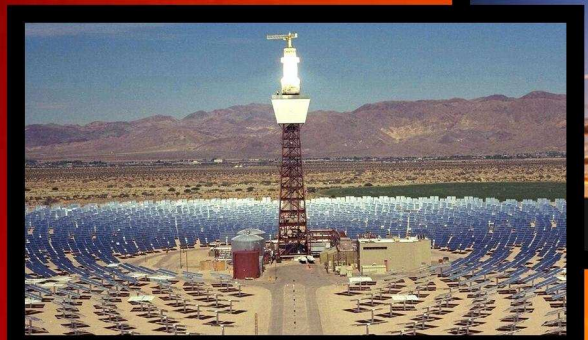
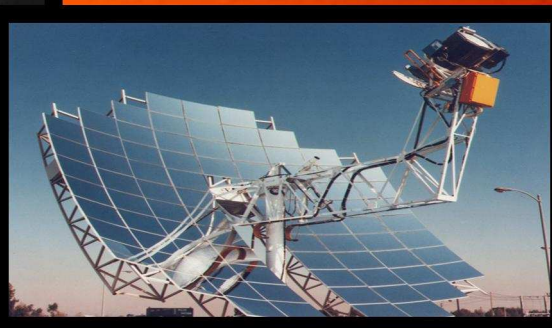
Solar Energy in Southern Arizona

Community Solar Energy Initiative

Report to

Congresswoman Gabrielle Giffords





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Executive Summary

The Community Solar Energy Initiative report, *Solar Energy in Southern Arizona,* provides a snapshot of the current status of solar energy in Southern Arizona. Experts who developed the report agree that Arizona has enough daily sunshine to provide power for the entire United States. However, despite the bountiful sunshine, well over 90% of Southern Arizona's electricity is fueled by coal.

The challenge that looms is how to transform Arizona's energy portfolio by significantly increasing the production of solar generated electricity for use by the people of Arizona, and, ultimately, for transmission to other states.

The approval by the Arizona Corporation Commission (ACC) of the Renewable Energy Standard and Tariff (REST) should provide a big boon to solar growth. The REST will require electric utilities to generate 15% of the total electricity they sell from renewable resources, including solar, by 2025.There are still a number of procedural steps before final implementation, but agreement is widespread that full implementation of the REST will significantly increase solar growth and development.

The potential for solar growth in Southern Arizona is tremendous, and the technology is in place for large-scale distributed solar generation. Moreover, on a smaller scale, photovoltaic (PV) installations on roof tops and commercial buildings are the fastest growing segment in the United States. With continued growth, financial incentives and increased research and development, the costs could drop to between $.08 to $.10 per kWh by 2020 for utility-owned and residential systems, and $.04 and $.06 for concentrator systems by 2025 *(NREL 2005, 2003).*

In short, current technology is in place, but financial incentives that reduce costs and remain in effect long enough to grow the solar market are needed. Technological advances, in addition, can continue to drive down costs. Add in a strong public education campaign and the use of solar generated energy should skyrocket.

The process of developing the *Solar Energy in Southern Arizona* report exemplifies the "fuel" that could propel this potential skyrocketing – a strong spirit of collaboration. The report resulted from a collective effort among academicians, researchers, business leaders, environmentalists, policy experts, elected officials and interested citizens. Members of three subcommittees – Market Growth, Research and Development, and Education and Outreach – dedicated significant time and expertise. The level of interest and the desire for solar success burns brightly in the region!

This spirit of regional collaboration that has imbued the work of the Community Solar Energy Initiative must continue, and expand. As William Harris, president and CEO of Science Foundation Arizona, pointed out in the Foreword to the report, other states and countries are not sitting idly by waiting to see who wins the solar lottery. The competition is fierce, which means that Arizona's commitment must be fiercer!

There is a need for an accurate, authoritative and respected "solar energy commons" where ideas and resources can be freely shared, meaningful priorities established, and where interested parties know to go for accurate information. In Southern Arizona nothing exists that truly fulfills this need. *The Solar Energy Center of Excellence* has much potential in this area, and Congresswoman Giffords' Community Solar Initiative can also continue to serve as a catalyst.

The report includes a number of action steps that could jump start solar energy in the region. Achieving these steps will require all parties to honestly examine the obstacles and challenges that could delay the growth of solar energy usage in the region, and the state.

A major question exists as to who will assume the financial obligation that is essential to growing a new market. The universal belief is that incentives are essential, with some combination of federal, state and utility investment needed to assure market growth. Moreover, these incentives must remain in place long enough for the market to expand to the point that solar technology is widely available and affordable.

Incentives alone will not guarantee solar market success. In fact, real growth will result from an integrated effort that weaves financial incentives with enhanced education and community outreach that is, in turn, woven with breakthroughs in research and development. Each of the strands is critical to solar energy growth and usage.

Among the most important action steps that are recommended:

Market Growth:

1. Extend the federal solar energy investment tax credits for homeowners and businesses through 2016;
2. Encourage full implementation of the Renewable Energy Standard Tariff (REST);
3. Implement state incentives that attract new solar businesses to the state, and that help assure the economic success of existing businesses;
4. Extend Federal investment tax credits for utilities;

Research and Development:

1. Develop cost effective and efficient solar energy generation;
2. Devise new and improve existing technologies for storage capacity;
3. Research new methods of energy transmission;
4. Establish bricks and mortar research center dedicated to solar.

Education and Outreach:

1. Organize and coordinate educational resources on solar energy and disseminate it through existing networks—environmental associations, school districts, library interconnections, science teacher organizations, neighborhood and homeowner's associations, and faith-based communities.
2. Encourage partnerships between educators and businesses to create funding for professional development for teachers on solar education;
3. Promote Federal funding to install solar in all public schools;
4. Collaborate with the Arizona Department of Education to include solar in state standards.

Again, the need for collaboration is vital. What is not explicitly captured in this report are the many ways in which relationships among the various sectors of the solar industry have been strengthened over the months of work on this report. Researchers, market experts, business leaders and educators have learned to view solar from a shared perspective. This cross-fertilization is an important element in the future success of solar. Hopefully, these relationships will continue to bear solar fruit.

