing jobs within the U.S., while federal programs are designed to provide equivalent assistance and incentives to companies in all states. The combination of state, federal and local programs represent the national competitiveness strategy for manufacturing for the nation, however many of these programs are ineffective, inconsistent and work at cross purposes.

State and Local Programs

These programs vary widely and often involve research partnerships, workforce development and job training, business planning and marketing, and business capital and funding. Most states have numerous departments and programs that are involved in economic development. California state government, for example, currently operates 84 economic development programs administered by 30 departments. Local government institutions work closely with state governments to attract and retain manufacturing jobs. To compete on a national and international basis, state resources are often targeted for land, tax incentives, and financing programs, while local governments assist companies with workforce development, site selection, permitting, and intergovernmental relations.

Most states and cities offer customized economic development packages on a case-by-case basis to aggregate and target benefit packages to specific companies. These customized programs may include free or reduced-price land, reduced and guaranteed utility rates, research funding in collaboration with local colleges or universities, and job training incentives. States may also develop demand-side policies such as Renewable Portfolio Standards or solar tax credits to compliment economic development programs targeted at job creation. A manufacturer looking to site in the US will look for both supply-side and demand-side commitments. Moreover, states that have done well in capturing manufacturing set up "one-stop shops" to assist manufacturers in reviewing city, county and state issues and incentives.

State and local programs have played a major part by providing the largest investments in solar PV manufacturing capacity and employment in the United States. Some notable examples include:

- Oregon has utilized a Business Energy Tax Credit (BETC) equal to 50% of the incurred capital investment costs for eligible renewable energy manufacturing activities in combination with property tax abatements, certified "shovel-ready" sites, and other financial incentives to attract several solar PV manufacturers. The largest project was the sale and conversion of former semiconductor manufacturing site by SolarWorld, a German manufacturer of solar wafers, cells, and PV modules, to a 500MW production capacity employing nearly 1000 workers.
- New Mexico has established a comprehensive set of tax credits intended to stimulate both the PV products and PV energy generation sectors, such as the High Wage Jobs Tax Credit, the Alternative Energy Product Manufacturers Tax Credit, and the Advanced Energy Tax Credits, the Renewable Energy Production Tax Credit, as well as Industrial Revenue Bonds to finance new machinery and equipment.
- Michigan uses targeted state and local financial incentives for renewables and solar manufacturing, including the NextEnergy program that provides tax credits and general property tax exemptions, the 21st Century Investment Fund, created to leverage private sector investments, State tax credits for "anchor" technology companies that assist in attracting a supply chain facility within 10 miles of the "anchor" facility. In addition a solar PV-specific tax credit for manufacturing activities or development of PV energy, systems, or technology. The credit is equal to 25% of capital investments in a new facility in a given year, up to $15 million. Also, state and local governments have worked together to create Renewable Energy Renaissance Zones. Businesses located within these zones receive exemptions from the state business tax, education tax, personal and real property taxes, and local income tax, where applicable. Tax abatements are available for up to 15 years, with a 25% incremental phase-out over the last 3 years.
- Colorado and the city of Denver have worked together to develop incentives and assistance programs offered to manufacturing companies including tax credits, grants, and loans from a strategic fund, and job training and investment tax credits available to small innovative companies. Abound Solar, Ascent Solar, SMA Solar, and PrimeStar Solar are among the companies to take advantage of the incentives to locate their facilities in Colorado.

U.S. Policy Landscape

In the mid-to-late 2000's, U.S. federal public policy made some strides forward in its support of renewable energy. One of these federal policies was in 2008 when Congress extended the thirty percent Investment Tax Credit (ITC) for eight years to 2016. Additional support came from the 2009 American Recovery and Reinvestment Act (ARRA), which introduced the Sec. 1603 Treasury Grant Program

(TGP), which allows businesses to take the ITC as an upfront cash grant, and the Sec. 48(c) Advanced Manufacturing Tax Credit (MTC) which invested $2.3 billion as a 30% tax credit for U.S. manufacturing of "clean energy." SEMI PV Group was active in advocating for the inclusion of these measures in ARRA on behalf of its member companies. The certainty of the credit extending to 2016 is of paramount importance to manufacturing investors.

