Critical Mass:

Building the Road to Unsubsidized Photovoltaic Solar Energy

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25 August 2009

Contents

Executive Summary

Solar photovoltaic (PV) electrical generation has the potential to solve a number of economic, technological and security issues. PV's unique application as distributed generation especially provides a number of opportunities to the nation. However, the cost of PV installation must come down to realize these solutions. The federal government can rapidly reduce cost and expand the industry with well-formed policy.

Encouraging demand for photovoltaics will help spur installation of PV systems. Installations necessarily create jobs. Large enough demand can attract manufacturers onshore and bring growth in the high tech job market. Widespread implementation can have effects on bulk power generation. PV produces electricity when consumers demand the most electricity. Consequently it offsets expensive peak electricity generation, and prevents the need for additional infrastructure improvements. PV also gives consumers backup power during outages, saving thousands, or even millions of dollars by preventing electricity loss. PV also encourages development of the smart grid and mass energy storage technologies.

The cost of PV, risk of capital development, intermittency of the generation, and poor policy currently prevent greater PV penetration. The cost of PV has fallen dramatically in the past few years, and increase in manufacturing scale will likely decrease costs further. However, with most of the demand overseas, manufacturers have little incentive to do their work in the United States. The risk of capital investment in a new industry also prevents manufacturers from moving forward. Intermittent and irregular subsidies have not inspired the investor confidence to build the U.S. Solar Industry.

Congress can encourage growth in the renewable energy industry by implementing a finely-tuned feed-in-tariff (FIT) program. FITs have worked well in Germany and Japan, the leading nations in the photovoltaic industry. A regional-scale, federally-funded, competitive FIT should give the necessary incentives to spur industry growth. A long term guarantee, and metering to record total production will also accelerate the growth of the industry. Reimbursing consumers for electricity produced based on the instantaneous price of electricity will allow consumers to make a return on investment faster. R&D consortia will help to decrease the costs of PV panels. Finally, the federal government can encourage local governments to do their parts to smooth regulation for PV installers. Through these policy implementations, the federal government can capture the benefits of PV technology in the most efficient way.

Introduction

Solar Photovoltaic (PV) technology provides a reliable source of abundant, wireless electricity. The United States could solve myriad defense, infrastructure and economic problems by installing as many of these devices as possible. However, solar technology can make no significant change until market forces drive its implementation. Fortunately, in many places, only a small gap remains between the cost of photovoltaic energy and that of conventional energy. When the technology finally crosses that cost point, the PV industry will reach critical mass. This means the industry will have the demand, supply chain, and infrastructure to grow independently, innovating and advancing in whatever direction the market deems best. The opportunities for PV clearly demonstrate the advantages of pursuing this technology. Examining the challenges indicates the largest problems the government must tackle to realize this goal. The federal government must implement several policies to help the market naturally grow this technology. America must use distributed generation to achieve critical mass in the solar photovoltaic electricity generation industry.

Opportunities: How will it benefit us?

Distributed photovoltaic technology has the potential to provide energy, expand the national economy, improve electrical reliability, grow our technical prowess and promote national security.

Promote National Economy

Effective policies will strengthen America's share in the global photovoltaic market. Such growth will generate revenue in turn creating jobs in the United States.

Generate Revenue

Government support of PV will encourage other additional spending in the American economy. A PV system installed on a home produces electricity, therefore offsetting the cost of electricity a consumer must purchase from the electrical utility. These cost savings add up over time. In the right conditions, the solar panel will offset its entire purchase price in electricity savings. At this point, the system has "paid for itself." Customers tend to purchase PV systems when they have a short payoff period. PV installation firms recommend about a seven year payoff period for customers. Government subsidies help reduce this time and encourage consumers to buy PV systems. In this way, a government investment encourages greater public investment. A widespread investment can incite higher overall demand.

Increasing PV demand can exponentially increase the influx of money to the American economy. PV manufacturers respond to demand by increasing manufacturing capacity. Each doubling of capacity reduces the cost of PV modules by about 20 percent [1]. Lower cost PV products open new markets and further increase demand. With each new generation of technology, the same government subsidy encourages comparatively more revenue for the PV industry.

Distributed generation can help lower the overall cost of electricity. Electricity prices spike during the daytime and early evening. However, large-scale PV implementation provides additional energy during these peaks. The additional generation reduces the need for expensive natural gas peaking plants, reducing the cost of electrical production. This phenomenon, known as the merit order effect, introduces a cost savings to all consumers of electricity.

Create Jobs

Distributed generation will add important jobs to the American workforce. PV requires jobs in the manufacturing and high-tech sectors. Additionally, PV necessarily promotes entrepreneurship and on-shore job creation. Figure 1 gives an example of the number of jobs created for each megawatt (MW) of demand.