To help assure that this happens, the work of the Community Solar Initiative will continue. Over the next year, Advisory Council members will identify the Action Steps that would benefit from additional hearings and public input. These will then be the subject of hearings that will be held before Congresswoman Giffords and the Congressional Advisory Council on Solar Energy. The intent of these hearings will be to shine a strong light on the most critical action steps recommended in the report, to identify impediments and propose actions to keep the momentum alive.

In addition to the Advisory Council hearings, there will be a second track of action that will focus on the "smaller bite" proposals that can begin immediately. These include such things as creating solar information sessions for classrooms and public libraries and working with media outlets to promote solar programming and public service announcements. These actions steps will be guided by newly formed Implementation Committees, which will include many Working Group members.

The Solar Energy in Southern Arizona report is an important first step in a long-term process. The action steps included in the document are intended to keep solar magic growing in Southern Arizona, with people from a wide range of disciplines dedicated to mining the potential and working together honestly and diligently toward the greater good of our region.

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FOREWORD

Cracking the Code:
Solar Energy Signals a Significant Opportunity for Arizona

William C. Harris
President & CEO, Science Foundation Arizona

Arizona is the solar capital of the United States. In fact, with the necessary technology, Arizona has enough sun to provide power for the entire country. We have the opportunity to lead the world in solar technology development in a span of five to 10 years and reap enormous benefits: environmental impacts, wealth generation resulting from commercialized technologies and economic implications for entire regions.

We're not alone in recognizing and valuing these benefits. States like California, Texas and Florida and countries including Germany and Japan are aggressively advancing their positions to effectively compete for this leadership position.

In order to lead, we must crack the code of cooperation. This starts with educating the public about the numerous benefits of solar energy. It includes the CEO leadership groups and economic councils recognizing the need for alternative fuel sources and understanding Arizona's unique opportunity given its abundance of sunshine. It continues with local utility companies taking drastic measures to support solar technology development. And it engages our state leaders in both the public and private sectors to embrace the possibilities, walk the talk and develop public policy to support our state's short- and long-term plans.

We're already on the right track thanks to the leadership of Congresswoman Gabrielle Giffords, who launched the Community Solar Energy Initiative in April 2007, and Governor Janet Napolitano and the Arizona State Legislature, who supported several key competitiveness investment initiatives this year that emphasized innovation. One example was the allocation of $100 million over four years to fund the nonprofit Science Foundation Arizona (SFAz). SFAz's priorities include investing in statewide sustainability research, such as solar technology, in addition to advancing other scientific and medical research opportunities.

Arizonans need to understand that small steps by one region of a state will not create the transformation we need to become less dependent on oil. The U.S. needs a large-scale approach to truly transform the solar-industry landscape, and leadership at a national level is essential. That is why Congresswoman Giffords' leadership is so important. The solar energy focus in Arizona should not be

divided into regions. It must be “Arizona Inc.” working together to become a world leader in solar energy research, development and implementation. If we do not capitalize on the opportunity we have now to work collectively as a state by pooling our assets, we will miss an important chance to build the critical mass essential for success in this arena.

This report begins the process of engaging Arizona’s future in a serious manner. It is significant that Southern Arizona has seized the initiative provided by Congresswoman Giffords. The next step is extending the leadership statewide, forming an action-oriented working group and establishing incentives to create a competitive advantage for Arizona.

While such statewide collaboration may not be common, the Flinn Foundation has demonstrated the power and potential of such cooperation with its Arizona Biosciences Roadmap. Let’s build on that spirit and make “Arizona Inc.” the new 21st century model for solar energy development and utilization by creating both the R&D and business enterprises to carry us forward.

Arizonans can make the next big photovoltaic and concentrating solar research discoveries, secure the patents that protect them, and build and market successful products to the world. Cracking the code to statewide collaboration is the most important step we can take to advance solar energy in the 21st century economy. If not Arizona, then who? If not now, then when?

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Solar Energy in Southern Arizona

Congresswoman Gabrielle Giffords is committed to gathering the knowledge, data and consensus needed to transform Southern Arizona into the *Silicon Valley of Solar Energy.* As a core demonstration of this commitment, she launched the Community Solar Energy Initiative in April 2007.

The Initiative began with the formation of a Solar Energy Advisory Council, whose members include leading experts from all aspects of solar, including scientists, environmentalists, venture capitalists, government officials, educators and business people.

The short-term goal of this Council was to complete a report to Congresswoman Giffords that she will present publicly on September 14, 2007, at the Pima Association of Government's *Tucson Regional Alternative Energy Forum and EXPO.*

The presentation of this report is only a first step. The report includes short and long-term actions that can and should be taken to facilitate the growth and usage of solar technology in the region. The overriding goal of the ***Community Solar Energy Initiative*** is to stimulate collaborations, ignite statewide cooperation and provide the necessary oversight and accountability measures needed to grow and expand solar markets in Southern Arizona.

This report, which has been developed by three separate Working Groups, provides a snapshot of current solar usage and technology in Southern Arizona in the following areas: ***market growth***, ***research and development***, and ***education and outreach***. The report also presents action steps necessary for the optimum growth of solar technology over the next 5 to 10 years.

The ***Solar Energy in Southern Arizona Report*** focuses on the potential for solar growth and usage in Southern Arizona. However, the underlying hope is that the focused attention and resultant strategic actions that take place in Southern Arizona as part of Congresswoman Giffords' ***Community Solar Energy Initiative*** will integrate with, and further stimulate, the overall growth of solar technology in Arizona.

The Working Groups met on June 15, July 13 and August 17, 2007. Following are the reports of each of the groups.

MARKET GROWTH

Overview

Arizona's large desert areas offer the highest solar power potential in America. This potential for solar growth and development has been recognized throughout the state. Notably, Governor Janet Napolitano has appointed a Solar Energy Advisory Council and also launched the Arizona Innovation Awards.

The Governor's Arizona Department of Commerce (ADOC) also commissioned the *Arizona Solar Electric Roadmap Study,* which was released in January 2007. The study proposed five key initiatives for jumpstarting solar growth in Arizona. As the study noted, "Arizona has the potential to become a world leader in many aspects of solar development, and is a model location for the evolution of new solar technologies and applications."

Finally, ADOC's Commerce and Economic Development Commission's (CEDC) 2004 *Sustainable Systems Prospectus* identified solar as an "economy defining" industry opportunity for Arizona.