With the U.S. Federal Government now divided between the Democratic White House & Senate and the Republican controlled House of Representatives, very little legislation has been passed by both Houses and signed into law by President Obama since the beginning of the 112th Congress which started on Jan. 5, 2011. In fact, the President has signed only 63 bills into law as of late December 2011, as compared with 385 for the entirety of the previous Congress.[23] The most important legislation to have passed in this Congress to date is undoubtedly the Budget Control Act which cut $900 billion of federal spending over 10 years, and set up the "Super Committee" to find an additional $1.2 trillion in cuts, or face automatic sequestration of funds. The committee's failure to come to agreement means that funds will now be automatically sequestered, further reducing federal spending.

In part because of these fiscal challenges, the U.S. solar industry is facing increased scrutiny. After the bankruptcy of thin film module manufacturer Solyndra, which had received a $535 million Department of Energy Loan Guarantee, as well as other high profile shutdowns (Evergreen, SpectraWatt, and BP Solar), the viability of solar module manufacturing in the U.S. is being called into question. Although Solyndra represented less than 1/5 of 1% of total U.S. solar production, the high profile nature of the bankruptcy, and the company's ties with the Obama Administration, have given a distorted view of the nature of the U.S. solar manufacturing supply chain. Nevertheless, this high profile failure has damaged the image of solar energy in the U.S., and given ammunition to policymakers who oppose government support of solar.

In addition, the U.S. government now finds itself in the middle of a trade dispute between U.S. solar cell and module makers, led by SolarWorld Industries America Inc. and backed by a consortium of other companies called the Coalition for American Solar Manufacturing (CASM), and China. SolarWorld filed dual trade petitions against the Chinese crystalline silicon solar cell and module industry with allegations of illegal trade subsidies and dumping. If SolarWorld and CASM is successful, the U.S. may levy tariffs against imported Chinese cells and panels, potentially at duty margins of more than 100%.

Overall, the debate in Washington, DC will continue to focus on cutting government spending, not on a substantial overhaul of overall energy policy. With the 2012 Presidential election taking the forefront of American politics, very little new legislation, if any, is expected to be enacted into law prior to the 113th Congress being seated in January, 2013.

Federal Incentives

The ITC and the TGP have been useful tools to increase domestic production of electricity from solar PV. Since the inception of the TGP in 2009 and its extension at the end of 2010, the TGP has been responsible for the outlay of $1 billion in federal money to support the deployment of solar PV in the U.S. Since this is a 30% tax credit, this means that it has successfully leveraged over $2.3 billion in private investment for solar PV. With this, solar PV installations in the U.S. have gone from 340 MW in 2008 to 480 MW in 2009, 887 MW in 2010, and estimates for 2011 for installations range from 1800–2400 MW.[24, 25] Such rapid growth has experts believing the U.S. will be the top global market for PV installations by 2013.[26]

While the market for installations continues to grow in the U.S., manufacturing of solar modules has increasingly moved overseas. As of 2000, 27% of panels were made in the U.S., down from a high of 43% in the mid-nineties, but that number has now declined to only 6% as the share of the global market in China has gone from zero to over half of the world's production in the same time period.[27] Although ARRA provided for $2.3 billion in tax credits under the MTC, that program was almost immediately oversubscribed with $8 billion in initial applications, with $1.1 billion going to solar PV related projects. This clearly demonstrates a need for additional capital resources to support domestic manufacturing of clean energy technology, especially solar PV. As the fossil fuel industry can attest, current and new manufacturing investors need market policy commitments coupled with supply-side resources to keep updating production agility.