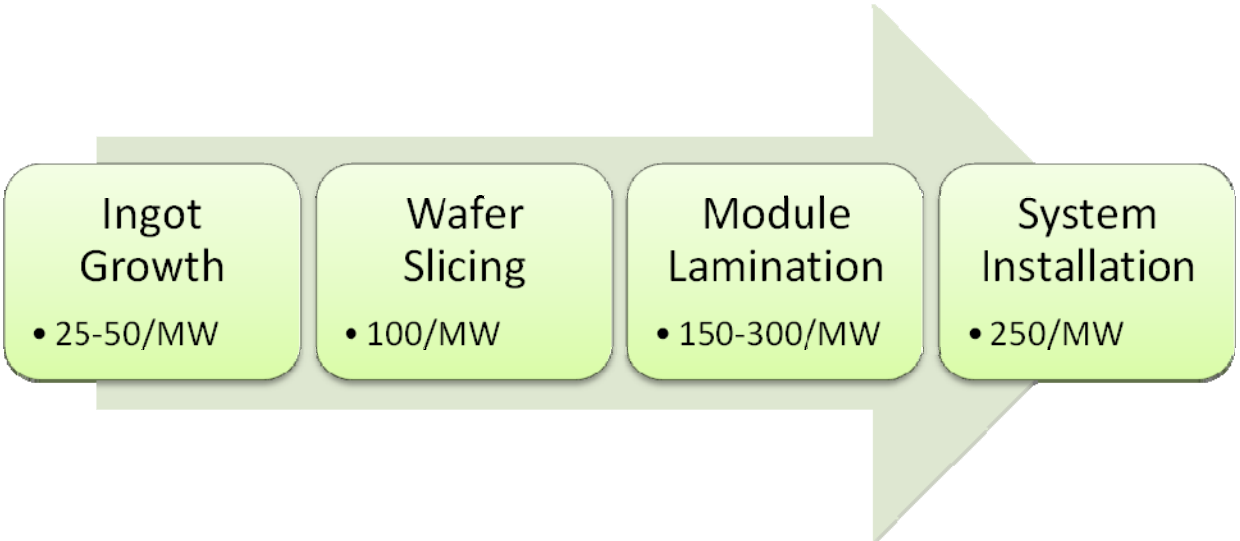

Figure 1. Job Creation in PV Supply Chain (Jobs per MW per Year) [2]

For example, 1 MW or 1000 kilowatts (kW) per year of demand for crystalline PV creates between 525 and 700 jobs. One MW powers about 33 homes [3]. A typical residential PV installation has about 4 kW of capacity [4]. A typical coal plant provides 300-400 MW of capacity, and a typical nuclear plant about 1000 MW of capacity. Programs in other nations provide a precedent example of this job creation. Germany has experienced significant growth in this area. As of 2009, Germany has 180,000 jobs in the PV sector, more than the entire automobile industry [5]. The correct government action could spur such job growth in the United States as well.

Local Job Growth

Distributed generation guarantees certain American jobs. The last part of the PV supply chain, System Installation, necessarily requires local jobs. The firm which installs the system must work in the United States. Figure 2 shows where the costs of PV installation go on the supply chain.

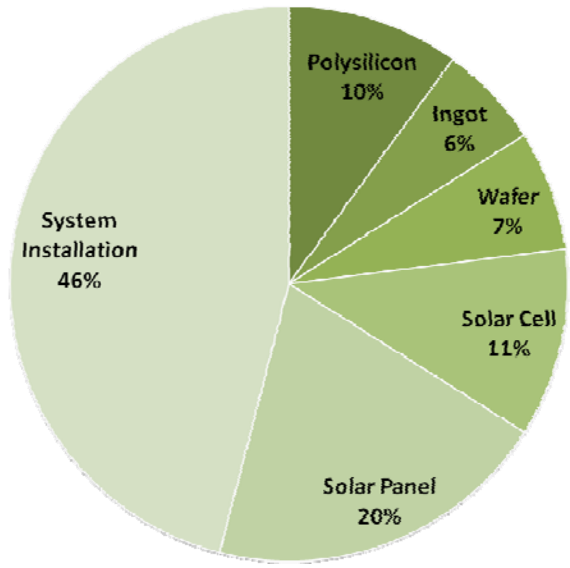

Figure 2. Cost Distribution in the PV Supply Chain [6]

Forty-six percent of money spent on PV would go to US businesses. Widespread implementation prevents ample opportunity for small business innovation. Small local contractors typically install distributed generation at the residential level. These small businesses grow with demand in the region. Cities with strong incentives already have multiple installers in competition. These firms naturally settle on different portions of the market, with smaller, more flexible firms performing residential installations and larger firms handling commercial and industrial projects.

PV encourages our high-tech workforce as well. The advancements to lower PV costs require extensive work in applied sciences and basic research. Universities, national labs, and private research all stand to see job growth as a result of encouraging this technology.

Improve Electrical Generation

The nation's electrical generation must improve to sustain future growth. Electricity demand increases steadily with population growth. However, few in that population accept construction of new transmission lines in their backyard. Consequently, the electrical grid becomes more overloaded each year as the system continues to rely on existing, outdated infrastructure. Two primary failures occur during overloading: brownouts and blackouts. Imagining electricity as water helps make grid reliability problems more concrete. If the electrical grid is a series of tubes, then the consumers draw electricity out of one end of the tube, and the producers push it through the other. The utilities create "electricity pressure" (voltage) at power plants. The changes in pressure (voltage) happen instantly so that what utilities push in at one end, consumers instantly draw out at the other. Two problems can occur here. First, if all the consumers collectively draw too much electricity at once, the voltage on the lines will drop too low. This is called a brownout - lights flicker, computers shut off and delicate medical equipment malfunctions. In another case, the electrical lines can have too much current (the amount of electricity flowing through a line per second). This can happen when the users draw less than the utilities are producing, or if a user in one place draws too little and in another too much. Either way, more electricity flows through a line than it is designed to hold. Then something breaks. This is called a blackout. Electricity losses can cause dramatic losses for businesses. Table 1 shows the costs of one hour of energy loss for several sectors:

Table 1. Cost of One Hour Electricity Loss for Various Industries [7]

Sector	Cost
Cellular Communications	$41,000.00
Telephone Ticket Sales	$72,000.00
Airline Reservation System	$90,000.00
Semiconductor Manufacturer	$2,000,000.00
Credit Card Operation	$2,580,000.00
Brokerage Operation	$6,480,000.00

Reliability Issues

Solar PV can help reduce the demand for centralized energy distribution which causes grid unreliability. PV produces the most energy during the day, during periods of highest demand. No other renewable energy naturally produces electricity when the grid most needs it. This reduces the strain on the grid and offsets the need for expensive variable generation. Additionally, PV provides backup power during outages.