In short, there appears to be growing consensus and enthusiasm for taking solar growth, development and usage to the next level in Arizona.

This section will examine three aspects of market growth: Current Market Conditions, Impediments to Market Growth and Incentives for Market Growth. In addition, recommended actions to achieve greater market growth will be included in the Action Steps section of the report.

Current Market Conditions

Solar generated electricity remains a small fraction of today's total capacity in Southern Arizona, where less than one half of one percent of total electricity generation is solar based. More than 90% of Tucson's electricity is currently fueled by coal. According to recent Arizona Corporation Commission (ACC) summer preparedness reports, peak loads in states like Arizona are projected to grow by nearly 600 megawatts (MW) per year for the next 15 years.

The photovoltaic (PV) market in the United States grew dramatically in 2006 where 112 megawatts of solar PV were installed in the U.S. grid connect market, up from 80 megawatts in 2005 *(U.S. Grid Connect PV Market 2007: Report Introduction, Solarbuzz LLC).* However, very little of that activity occurred in Southern Arizona. It is estimated that approximately 800 kW of Solar PV generated electricity was installed in Southern Arizona in 2006. Comparatively, the total amount of PV installed in the Phoenix market was at least two to four

times that amount of activity. However, on a per capita basis, the installed capacity per person was greater in Tucson than in Phoenix.

Experts agree that the cost of solar technology and usage remains a barrier to market growth. The current cost of solar-generated electricity, before any incentives, is approximately 25 to 50 cents per kilowatt hour for residential and 16 to 35 cents per kilowatt-hour for large scale operations.

The cost approaches for different technologies are not an apples-to-apples comparison. For example, central station technology usually requires large, more remote locations, which means that distribution costs must be taken into account. Experts claim that costs in this sector are more comparable to wholesale prices. Other systems, without distribution needs, have costs more directly comparable to retail prices. The net result is that because of scale, larger systems are cheaper per kilowatt hour but not necessarily on a proportional basis since they require distribution resources. Local or distributed generated electricity requires less utility-level infrastructure cost.

In addition, there are some who consider medium scale distributed generation (MSDG) to be the most desirable configuration. They point out that MSDG could add value to public and private land currently being used for things like solar arrays over automobile parking lots at Tucson International Airport or a Tucson mall.

Many market experts agree that about 10 cents per kilowatt-hour is the “magic barrier” that solar-generated electricity needs to reach to compete with the price of electricity. Prices would need to reach about 5 cents a kilowatt-hour to compete with present coal-generated electricity while natural gas-generated electricity is between 8 and 15 cents a kilowatt-hour, depending upon a highly variable natural gas market.

These projections assume that the price of fossil fuels do not rise, either due to the constraints of supply and demand, related carbon/environmental taxes or other regulatory requirements. As true costs are allocated to these resources and as prices rise with demand pressures, the “magic barrier” could rise as well.

The price of electricity is only one of several factors used when deciding on purchasing solar electric systems. In particular, the time for payback is what many use to decide. While this is discussed later in this report, it is important to note that when the return on investment of a system has been fully realized, the price of electricity is almost zero since maintenance costs are minor.

In fact, the current pricing of solar energy is certain to change dramatically over the next 18 years in conjunction with regional and national requirements to include renewable energy generation in the power mix. In Arizona, those requirements were expanded and solidified with the recent adoption by the ACC

of the **Renewable Energy Standard and Tariff (REST)** in ACC Decision 69127, November 14, 2006.

On June 15, 2007, Arizona Attorney General Terry Goddard certified the REST, which will require electric utilities to generate 15% of the total electricity they sell from renewable resources, such as solar, by 2025. Of this amount, 30% must come from distributed generation. The REST became effective August 14, 2007.

Experts note that the approval of this rule will increase the amount of solar installed in Arizona by several hundred percentage points over the next two years. There is widespread agreement that the REST process will be a major milestone in the growth of solar technologies in all of Arizona.

The certification of the REST will be followed by a tariff filing by larger Arizona utilities. At least six Southern Arizona untiites will have to file with the ACC their REST programs, including Tucson Electric Power (TEP), APS, UNSE, TRICO, and Sulfur Valley Springs. Filing of implementation plans and funding requirements must be in compliance by October 14, 2007. Nothing becomes effective until final approval by the ACC, which means it is uncertain what the timetable is before a renewable energy program is in place.

Solar in the City of Tucson: Another positive milestone in the potential growth of solar energy in Southern Arizona occurred on June 20, 2007, when it was announced that Tucson had won a **$200,000 Solar City grant from the U.S. Department of Energy.** The city has committed to an additional $350,000 over two years to complement the grant money.

In addition to this funding, the City plans to expand by 6,200 kilowatts of solar generation in the next few years. According to Doug Crockett, Energy Manager for the City of Tucson, since 1999, the city has generated 267,000 kilowatt hours of solar electric and solar thermal energy. The city is also looking at sites in Avra Valley to use concentrating solar troughs.

Solar in Pima County: The County has committed to the following:

- Achieve LEED silver certification for its new facilities;
- Build a medium-sized showcase zero energy building;
- Generate 15% of its electric energy consumption through renewable sources by 2025;
- Incorporate solar systems, orientation and access into County development planning;
- Explore the possibility that a minimum of 50% of homes constructed after 2010 shall contain solar hot water or PV elements;
- Implement measures to reduce heat island effects;

- Revisit the development and building regulations to move toward more friendly sustainable and performance-based approaches;
- Create new positions for both a sustainability coordinator and an energy manager.

Solar in Cochise County: The most focused solar activity in Cochise County is the *B Cool Bisbee* initiative that is designed as a collective, city-wide energy effort by City government, businesses, schools, churches, non-profits and residents to build a solar footprint. The principle aims of the initiative are to:

- Increase energy efficiency
- Reduce energy consumption
- Invest in renewable energy sources, especially solar

In addition, a solar trough-based heating and air conditioning unit was developed in Douglas and is in use at Cochise Community College. The college began using the system in February 2007. The system was installed through a partnership with APS and is expected to save the college more than $15,000 per year.