The bright side of the solar manufacturing story is in the PV equipment and materials sector. The U.S. continues to lead in this area, exporting $1.4 billion in equipment and $2.5 billion in polysilicon in 2010.[28] In conjunction with solar cell and module production solar manufacturing now employs nearly 24,000 workers in the U.S., and an increase is projected from 2011 to 2012.[29] The downside is that if module manufacturing does not take hold in the U.S. in a more meaningful and sustainable way, equipment and materials industries will more likely move overseas to be closer to their customers.

23. Thomas.loc.gov
24. http://www.greentechmedia.com/articles/read/America-Finally-Joins-the-1-Gigawatt-PV-Club/
25. http://www.pv-tech.org/news/us_pv_installations_set_to_reach_2.4gw_in_2011_according_to_ihs_isuppli_rep
26. http://greentechadvocates.com/2011/09/23/u-s-pv-market-poised-to-be-world%E2%80%99s-biggest/
27. U.S. Department of Energy
28. U.S. Solar Energy Trade Assessment 2011: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States, A GTM Research Study, Prepared for Solar Energy Industries Association® August 2011
29. National Solar Jobs Census 2011, A Review of the U.S. Solar Workforce, October 2011

The Role of Federal Agencies

Department of Energy, SunShot: The DOE SunShot Initiative aims to dramatically decrease the total costs of solar energy systems by 75% by 2020, bringing it down to a goal of $1 per watt. Reaching this goal will make solar energy price-competitive with conventional forms of electricity without subsidies and enable widespread deployment across the United States. As part of the SunShot Initiative, the DOE has also rolled out its SUNPATH (Scaling Up Nascent PV At Home) Initiative which is a $50 million fund for domestic PV manufacturers to commercialize solar technology to help restore the United States' position at the forefront of solar manufacturing. The SUNPATH initiative is designed to support companies with pilot level commercial production facilities to scale up their manufacturing capabilities so that they can fast track the ramp up to full production capacity. This is often the most difficult stage for start-ups to bridge. As part of the SunShot program, the DOE is investing $112.5 million into three different programs aimed at developing advanced manufacturing techniques that will lower the cost of producing PV panels. This effort is known as the Photovoltaic Manufacturing Initiative (PVMI).[30]

30. SEMI PV Group is a member of two of three PVMI projects

VII. SEMI PV Group Policy Recommendations

The following policy recommendations are essential to the solar PV manufacturing industry in the U.S.:

Renewable Clean Energy Standard (RES)—Large, long-term, and stable, market-side support policies, including: a national Renewable Clean Energy Standard (RES), state Renewable Portfolio Standards, buyer incentive programs, sales and property tax credits.

Maintaining the Investment Tax Credit (ITC) to 2016—With tax reform on the table, the ITC could be vulnerable in discussion of "cleaning up" the tax code. Without this tax credit, solar installations in the U.S. would all but dry up, eliminating the 100,000 (25,000 manufacturing) solar jobs in the U.S. This credit must be protected. Manufacturers need the certainty of this credit out to 2016.

DOE Funding—In the new age of fiscal austerity, the DOE has become a target for severe cuts to the EERE and the Solar Technologies program. SEMI PV Group urges Congress to support the R&D projects at DOE for solar, and urges DOE to focus on driving down costs of solar through the manufacturing process.

R&D Tax Credit—The federal government offers a tax credit for qualified research and development activities. The tax credit is typically extended every 1-2 years, which although it is helpful, would be better if made permanent to allow for certainty in tax planning. Continued federal support for R&D activities is crucial to advancing performance and driving down costs of solar PV systems.

Section 1603 Treasury Grant Program—SEMI urges Congress to extend the Section 1603 Treasury Grant Program that has provided a grant in lieu of the advanced energy investment tax credit (ITC). Although this program expired on December 31, 2011, SEMI supports the extension of this program to allow renewable energy projects the ability to utilize the ITC in a continued atmosphere of weak tax markets. This program has been critical to the increase in installations and should be extended so the solar industry can continue to grow and to provide more jobs in both installations and manufacturing in the U.S.