Promote Critical Technological Development

Maintain American Technical Leadership

Developing PV supports US technological leadership and promotes the advancement of other critical technologies. First, governmental support of PV leads to cost reductions. Germany gives a good example of this phenomenon. In the successful German policy (EEG), the government reduced the required payment by 5 percent each year for new plant commissions [8]. For example, a 4 kWh installation in 2004 received €0.574 per kWh of electricity produced. A plant installed in 2005 received €0.545 per kWh. In fact, the costs of producing PV modules have decreased faster than the subsidy; between 1992 and 2000, when Germany initially enacted EEG, PV module prices decreased by about 13 to 15 percent per year [9].

Japan's support of PV has yielded similar results. The Japanese PV subsidy began in 1996 at 50 percent of the installation cost. As of 2004, the Japanese government had reduced the subsidy to 7 percent. During that time period, the cost of installation dropped by half. By supporting the technology, the United States can help make critical advances as well. Advancements require keen technical skill, thus pursuing PV necessarily encourages the high-tech workforce.

Mass Energy Storage

Solar technology provides incentives to improve mass energy storage. Mass storage remains a key obstacle to widespread renewable energy implementation. All intermittent sources of electricity (i.e. solar, wind, wave, tidal) add some unpredictability to the grid. A means of storing electricity buffers the variable output and could make intermittent technologies as reliable as their fuel-based counterparts. As mass energy storage can greatly improve the efficiency of photovoltaic systems, widespread PV use will put forward pressure on storage research and development (R&D).

Smart Grid

"Smart Grid" technology will dramatically change electricity consumption in the United States. The current electrical grid, built throughout the 20th century, lacks many features of modern technology. Utilities have little control over distribution lines and almost no way to monitor outages. Frequently, utilities are unaware that a line has failed until a customer calls and reports a power loss. A smart grid adds information age sensors, computers and wireless communication to the grid. These advancements allow utilities to balance load flow and correct for problems before they happen. Adding distributed generation again encourages utilities to pursue this technology. A smart grid can combine energy efficiency, load management and renewable energy. Photovoltaics can pave the way.

Improve Electricity Security

Distributed PV generation can help secure US electrical supplies. The United States relies on fuel-based electricity generation. Figure 3 shows the breakdown of US energy consumption by type.

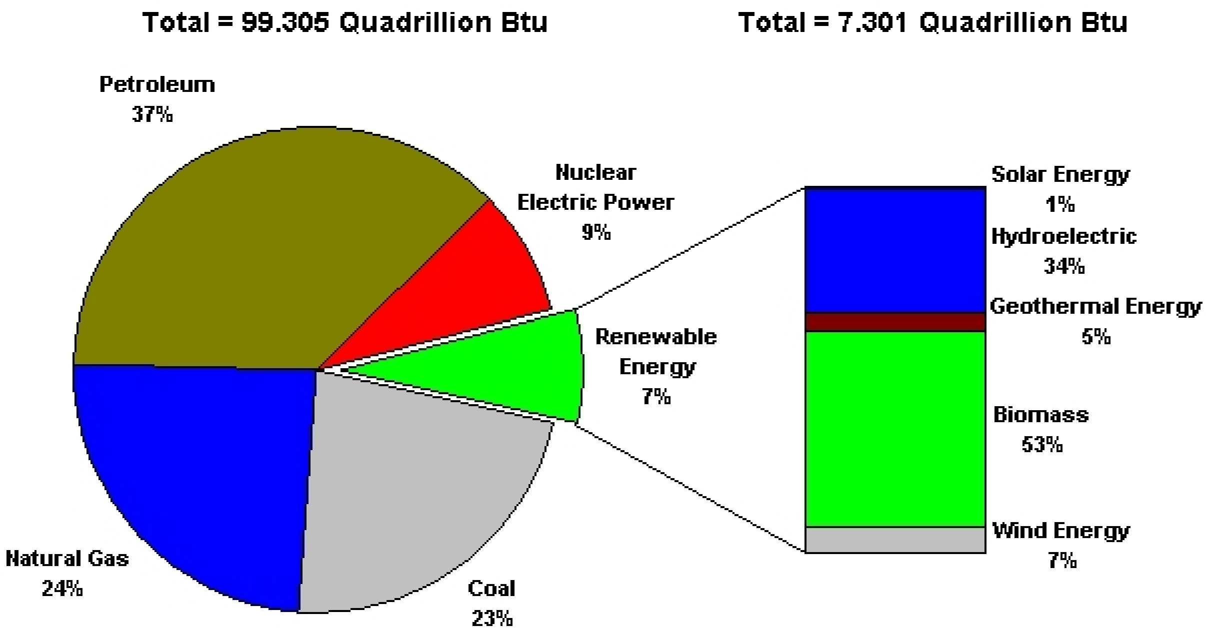

Figure 3. US Energy Consumption by Type [10]

Coal, natural gas and petroleum make up the majority of energy usage. However, the market cannot easily predict the prices of these fuels. Distributed generation helps strengthen US fuel reserves and improve national security.