Solar on Tribal Lands: Indian Trust Land in Arizona is equal to 20 million acres or 27% of state lands. Given the vast amount of tribal lands in Southern Arizona, efforts are underway to determine the possibility of using some of the land for large scale solar developments. In addition, according to the *Arizona Roadmap*, tribes are eligible for incentives from a variety of sources and are working to leverage Renewable Energy Certificates.

Other Solar Trends: Several positive trends bode well for heightened market growth in the region. The **Southern Arizona Home Builders** last year launched the **Green Building Council,** chaired by John Wesley Miller of John Wesley Miller Companies. The goal of the group is to facilitate the development of green homes in Southern Arizona. According to Miller, the Council is working to educate and sell builders on green building and then to reach out to consumers.

Also, **solar installers** in the region provided anecdotal reports of increases in market demand. They pointed out that they are feeling the “pinch to grow quickly enough” to keep up with these new installation demands.

A national solar organization, *Solar Alliance,* headed by former Congresswoman Claudine Schneider, has recently launched an Arizona chapter. The organization has united formerly separate solar advocacy groups to achieve a more unified voice on solar issues. Members include many of the largest solar manufacturers including Sharp, BP and Kyocera.

Photovoltaic Market

The current PV market in Southern Arizona is more fully developed than the concentrating solar market, but it also has room to grow. Significant excitement exists among PV proponents for the potential of decentralized PV generation, where the vision is *Every Roof a Solar Roof in 2020.*

According to the WGA Solar Task Force Report (2004), if programs promoting solar are pursued, 300 to 400 MW of distributed solar could be installed by 2015 in Arizona given current demand, weighted solar resources, electricity and projected population growth.

Currently, the Southern Arizona PV market comprises fewer than 20 solar designers and builders, most of which are small companies of 3 to 6 employees. In addition, there are two medium-sized manufacturers of panels or panel components and several start-up or research companies.

The designer/builder companies include Geo Innovation, Expert Solar Systems Technicians for Sustainability, Progressive Solar, Solar Turtle and The Solar Store. Manufacturers include Global Solar Energy Company and SOLON America. Research and start-up companies include Solar Technology Research Corporation.

The market in Southern Arizona has three key drivers: individuals who want solar installations, specific projects by the private sector and utility initiatives.

Many individuals have purchased solar water heaters and solar electric systems for their homes. In fact, PV installations on rooftops are one of the fastest growing segments in the U.S.

Private sector projects include the Community of Civano, which totals more than 2000 residences that require “the beneficial use of solar energy.” In addition, Amory Park Del Sol includes solar energy that was added voluntarily by builder John Wesley Miller and was also supported by requirements for utility use of renewable energy.

On the utility side, major installations of solar energy in the past five years have been driven by the ACC’s requirements that all regulated utilities incorporate renewable energy into a percentage of retail sales.

There was some dispute among participants on the level of TEP’s activity with Renewable Energy Credits (RECs). Several pointed out that TEP has self-built instead of purchasing RECs, a mechanism for complying with the ACC’s prior renewable requirements. This contrasts with considerable REC activity by Arizona Public Service Company (APS) in the Phoenix market. This sale of credits is considered an excellent source of financial support for customers who

invest in solar energy. However, TEP pointed out that they have begun selling RECs from the Landfill Gas project to APS and other utilities given TEP's surplus of credits since much more renewable energy is produced in Southern Arizona then elsewhere in Arizona.

RECs were first initiated in 1999. For the 30 years before RECs hit the market, the growth of solar energy was driven by off-grid installations in residences usually located in remote and scenic locations. TEP pointed out that it was the first utility in Arizona to purchase solar generation REC customers through its *SunShare* program initiated in January 2001. Currently, more than 400 TEP customers participate in selling RECs, according to TEP.

Emerging PV Market: As the market grows, distinguishing among the various markets for PV is of value. These markets are as follows:

- Retrofit of existing residential structures
- Incorporating solar in new residential construction
- Solar usage in commercial and industrial buildings.
- Solar usage by the government
- Expanded solar investment and usage by utilities

Nationwide, the sectors of these five markets that have seen the most growth are the utility, government, and nonresidential markets. Also, retail outlets led the market with 13.3% of projects (in megawatts). The largest application segment was commercial flat roofs, which accounted for 33.8% *(U.S. Grid Connect PV Market 2007: Report Introduction, Solarbuzz LLC).*

In all five markets across the nation, financing mechanisms and business models for commercial applications have been developed and are widely used. The four critical requirements for the full development of solar PV markets are:

- Requirements for utilities to include renewable energy in their portfolios with sufficient incentives offered to provide competitively priced energy;
- Standard electric grid interconnection agreements;
- Net metering;
- Recovery of solar incentives for utilities through cost and risk system benefits, and through rate structures where necessary.

In most states, as in Arizona, the residential market is supported by specific requirements for solar PV installations. Nationally, as well as in Arizona, the financing mechanisms and business models have not been fully developed for the residential market. As the Arizona market expands to catch up with other regions (such as California, New Jersey, Colorado, Connecticut and Maryland)

there is no reason to believe that Arizona would stray from the market development trends other states have experienced in their growth.

TEP did point out that in the first six months of 2007, the TEP residential PV market outpaced the New Jersey residential PV market on a watts per capita basis by nearly a factor of two. According to TEP, the commercial PV business has been underperforming in Southern Arizona, due primarily to the inability of utilities to offer adequate incentive packages to support commercial PV installations. TEP states that this is because of the very low funding levels provided in the ACC's Environmental Portfolio Standard (EPS) to justify investment by third parties, as has happened in California and New Jersey. Industry participants have called out funding scale issues as well as net metering as key obstacles to more commercial deployment.

Concentrating Solar Power Market

The concentrating solar power (CSP) market in Southern Arizona is less developed than the PV market. The promise, however, exists. The U.S. Department of Energy Solar Energy Technologies Program stated in its May 24, 2007, Funding Opportunity Announcement that, "CSP technologies are one of the most attractive renewable energy options for large scale power generation in the U.S. Southwest, which is home to 15 of the 20 fastest growing metro areas in the country."

In Southern Arizona, the one megawatt *Saguaro Solar Trough* project, located in Red Rocks, is the sole CSP project. However, it was the first solar trough in 15 years to be built, and it has helped spawn interest and additional projects in other states.