Additional Policy Objectives

SEMI PV Group believes that strong federal government support is key to a strong solar PV manufacturing base in the U.S. While the above mentioned polices are important for solar, the following polices would be truly transformational in the use of solar PV, but have a less likely chance of being implemented because of the current political and fiscal state of the U.S.

- **Reviving the Advanced Energy Manufacturing Tax Credit (MTC)—**In 2009, Congress authorized $2.3 billion in tax credits for qualified investments in advanced energy projects, to support new, expanded, or re-equipped domestic manufacturing facilities. The goal of the advanced manufacturing tax credit (MTC) is to grow the domestic manufacturing industry for clean energy, create jobs, and reduce greenhouse gas emissions. The initial cap of $2.3 billion proved to be too low, as the program was immediately oversubscribed with the Department of Energy receiving $8 billion in applications. SEMI PV Group urges Congress to revive the MTC so that more companies can take advantage of the MTC, create more jobs, and increase domestic production of renewable energy technologies.
- **National Renewable Energy Standard/Clean Energy Standard—**A Renewable Energy Standard (RES) requires that a certain percentage of energy production come from renewable energy sources. Such a policy is now in effect in over half the states and the District of Columbia. SEMI PV Group supports the implementation of a strong national RES to help drive the market for increased deployment of Solar PV. If Congress were to consider a broader Clean Energy Standard, to include nuclear, natural gas, and "clean coal," the SEMI PV Group strongly asks the solar technologies be afforded a "carve out." Such a consideration would insure that our technologies are treated fairly and recognized for absence of certain negative externalities,

such as nuclear processing and securitization, carbon emissions, or other harmful pollutants. Such a carve-out would also level the playing field between large non-solar utility-scale technologies and solar PV which is largely deployed in smaller scale projects. In addition the carve-out would help to recognize the benefits of solar as a distributed generation technology.

- **"Green Bank"—**SEMI PV Group supports the creation of a Green Bank to help finance America's transition to cleaner and renewable forms of energy, specifically solar PV. The Green Bank would be a publicly owned bank, started with federal government seed money, designed to provide low interest financing to businesses to invest in clean-energy technologies. By working closely with private banks to provide loans, credit enhancements, and other financing tools, the Green Bank would stimulate private-sector lending and investment for projects that are currently unable to access conventional financing on the size and scale needed.
- **Trade Policy—**Global trade policies serve a fundamentally important function in the photovoltaic industry since many companies throughout the supply chain are highly dependent on exports and work with a range of customers around the world. International market opportunities are critical to the success of this industry. SEMI PV Group has long advocated for a strong, effective and enforceable rules-based international trading system that promotes free and open trade. This allows companies to compete on the basis of quality, technology and service within a predictable system according to rules that governments have negotiated in bilateral, regional and multilateral settings. SEMI PV Group urges that the pending trade cases currently under review proceed on a factual basis and that the process not become politicized. As a global association, SEMI PV Group provides a unique forum for companies from around the world to work together to lower costs, increase adoption and make solar competitive with other forms of energy. We invite all interested parties to join us to discuss and pursue policies that are in the best interests of the industry, our customers and consumers.

About SEMI and PV Group

SEMI is the global industry association serving the nano- and microelectronics manufacturing supply chains. The SEMI PV Group represents SEMI member companies involved in the solar energy supply chain. SEMI member companies are the engine of the future, enabling smarter, faster and more economical products that improve our lives. SEMI maintains offices in Beijing, Bengaluru, Berlin, Brussels, Grenoble, Hsinchu, Moscow, San Jose, Seoul, Shanghai, Singapore, Tokyo, and Washington, D.C. For more information, please visit www.semi.org and www.pvgroup.org.

About the SEMI North American PV Advisory Committee

The SEMI North American PV Advisory Committee consists of representatives from equipment and materials suppliers, cell and module manufacturers, national laboratories and other entities. The committee provides guidance and input into SEMI's North American activities such as public policy, technology roadmap and standards development and other issues pertinent to the U.S./North American PV manufacturing supply chain. Many committee and subcommittee members have contributed to this white paper.

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