Fuel Reserves

Photovoltaics help to extend the reserves of important domestic fuels. To compensate for the increase in demand, utilities must use spinning reserves and peaking plants. Spinning reserves generate a constant amount of electricity, but put this electricity on the grid only when needed. Producers must waste the excess energy to prevent overloading the grid. In a peaking plant, producers use natural gas generators to quickly ramp-up production. This method produces electricity much less efficiently than in combined-cycle natural gas plants. Even so, the cost of natural gas represents a large portion of the cost of natural gas production. Distributed solar generation reduces the cost of electricity by offsetting the cost of expensive peaking generation. Additionally, reliable solar electricity hedges against high fossil fuel prices. Solar energy has no variable cost, so generation costs remain consistent after system installation.

Grid Vulnerability

Distributed generation reduces the impact of electrical terrorism. A system with many smaller generation sources cannot be attacked as easily as one with few large sources. Even in the event of an outage, distributed generators can maintain electricity. Distributed PV gives consumers robust, reliable power that conventional generation cannot provide.

Challenges: Why can't we do this now?

Economic, technical and regulatory barriers currently prevent widespread PV adoption. By recognizing and addressing these barriers, the United States can receive the wealth of benefits offered by PV. However, cost, risk, ineffective incentives, intermittency and homeowners associations present some of the largest problems.

Cost

Currently, PV modules cost too much for widespread installation. A residential photovoltaic installation can cost thousands of dollars. Consequently, most grid-tied customers cannot justify the capital costs of a PV installation. PV systems indirectly generate revenue for homeowners by offsetting electricity costs. The energy produced by the panels replaces energy otherwise consumed by the customer. A user in the continental US can typically offset on the order of a few hundred dollars per year [4]. Using this method, a consumer eventually recoups the cost of the PV panel. The time required to find this return on investment (ROI) depends on the cost of the system, the amount of energy produced by the system and the cost of the offset electricity. The shorter the ROI, the more demand to install PV panels.

Efficiency

Research and development can improve the maximum efficiency of PV panels and therefore, the amount of electricity produced. Every moment the sun shines during the day, it delivers energy to the Earth. Humans sense this energy when feeling the sun's warmth and seeing the light reflected off objects. Photovolataic panels convert this energy to electricity by a phenomenon known as the photoelectric effect. This same phenomenon allows digital cameras to take pictures and flat panel displays to make light.

Unfortunately, PV panels capture substantially less energy than strikes the Earth. Each square meter of space in the continental US receives roughly between two and nine kilo-watt hours (kWh) of electricity per day. An average American house uses roughly 30 kWh of electricity per day [11]. For perspective, running a 100 watt (W) light bulb for one hour requires 100 watt-hours of electricity or 0.1 kWh. While the solar energy incident on a home theoretically provides more than enough to power a home, PV panels capture only a fraction of this energy. The *efficiency* of a module refers to the percentage of solar energy converted into electrical energy by a pane. Figure 5 shows the growth in efficiencies for two common types of photovoltaics.

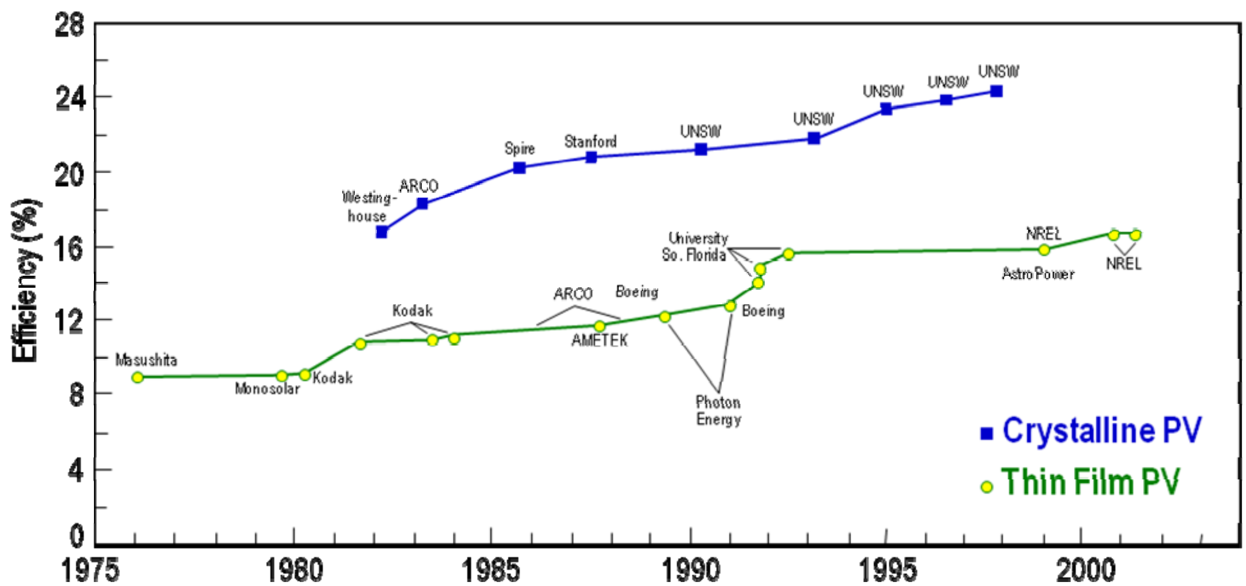

Figure 5. Record Efficiencies for Two PV Technologies [3]

Note these values indicate the maximum lab efficiency of PV. Typically installed panels have lower efficiencies. Increasing the efficiency of panels allows each square meter to produce more electricity, allowing greater generation without significantly higher production costs [5]. If considering solely efficiency, PV panels will not become cost effective for decades. Aggressive R&D efforts can help improve efficiencies. However, government participation can encourage other cost-reductions as well.