AUSRA, a Silicon Valley based company, recently established a location in Arizona. The company produces a process similar to the solar trough whereby the sun focuses on a tube filled with oil or fluid which heats water through heat exchangers until steam is produced. The steam then runs traditional steam turbines and generators. While this is not generally perceived as a major technological advance, it is a process that lowers material costs. AUSRA has a small pilot solar field project and is looking to create a larger solar field project.

Concentrated solar power and PV both provide energy at critical peak times and protects against fuel price fluctuations. It is predicted that if 4 GW of CSP were deployed in the Southwest, nominal costs would fall below $0.10/kWh. Arizona has excellent solar radiation and land availability near growing population areas, all factors that help drive down costs.

In fact, Arizona has over 19,000 square kilometers of available area and a capacity for 2.4 million MW of CSP at a 25%-50% energy generation factor.

Given these conditions and active promotion of solar energy by state and local agencies and by industry, Arizona is predicted to be able to deploy 1 GW of CSP solar by 2015 *(NREL and WGA Solar Task Force).*

Financial Capital Interest in Current Market

Some venture capital funding has begun to flow to Arizona companies for manufacturing and process improvements. Equity capital has also been injected by German investors through the acquisition of Global Solar Energy and the spin-off of its integrated systems business and re-organization as Solon America.

Capital to finance projects, which is being supplied by leading national system integrators, is available and poised to enter the Arizona market, once the proper regulatory environment and incentive funding is in place.

Policies and incentives that will significantly develop the local solar energy market must provide for predictable, stable long-term growth. Potential investors in solar energy equipment manufacturing plants need the financial surety to make the investment from assurances that the market growth in Southern Arizona will be sustained over sufficient time to recoup their investment.

In addition, customers who purchase solar energy systems need to be confident that the equipment will be supported by manufacturer guarantees and the installer for the life of the equipment – 30 years in many cases. This confidence will be gained only through long-term, stable, sustainable growth policies and incentive programs.

IMPEDIMENTS TO MARKET GROWTH

Following are the key areas that were identified as impediments to market growth in Southern Arizona:

Extension of Federal Investment Tax Credits: Current federal investment tax credits are set to expire in 2008. Legislation has been introduced in Congress, which Congresswoman Giffords is sponsoring, to extend these tax credits through 2016. Experts agree that without this extension, the time needed to grow their businesses would not be sufficient. Investors need to know these tax credits will be in place for a sufficient period of time to allow for growth of new businesses.

Need for Standardized Net Metering and Solar Friendly Rates: Several experts recommended that net metering up to 2 MW on a statewide level would serve as a real boon to the solar market. Both TEP and APS have established limits that, some believe, inhibit the growth of large scale commercial arrays.

As part of its recently concluded rate case, APS has begun to implement an expanded net metering program. However, commercial systems over 100kW are not eligible for net metering. It is the opinion of some that the current net metering limit to systems of less than 100 kW and stand-by demand charges, in addition to net buy-back at avoided cost for systems in excess of 100 kW is unfriendly to solar investment.

Since 2000, TEP has offered an annualized net metering program for customers with installed solar generation of 10 kW AC or less. While a program cap of 500 kW was initially part of the program, TEP has not enforced a net metering cap and currently has nearly 1,000 kW of net metering customer participation.

According to TEP, net metering offers a super-subsidy for solar generation that must be supported financially by all electric customers, including those low income customers least able to afford the extra expense. TEP recommends that an alternate to net metering is to provide sufficient financial incentives for the market through the REC purchase program, as is done in Germany.

Industry stakeholders differ in their characterization of net metering. They state that it is n a super-subsidy but a fair payment for value delivered to the customer-generator and the grid system as a whole.

These differing perspectives on net metering are being presented and reviewed, and ultimately resolved, by the ACC in several proceedings currently in process.

In addition to these utility specific efforts, the ACC has an ongoing net metering initiative that several participants stated would comprehensively resolve the issue across all regulated Arizona utilities. This initiative, driven by ACC direction under the generic investigation of distributed generation, is also a requirement of the Federal Energy Policy Act of 2005 to consider PURPA (Public Utility Regulatory Policies Act of 1978) standards. Those efforts have proceeded to the point of recommendations by ACC to begin a rulemaking process for comprehensive net metering rules as of August 7, 2007.

In addition to net metering, solar friendly rates, especially concerning partial requirements and demand charges, need to be aligned to support the REST requirement. TEP points out that the potential for rate increases for all customers needs to be balanced against the benefit of PV installed by a few customers. However, customer-installed renewable electricity could also benefits all customers by reducing risk factors and the utility's infrastructure costs for

generation, transmission and distribution equipment not required by the customer's installation.

TEP will soon propose (in its REST tariff filing) an incentive mechanism for compensating the company for its loss of revenues associated with renewable energy investment, similar to what it has been proposed for its Demand Side Management (DSM) program, as discussed in its July 2, 2007, Application for Rate Increase.

In its recently concluded rate case, APS presented a partial requirements rate that some participants claimed would penalize solar investment. Although this was not authorized as part of the rate settlement, APS was instructed to work with industry and other stakeholders and present a recommendation to the ACC. Those discussions are currently in process.

Trico Electric Cooperative Inc. offers a limited solar program: Trico Electric, which serves the Western Greater Tucson Area, has no net metering and caps incentives for residential systems at 2 kW and commercial systems at 5 kW

Interconnection Standards: The ACC on June 27, 2007, adopted a proposed interconnection standard for development and final adoption in a rulemaking process. The proposed standard was developed through a collaborative process that included distributed generation advocates, renewable energy advocates and utility engineers. TEP described the process as being simple and transparent for customers and utilities The rulemaking and public hearing process will likely take 3 to 12 months. In the meantime, ACC staff recommends that utilities adopt the practice in its operations.

Curtailment/Transmission Line Issues: Curtailment occurs when utilities require generating facilities to stop producing power when congestion threatens grid reliability. This congestion is primarily due to insufficient capacity in the transmission system. The power generating facility must comply and shut down or reduce output when a utility issues curtailment instructions.

Curtailment can cause economic harm to non-distributed solar systems through the loss of three incomes streams: 1) the income stream from the actual sale of energy produced; 2) production tax credits, applicable only to energy actually produced; 3) the loss of RECs as an income stream.