Manufacturing

Due to economies of scale, increasing manufacturing capacity decreases cost per PV module. Creating more PV modules allows manufacturers to smooth out inefficiencies in production. Once company estimates a 20 percent decrease in cost for each doubling of production capacity [5]. Many manufacturing hurdles still need solving. For example, wafer cutting yields material losses of about 50 percent. One PV company has dropped material usage from 12 grams of silicon per wafer to about 6 grams per wafer. By maintaining and expanding manufacturing processes, companies can compete to create more resource-efficient products.

Labor costs represent a high percentage of manufacturing costs. America's high standard of living and established labor unions drive the costs of manufacturing relatively higher. As shown in Figure 1, performing wafer cutting and cell lamination both require much labor input. Consequently, manufacturers have little incentive to maintain labor intensive operations in the US. However, highly automated manufacturing can compete with other markets on one of two conditions, large production capacity or a US centered logistics chain. Highly automated manufacturing requires more capital investment, but lower labor costs. Both guaranteeing domestic demand and providing incentives to reduce capital investment risk can encourage producers to stay onshore.

Research and Development

Reducing the costs of PV to grid parity requires many technological and process developments. Improvements in panel efficiency, manufacturing equipment efficiency, and manufacturing costs require research and development. However, prohibitively high R&D costs prevent many firms from making advancements. These costs affect small firms especially dramatically. To develop a new product or process, first a firm must make a basic scientific discovery. Next, the firm must prove the advancement with a prototype. Following this, they construct a pilot plant and finally a full manufacturing line. Between each step, a firm must raise capital to support their development efforts. Figure 6 shows the typical progress of a firm from initial concept to large-scale stability.

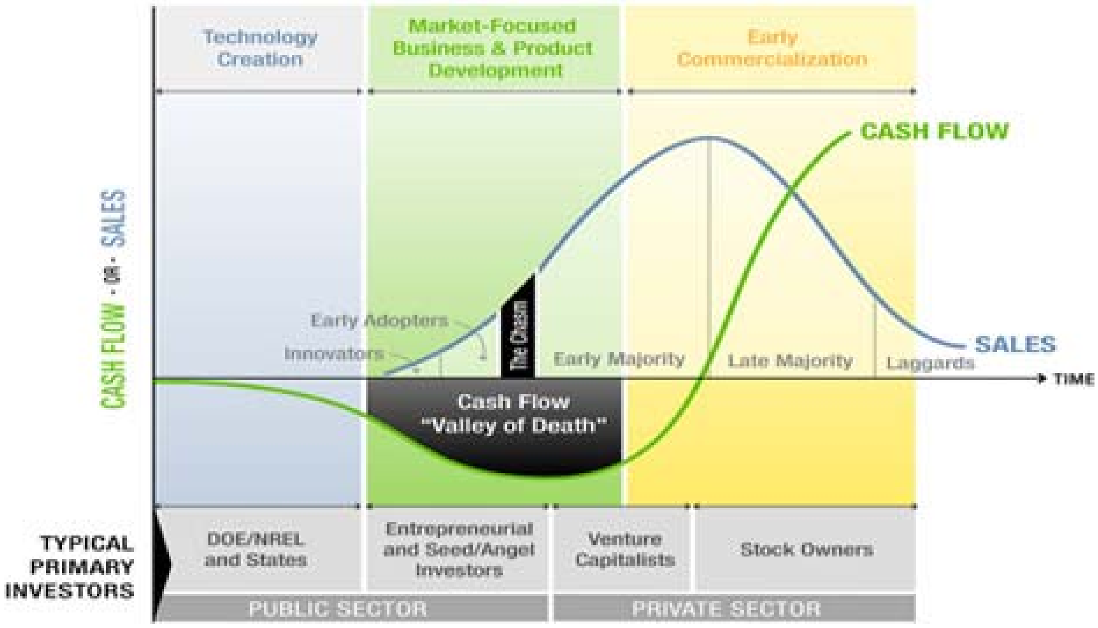

Figure 6. Income Timeline for Tech Start-Up [12]

The dark region, colloquially referred to as the "Valley of Death," represents the time after support for lab development ends, and the time before sales revenue begins. A large firm, given enough capital, may realize this entire process; however, startups and smaller firms have no hope of jumping these barriers. Sometimes a firm's entire business model relies on a single proprietary process improvement. Without proper support, the PV industry loses many good ideas.

Here, multi-party consortia can provide an answer. A consortium consists of a partnership between government, industry and academia to pool research and development resources. Consortia provide common lab space to perform experiments and prove results. Such a facility supports basic research, specific applied research and manufacturing research. Not only do partnerships provide businesses with new processes, they provide new workers. University students, either as interns or co-ops, gain valuable hands-on experience. These students can transition seamlessly into the PV industry, adding to the workforce and creating high-tech jobs.

Previous legislation gives a good example of how to form such a consortium. In 1987, Congress passed an act to recapture market share from the Japanese in the integrated circuit industry. The law began the formation of a 50-50 joint partnership between the U.S. semiconductor industry and the U.S. government called Sematech. With $100 million from industry and $100 million from Congress, Sematech helped set standards and lead massive changes in industry [13]. Additionally, Sematech explored technology that ultimately proved ineffective, saving money for the industry. In the end, each industry contributor saw a 540 percent return on investment. Such collaboration could also profoundly advance the PV industry.

RISK

Due to the uncertainties promoted by U.S. tax laws, manufacturers cannot raise sufficient capital to reduce the cost of PV modules. In the United States, PV firms rely on subsidies to remain profitable. However, PV subsidies have been inconsistent. The Renewable Electricity Production Tax Credit (PTC) shows this characteristic uncertainty. Congress originally enacted the PTC in 1992; it expired in 2001. Congress renewed the credit part way through 2002, and it expired again in 2003. In 2004, Congress extended the credit to the end of 2005. In 2005, another act extended the PTC to 2007, but dropped the subsidy for solar power altogether in favor of certain hydroelectric generation. In 2006, Congress extended the PTC until 2008. Finally, in 2008, legislation changed the subsidy to allow businesses to accept a 30 percent investment tax credit (ITC) in lieu of the PTC [14]. Unpredictable tax policies mean unpredictable returns. More unpredictability means less confidence for investors. With no guarantee on subsidies, firms cannot raise capital to expand production and reduce costs. The solar market relies on subsidies and a loss of subsidy means PV may lose competitiveness in some markets.

Ineffective Incentives

US policies to support the PV industry have not yielded the same growth as policies elsewhere in the world. While other nations have captured a large share of the market and seen substantial profits, U.S. policies do not emulate these policies. The structure of U.S. incentives and the method of U.S. electricity pricing dominantly hinder the growth of PV.

Incentive Structure

The two largest national incentives for renewable energy come from the aforementioned ITC and PTC. The small size of the PTC does not significantly lower the time for PV ROI. The ITC, while more substantial, rewards the producer for installing a system, not for producing electricity. An incentive program called a feed-in-tarrif (FIT) provides a more cost-effective method of promoting RE technology than other incentives such as Renewable Portfolio Standards (RPSs). RPSs typically use competitive solicitations in which the federal government must individually approve projects [15]. Such a process requires much time and money before a producer can connect to the grid.

However, the German, Japanese and Spanish programs use FITs. In a FIT policy, a producer receives a guaranteed payment for the electricity produced, in dollars per kilowatt-hour. This stands in contrast to installation or capacity incentives, which pay based on the size of the installed system, in dollars per watt [15]. FITs typically take the form of a long-term contract (greater than 10 years). Several forms of payment exist for FITs. Some FITs pay the producer based on the levelized cost of electricity, with an additional supplementary subsidy. European FITs typically pay the producer a fixed rate per kWh, without regard for electricity prices. Another type, such as the FIT in California, pays renewable energy producers based on the avoided cost of the utility. According to the National Renewable

Energy Laboratory (NREL), a levelized cost of electricity FIT provides the best incentive for growth.

Electricity Pricing

Basing payments on the actual market price of electricity instead of an artificial flat price encourages consumers to meet demand. Solar generators benefit the most when paid the instantaneous market price for electricity. Most utilities charge consumers a flat rate based on kWh of electricity usage per month. However, a flat rate plan hides variations in the market price of electricity. During the day, with office buildings lit, air-conditioners running, and houses in use, electricity demand increases. During the night, temperatures drop, businesses close and people consume less electricity. Consequently, the price of electricity varies throughout the day. Photovoltaic generation matches this variation well, producing electricity when most needed and when most expensive. If utilities paid PV generating consumers the market price of electricity, consumers would make more money. Such a change would help PV producers to capture a return faster. This would increase demand for PV production and help to reduce load during peak hours.

Intermittency

PV's variable output creates unpredictable fluctuations on the grid. Solar panels produce the most energy in the middle of the day, less in the mornings and evenings, and none at night. Cloud cover, shadows, and solar eclipses also significantly reduce power output. Abrupt drops in electricity supply strain the electrical grid, potentially causing blackouts or brownouts. To prevent these supply interruptions, utilities must use inefficient "spinning reserves," generators that produce electricity constantly, but only put it on the grid when needed. The more utilities use spinning reserves, the more energy we waste. Large interconnections can still handle several MW of production fluctuations, thus PV would not immediately create a problem. Even so, photovolatics require technological improvements and complementary technologies to obtain widespread use.

Siting Issues

Lack of zoning and siting regulations prevent widespread solar installation. In many communities, homeowners must obtain permission from a Homeowners Association (HOA) to install a photovoltaic system. In some cases, homeowners have been ordered to remove PV systems, or have faced legal proceedings for disobeying HOA resolutions. One company, Standard Renewable Energy, estimates $1 million in lost business because of homeowners associations [16]. Several states have programs which bar HOAs from prohibiting solar panels. Unfortunately, the laws vary from state-to-state and municipality-to-municipality and do not cover all cases [15].

Policy Recommendations

Well-formulated federal policy will encourage the growth of solar photovoltaics. Therefore, Congress should enact a distributed solar development program. First, the program should contain a strong, regional feed-in tariff. To support this program, the federal government should encourage time-of-day pricing, R&D consortia and installation guarantees.

1. Feed-In Tariff

A FIT increases demand for distributed generation most effectively. Germany, Japan and Spain, the world leaders in PV installed per capita, all built their infrastructures around such programs. A FIT allows anyone with sufficient capital to become a producer, and prevents regulatory bottlenecks. This approach keeps the incentive transparent to the public and lowers barriers to entry. NREL recommends a FIT based on the cost of electricity, opposed to a fixed rate or offset utility costs, as the most effective type of FIT. For these reasons, a cost-of-electricity based FIT should form the basis of the solar development program. However, to create a strong FIT, policymakers must carefully design the size, scope, method and means of implementing the policy.