Curtailment has created significant impacts in the wind industry already, especially in Texas and Minnesota. In Texas, the Public Utility Commission of Texas (PUCT) is working on a solution through the formation of competitive renewable energy zones (CREZ). The CREZ program designates renewable

energy transmission zones to develop transmission capacity where it is needed for renewable generation.

The ACC will no longer approve a new generation plant that does not have a minimum of two transmission lines to assure electricity delivery to customers. This should help avoid future congestion.

Shortages of Silicon: Market forecasts for solar PV panel producers are calling for silicon price increases through 2008, due primarily to shortages of silicon, which is used in the production of computers and solar panels. According to *Motley Fool,* prices for silicon have risen from just $9 per kilogram in 2000 to at least $60 in 2006.

Approximately 40% of the cost of solar panels is based on silicon prices. Solar panels use more silicon than semi-conductor devices, although less-pure silicon can be used for energy applications. The impact of a silicon shortage could impact panel prices.

Competing Incentive Programs: Renewable technologies compete for a limited pool of funding. The cost per kWh of wind has fallen in the last ten years, and thus, results in more kWh of power produced per dollar of funding since the best wind sites are being used. The perception of wind being a "better value" may reduce the incentive for solar research necessary to bring down costs and increase competitiveness with other fuel sources.

Amount Consumers Will Pay: How much consumers will pay for solar technology is a looming question. There was not agreement among participants about the reliability of data on the Southern Arizona consumer. According to TEP, many customers balk at paying an additional $2 per month to adopt a GreenWatts that would provide funds for solar investments in the community.

Other participants questioned the value of using green pricing programs as an indicator of consumer willingness to pay, since lack of enthusiasm for such programs nationwide has many drivers.

It was also pointed out that as overall interest in solar and global warming grows, and as energy prices rise, the amount consumers are willing to pay likely will change.

The solar industry agrees that residential customers need a 7-year payback and businesses need a 5- year payback to justify an investment in solar. Even if customers can afford to pay for it, it seems to be "bad business" to have a longer payback. The super benefit for solar systems is that when the investment has

been paid back, all future electricity is generated at no cost. In addition, there is agreement within the industry that residential customers need up-front subsidies, but at some point, performance based incentives are necessary. However, there is no consensus on what that point is. One suggestion is to provide up-front incentives through at least 2012 to get things going, and then to move to performance based incentives.

The bottom line on price elasticity is that there is no clear data or agreement on what people are willing to pay.

Inadequate Supply of Workers Trained in Solar Technology: As the details in the *Education and Outreach* section indicate, a shortage of educational and training programs exists in Southern Arizona. Action steps are needed to address the issue and are included in the Action Steps section.

Storage and Transmission Needs: In order for Southern Arizona to emerge as a large scale distributor of solar electricity, there need to be significant developments in storing solar power and in securing additional transmission systems to distribute solar energy within and outside of the state.

Lack of Adequate Consumer Knowledge of Solar: Extended discussion about the need for more coordinated and expansive information, both in the schools and for consumers, is detailed in the *Education and Outreach* section. However, it was agreed that this need is urgent enough that it is worth noting in the Market Impediment section.

Consumer Confidence/Education: Historical problems with consumers investing in solar technologies that did not live up to the promise have resulted in a lack of consumer confidence on the reliability, effectiveness and long-term reward of solar technology. Dedicated solar demonstration projects could help increase consumer confidence. Overall, educational efforts need to be expanded in the schools and with the general public.

INCENTIVES FOR MARKET GROWTH

There are a range of federal, state and utility incentives for solar technology. Following are brief descriptions of the key incentives in each area. Overall, the combined use of these incentives can reduce the cost of solar by 70% - 80% for commercial users, and 40% - 55% for residential. (Arwood, AZ Department of Commerce). Moreover, these incentives primarily are available for people in

higher tax brackets. For this sector of the population, low-interest, long-term financing could allow these households to spread costs over an extended period, such as the life of the technology.

In addition, several federal and state grant programs are providing research and development funding in several areas. Details are provided below.

Federal Incentives

Residential:

- 30% residential tax credit, with a maximum cap of $2,000.

Commercial:

- 30% Investment Tax Credit for commercial installations (set to revert back to 10% at the end of 2007 if not extended)
- 5-year accelerated depreciation

State Incentives

Residential:

- 25% State Income Tax Credit, capped at $1000. Applies to all solar technologies.
- Full property tax exemption for property owners installing solar energy systems was signed into law on June 26, 2006.

Commercial:

- 10% commercial tax credit capped at $25,000 per system and $50,000 per company annually.
- $3000 for each net-new qualified employee over a 3-year period for a maximum of $50,000 per company annually with an overall cap of $1 million.
- Reduction of property tax assessment ratio from 25% to 5% of all personal and real property for primary tax purposes for 5 years.

Utilities

All future utility incentives could change significantly within the next 6 to 12 months under the ACC REST. Current incentives are as follows:

Residential:

- Federal tax credits for residential dwellings are capped at $2000.

- Sulphur Springs Valley Electric Cooperative in Willcox offers residential rebates of $4.00 per watt up to 2000 watts of installed capacity to a maximum of $8,000 or one-half the cost of the system, whichever is less.
- TEP has a $3 per watt buy down – to buy a system with about 5 - 8 solar panels with a total of 1000 watts or 1 kilowatt, TEP would provide a rebate of $3000 or 40% of the total system cost.
- Solar installers claim that system payback time can be as short as 15 years or less if utility rates continue to rise.

Commercial:

- TEP has a $2.50 per watt buy down and a system cap is determined by a calculation of system size versus currently available funds.
- Sulphur Springs Valley Electric Cooperative offers commercial rebates of $4.00 per watt up to 5,000 watts of installed capacity to a maximum of $20,000 or one-half the cost of the system, whichever amount is less.

Grants/Subsidies

- The U.S. Department of Energy's *Solar America Initiative (SAI)* provides $148.4 million for FY 2007 for solar research and development, more than $66 million over FY 2006. The FY 2007 budget request for PV-related activities was $139.8 million and for CSP-related activities was $8.9 million.