1.1. Regional Scale

The development program should focus on the regional rather than the national scale. Germany, Japan and Spain all fared well with national subsidies. However, the size of the U.S., and the diversity in resources and political will makes U.S. policy a different game. Manufacturers do not need a cross-country incentive to raise capital and justify R&D efforts. One company estimates that a firm only needs 100 MW of demand to justify moving a manufacturing facility into an area [1]. U.S. electricity capacity has both the size and diversity to support new renewable technologies. Unlike smaller countries like Germany and Japan, the United States need only commit a fraction of its generation efforts to developing PV. Therefore, the development program should focus on regions with good solar irradiance and high energy prices. A regional focus will reduce the cost of the program and increase its probability of passage, while still allowing manufacturers to capitalize on high demand. This policy approach retains the demand increase and resource mobilization of a national program. Also, a regional program simplifies shipping logistics and dramatically lowers the cost to the taxpayer.

1.2. Competitive

A federally funded, regional program can help mobilize support by awarding the funding in a bid competition. The state or region that musters the best additional incentive package or demonstrates the greatest capacity for developing critical technology would receive the federal funding. Since other FITs – such as the German and Japanese FITs discussed in the background section of this report – brought considerable high-tech development to the center of demand, states should consequently expect job growth. This gives incentive to states and municipalities to bring the government money home. Such an arrangement can encourage states to not only provide funding, but smooth regulatory barriers, form partnerships with universities or implement public awareness campaigns. Many hurdles for distributed solar exist within state or local jurisdiction. Some challenges, such as utility policy and standards development, lie outside the public realm entirely. Inspiring change on a regional level more appropriately fits the U.S. system than mandating policy changes from the federal level.

1.3. Federally Funded

The federal government should pay the primary costs of the feed-in tariff. A FIT will benefit all levels of government and commerce, but certain goals should remain federal priorities. Distributed solar generation benefits the U.S. in the interest of national security, grid reliability and technological leadership. Although the winning region will benefit most, the program should focus on promoting national goals. This approach reduces the problems working over state lines and gives additional leverage for partnerships in the academic and governmental sectors. Congress should generate revenue for this program by cutting oil and gas subsidies, and corn ethanol subsidies. Also, the DOE should commit funds toward the program.

1.4. Decreasing Return

A strong FIT would decrease the guaranteed payment rate each year. That is, PV systems installed in the first year of the incentive would receive the highest payment per kWh. Installations in the next year would receive a smaller payment rate, and so on. This policy does two things: first, it helps cover the risk of early adoption; second, it puts pressure on manufacturers to reduce costs each year. To encourage competitive growth, a good FIT policy should seek to decrease the subsidy at a rate similar to the decrease in module prices. Each doubling of PV production capacity reduces the cost of modules by about 20 percent [9], likely resulting in a similar decrease rate in a FIT return.

1.5. Long Term Guarantee

The program must implement a 15 year minimum guarantee for a subsidy to grow confident capital investment [17]. A power purchase contract gives producers assurance that their investment will generate profit. A long term contract tells manufacturers that demand for new installations will exist for a long time. This reduces the levelized cost of the system per year. A lower levelized cost gives banks and VC investors' confidence. Investor confidence remains a critical part of PV development as a new industry means greater uncertainty for investors.

1.6. Metered

Currently, most electricity meters simply provide a reading of the net electricity consumed in a home or business. To accurately record the amount of electricity produced, utilities must install new meters at the site of generation. This allows utilities to separate the gross production in each location and pay each producer accordingly. To effectively monitor distributed solar generation, someone must assume the costs for the replacement of the meters. Austin Energy and Southern California Edison took a simpler approach by independently purchasing and installing the devices. The responsibility of installing meters could likely be left to utilities in a national program as well. New meters typically give utilities the ability to remotely monitor and control electricity usage. Utilities benefit the most by this additional control, and so should contribute to the development program by paying for new meter installation.

1.7. Size Differentiated

With promoting distributed solar as the chief goal, a good incentive should necessarily favor smaller applications. Distributed generation improves infrastructure and national security. Therefore the development program should grant a higher incentive to smaller producers. Scaling the incentive to size helps to level the playing field for residential and commercial installation. Therefore, installers will have reason to pursue residential projects alongside larger commercial and industrial projects. Lowering barriers to entry allows for new streams of capital into the electrical generation market. Supporting small growth will encourage consumers to take action, and induce secondary benefits to the market. Home energy efficiency improvements save electricity at about one tenth the costs. Consequently, consumers will recognize other ways of saving energy and reducing the strain on the grid.

2. Time-of-Day Electricity Pricing

The program should encourage utilities to charge time-of-day electricity prices to consumers. The daily variations in electricity prices – mentioned in the background section – complements the production cycle of solar panels. Time-of-day pricing will give encouragement for distributed generation, with no additional variable costs. Such a change will help PV producers to recoup costs faster. When consumers save money by consuming less during peak times, the electrical grid experiences less stress. Reducing stress reduces the probability of power failures, and the general reliability of the grid. With reliable, consistent distributed generation during peak periods, utilities can lower reliance on expensive natural gas peaking plants.

3. Research and Development Consortia

The government should encourage the formation of academic-commercial-federal R&D ventures. Such programs will accelerate technological and process improvements, lowering module costs. The federal government should open national labs to perform more applied research in conjunction with industrial clients. This will allow PV manufacturers to perform tests without finding the capital support to buy expensive lab equipment. These partnerships should also share resources with universities. University experience in applied research benefits manufacturers, and compliments national lab applied research. The National Science Foundation should encourage such partnerships in funding university research. Student involvement in the PV manufacturing industry provides professional training. In this way, university partnerships also train a high-tech workforce.

4. Installation Guarantees

The federal government should streamline installation and connection hurdles. Users can face interconnection barriers from utilities, zoning problems from local governments and aesthetic concerns from homeowners associations. Congress should require the winner of the development program to smooth regulatory barriers on the state and local level. Utilities must accept interconnection from properly installed PV systems. Regional governments should establish standard zoning guidelines to simplify the regulatory process for installers. Local governments should bar homeowners associations from blocking PV installations on aesthetic reasons. The regional electrical regulatory commissions should fast track applications for large PV installations. While the federal government usually does not have jurisdiction in local and regional regulatory affairs, it can give incentives to local governments to promote PV friendly regulations.

Conclusion

Economic and technological development can bring solar PV to grid parity. A well formed subsidy provides the best way to encourage growth and reduce costs. Time-of-day pricing, focused research and development and simpler regulations help remove additional barriers. The United States can expect to see job growth and technological development from aggressively promoting renewable energy. The federal government ought to learn from the experiences of other nation's successful solar photovoltaic promotion and use them to capitalize on the resources that only we have.

WORKS CITED

[1] Ahearn, Michael. "Opportunities and Challenges Facing PV M." The National Academies, Washington, DC. 2009. 20 June 2009 <http://sites.nationalacademies.org/PGA/step/PGA_050573>.

[2] Swanson, Dick. "Opportunities and Challenges Facing PV M." The National Academies, Washington, MI. 2009. 20 June 2009 <http://sites.nationalacademies.org/PGA/step/PGA_050573>.

[3] "Best Research-Cell Efficiencies." . 2004. National Renewable Energy Laboratory. 8 July 2009 <http://www.nrel.gov/ncpv/thin_film/docs/kaz_best_research_cells.ppt>.

[4] National Renewable Energy Laboratory. PVWATTS v. 1. National Renewable Energy Laboratory. 12 July 2009 <http://rredc.nrel.gov/solar/codes_algs/PVWATTS/version1/US/Florida/Daytona_Beach.html>.

[5] Guha, Subhendu, and David Eaglesham. "The Industry Perspective." The National Academies, Washington DC. 2004. 29 July 2009 <http://sites.nationalacademies.org/PGA/step/PGA_052440>.

[6] Rose, Doug. "An Industry Perspective on the Roadmap." The National Academies, Washington DC. 2009. 29 July 2009 <http://sites.nationalacademies.org/PGA/step/PGA_052440>.

[7] Electricity Advisory Committee. Smart Grid: Enabler of the New Energy Economy. Electricity Advisory Committee, 2008.

[8] "Renewable Energy Sources Act." English Translation of German Feed-In-Tarriff Act. 21 July 2004. Bundesministerium fuer Umwelt, Naturschutz und Reaktorsicherheit. 24 June 2009 <http://www.bmu.de/files/pdfs/allgemein/application/pdf/eeg_en.pdf>.

[9] Frondel, Manuel, Nolan Ritter, and Cristoph M. Schmidt. "Germany's Solar Cell Promotion: Dark Clouds on the Horizon." Ed. Sabine Weiler. Mar. 2008. Ruhr-Universitaet Bochum. 16 June 2009 <http://repec.rwi-essen.de/files/REP_08_040.pdf>.

[10] Energy Information Administration. Renewable Energy Consumption in the Nation's Energy Supply. Ed. Louise Guey-Lee. July 2009. Energy Information Association. 24 Aug. 2009 <http://tonto.eia.doe.gov/ask/electricity_faqs.asp#electricity_use_home>.

[11] Energy Information Administration. Frequently Asked Questions - Electricity. 6 Feb. 2009. Energy Information Association. 24 Aug. 2009 <http://tonto.eia.doe.gov/ask/electricity_faqs.asp#electricity_use_home>.

[12] "Commercialization Valley of Death." Image of Commercialization . United States Department of Energy. 2 Aug. 2009 <http://www1.eere.energy.gov/commercialization/images/valleyofdeath_sm.jpg>.

[13] Polcari, Michael. "The SEMATECH Model: Potential Applications for PV." The National Academies, Washington DC. 2004. 29 July 2009 <http://sites.nationalacademies.org/PGA/step/PGA_052440>.

[14] "Renewable Electricity Production Tax Credit (PTC)." Federal Incentives/Policies for Renewables & Efficiency. 20 July 2009. Database of State Incentives for Renewables and Efficiency. 16 July 2009 <http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F>.

[15] Couture, Toby, and Karlynn Cory. "State Clean Energy Policies Analysis (SCEPA) Project: An Analysis of Renewable Energy Feed-in Tariffs in the United States." May 2009. National Renewable Energy Laboratory. 26 July 2009 <http://www.nrel.gov/applying_technologies/pdfs/45551.pdf>.

[16] "Homeowners Associations: The Enemy of Solar?." Green Inc. Ed. Kate Galbraith. 15 May 2009. The New York Times. 19 July 2009 <http://greeninc.blogs.nytimes.com/2009/05/15/homeowners-associationsthe-enemy-of-solar/>.