- The U.S. Department of Energy's Solar Energy Technologies Program announced May 24, 2007, a funding opportunity for companies "to develop storage solutions, manufacturing approaches, and new system concepts for large-scale CSP plants." The announcement calls for collaborative public-private partnerships that work together to "reduce the nominal levelized cost of energy of CSP power plants from 13 – 17 cents a kilowatt hour in 2007 to a target of 7 – 10 cents a kilowatt hour by 2015, and 5 – cents by 2020."

- The U.S. Department of Energy awards grants specifically to tribes for solar installations.

- The U.S. Department of Agriculture has a Renewable Energy and Energy Efficiency Grant and Guaranteed Loan program, available for rural businesses, agricultural and ranch operations. Several Arizona companies have applied for and received funds in 2005 and 2006, but none are in Southern Arizona. Qualifications for this program include demonstration of electric rates that are much higher than the national average, something not applicable in nearly all of Southern Arizona.

- The state of Arizona provides grant money to companies creating full-time, permanent new jobs or training for an existing worker in the state.

- The *Arizona Workforce Connection* provides free services to employers who seek access to skilled new hires or existing worker training resources.

RESEARCH AND DEVELOPMENT

Overview

The innovations that can be achieved through focused research and development are essential to the continued market growth of solar energy.

Currently, there are a great many solar energy studies underway, both in the U.S. and internationally. Details on these are outside the scope of this report, which focuses only on those in Southern Arizona. However, it is important to note that research in Southern Arizona lags behind states like Maryland, Delaware, New York, and California.

Arizona also could benefit from the sense of long-term commitment that can be created through a national solar center such as the National Renewable Energy Laboratory (NREL) in Colorado. The University of Arizona's *Solar Energy Center of Excellence* (described below) could be that focal point that helps to maintain and engender a stronger sense of commitment. In addition, the University will compete in two years in the Solar Decathlon (described below), which can also serve to focus interest and commitment.

The bulk of solar energy research currently underway in Southern Arizona is conducted at the University of Arizona. This includes research focused on improving the efficiency and lowering the costs of energy generation; developing efficient, inexpensive and reliable energy storage methods; and, researching high resolution cloud and solar forecasting.

At least six of the projects underway at the University of Arizona are being funded by the private sector. In addition, there are a number of diverse utility solar support projects being conducted by TEP.

Complete charts on each of the research topics described below are included in the Appendix of this report. These charts include information describing the research, where it is being conducted and the status.

Energy Generation

University of Arizona*:*

Most of the research at the University of Arizona dedicated to energy generation is taking place in the Materials Science and Engineering, Astronomy, Chemistry, and Electrical and Computer Engineering departments.

Solar energy generation can occur in a variety of ways. Most commonly, silicon-based photovoltaic modules absorb sunlight, which dislodge electrons and create direct current electricity. This electricity can be stored in a battery or converted to alternating current and used on-site or transferred to the grid. Concentrated solar energy devices collect sunlight which is converted to heat that can be used to boil water and run turbines, creating alternating current electricity. There are many forms, including parabolic trough, power tower, Stirling engine, and others.

Solar collectors can be used on-site (such as with rooftop hot water heaters), or they can be arranged in large arrays that are typically found in remote locations where more land is available. Accordingly, the generated electricity is transmitted elsewhere for consumption. The electrical output of large utility scale photovoltaic arrays, which for similar land-availability reasons are often found outside of cities, also may be transmitted over large distances. There is a loss of electricity when electricity travels through any wire over long distances.

Three researchers at the University of Arizona are deeply engaged in energy generation research. They are:

Dr. Joe Simmons, Materials Science*:* Dr. Simmons is an expert in optical materials and was a member of the *Arizona Solar Electric Roadmap Study* committee. He is working on using nano-particles to increase the efficiency of both silicon and non-silicon solar cells. A demonstration is expected in early 2008.

Dr. Roger Angel, Astronomy: Dr. Angel has spent much of his career designing optical lenses and trackers for large telescopes. He is now focusing those skills on designing a form of concentrated solar energy generation that uses optical lenses to focus sunlight on small but high-efficiency photovoltaic cells. The result is high performance energy generation while lowering the cost by using less silicon. A prototype system is under development at the Mirror Lab. A related project aims to build precise trackers necessary for this technique.

Dr. Neal Armstrong, Chemistry*:* Dr. Armstrong is working to increase the efficiency of organic solar cells, and using nano-particles with built-in nanowire arrays to conduct electricity to external electrodes.

Other U of A Research: Researchers at the University of Arizona are also studying biomolecular cells, silicon processing, accelerated UV exposure,

degradation of systems components, solar tower concentrators, direct solar hydrogen generation, and electrolytic formation of hydrogen.

Private Sector Research on Energy Generation:

There are a small but growing number of private companies in Southern Arizona working to create innovative and cost effective energy generation devices. Some products are already on the market, and others are close to commercialization.

Global Solar specializes in thin film solar cells using CIGS (a copper-indium-gallium-diselenide mix) deposited on a polymer substrate. Thin films use less material than crystalline silicon solar cells and are widely regarded as a promising approach to reducing the cost of energy generation. These flexible cells can be used in a wide variety of portable applications, and are widely used by the military. Global Solar will soon be expanding to a large-scale production facility. The product from the new factory will be integrated into low-cost power modules for rooftop and utility scale solar arrays. Researchers at Global Solar are studying approaches to further reduce cost, increase conversion efficiency and improve product field reliability.

Raytheon is developing a high efficiency enclosed solar cell that promises to reduce the cost per kilowatt.

Solar Technology Research Corporation (STRC) is working to reduce the cost the basic materials that make up silicon cells. The company will purchase metallurgical grade silicon and purify it in a special crucible at high temperatures, then supply this polysilicon to companies who manufacture solar cells. Once this process is fully operational, STRC may look into producing cells themselves.

Brush Ceramics manufactures beryllium oxide (BeO) ceramic products. Beryllium oxide is a light weight electrical insulator that conducts heat very well. A photovoltaic concentrator is being developed to capitalize on the properties of BeO.

Prism Solar Technologies, with the University of Arizona, has developed a method of using holographic concentrators that reduce the amount of silicon needed and can work in direct or diffuse sunlight. A production model could be ready by late 2008.

Energy Storage

Energy storage involves a range of technologies including the use of batteries or the conversion to potential energy that can be converted back to electricity at will.

The three primary reasons storage is so important to solar energy:

- The need to store energy for use during night-time hours.
- The short-term needs for backup power for use on cloudy days.
- The need for seasonal storage. (Arizona solar energy is more abundant during the largely cloud free spring and autumn days, but the highest electricity usage is during the summer. Solar energy collected and stored in the spring could be used to meet the summer peak demand.)

University of Arizona

Several key researchers are involved in research in this area. These include:

Dr. Oleg Palusinski, Electrical and Computer Engineering: Dr. Palusinski is using electrochemical etching of metals to produce a large surface area that can store electrical charge. This can be used for fast-response energy storage.

Dr. Ben Sternberg, Geological Engineering: Dr. Sternberg is working to conduct geological surveys for areas in Arizona that are suitable for underground compressed air storage. This promising concept would allow energy to be stored in the form of compressed air, which would be used to power turbines at a later date. This potentially could address the problem of seasonal variation in energy generation and energy use. Currently, natural gas is stored similarly in underground cavities.

Dr. Roger Angel, Astronomy: Dr. Angel is researching pumped hydroelectric energy storage. This involves pumping water to a high elevation during periods of excess solar production. When electricity is needed, the water is released to flow downward through the force of gravity to turbines, as in a hydroelectric dam.

Tucson Electric Power

Since 1999, TEP has been working to reduce the costs of components other than solar panels. As the cost of solar modules is reduced over time, the other components needed to produce a functional solar generator must also be reduced in cost. The idea is to reduce costs across the board.

Tom Hansen, Vice President of Environmental Services, Conservation and Renewable Energy at TEP, designed one of the world's first utility scale solar arrays – the Springerville Generating Station Solar System in Springerville, Arizona. The 4.6 megawatt array currently provides power for the TEP plant in Springerville. Hansen is also working with national research labs and universities on ways to reliably integrate large amounts of solar generation from distributed solar units and utility-scale solar generation into the existing generation portfolio.

TEP is working on creating very large solar panels, as well as developing a manufacturing plant at the Springerville site. This has the potential to cut costs significantly.
In addition, TEP is collecting data on long-term maintenance costs for both utility and residential scale systems. This topic has not been studied in great detail in the past. TEP is providing the collected data for use by solar developers.

Along with Carnegie-Mellon University, TEP is studying how to deal with the intermittent nature of sunlight due to cloud cover. Results indicate that additional utility generation management tools are needed when integrating solar power on a large scale. The studies also indicate these tools are not needed at the relatively low levels of solar generation expected over the next five years.

Without reliable storage, utility companies must carefully balance the amount of power produced with the amount needed in real time. Compared to fossil fuel energy generation, which can be accurately controlled, solar energy is quite variable. Although general production is predictable using currently available weather forecasting, fine-tuned responses to short duration production surges and drops will become more important as hundreds of megawatts of solar energy production are deployed. Utilities need tools for managing this variation.

Finally, TEP is studying a solution to an issue impacting inverters that has been created by the Institute of Electrical and Electronics Engineers (IEEE) standard. Inverters change the direct current generated by photovoltaic cells into alternating current. Present IEEE standards for interconnection of inverters to the electrical grid require the inverter to disconnect from the grid when there is a non-standard fluctuation in the voltage or frequency of the grid supply.

While this standard-imposed operating characteristic is not a concern to utilities at the relatively low levels of solar generation expected in the next five years, as more and more solar generation systems come online, this could create grid reliability management concerns. However, a change in the operational standards to mirror recently developed wind generation standards is the solution. The study focuses on proposing those new standards for solar inverters.

Weather Modeling

University of Arizona

Dr. Eric Betterton, Atmospheric Sciences: The Department is already running a high resolution weather forecasting model, which is essential for predicting cloud cover and temperature. This is important for utilities so backup power sources may be economically employed when it is known that clouds will be limiting the amount of solar energy captured. Currently, forecasts up to 36 hours in advance are made on a one-mile scale, which is nearly 10 times better than

National Weather Service models. TEP and the University are exploring the possibility of using weather data already being collected to help better anticipate cloud cover and energy collection potential.

Solar Decathlon

Every two years the Solar Decathlon competition is held, sponsored by the Department of Energy and the National Association of Home Builders. Colleges and universities nationally and internationally assemble teams that build energy efficient houses capable of being powered entirely by solar power for two weeks. The houses are built locally and then transported for the competition to the national mall in Washington D.C. where a solar village is formed. Each house is judged on 10 categories, including architecture, engineering and market viability. The team with the highest overall score wins. The University of Arizona is gearing up to compete in the 2009 competition.

Solar Research Institute

The Arizona Solar Roadmap recommends the establishment of a solar research institute, formed collaboratively by the University of Arizona and Arizona State University. This Center, on which initial planning has begun, will establish interdisciplinary programs, and provide broad coverage of all aspects of solar, including education and workforce training, research and development, development of integrated systems, architectural designs, energy storage, power distribution, intellectual property, public policy and economics.

The institute will identify potential opportunities for funding, and research strategic state investments. It will also serve as an important central point of contact for all entities related to solar energy. The overall goal is to increase the visibility and prominence of Arizona as a major player in the solar arena. The structure of the institute is still being determined, but many experts consider its establishment as vital to the development of solar energy in Arizona.

Identified Needs for Future Research

Overview

The three basic research areas identified as important for the development of solar energy are **energy generation**, **energy storage**, and **energy transmission**. There is also the need to develop tools for managing an intelligent grid and for the interconnection of residential and commercial solar generation systems.

Additionally, integration of green building certifications, research and action on improving local building codes and permitting for solar installation were identified as priorities. Finally, it was noted that funding for solar energy research needs to be consistent and continuous from year-to-year for progress to continue. Funding has been historically inconsistent, which can stall research findings.

Energy Generation:

- Improve the conversion efficiency and lower the cost of energy generation technologies
- Identify areas to build large arrays that are economically viable, including Bureau of Land Management and existing remote power plant locations;
- Conduct an advanced sunshine survey to determine the best areas for locating concentrated solar arrays;
- Track the weather so backup power sources can be utilized economically if solar capacity is expected to be diminished by clouds;

Energy Storage:

There were several needs identified for energy storage, and a number of proposed solutions, none of which involve traditional batteries (elsewhere, traditional and new battery research projects are being aggressively pursued by automotive, defense, and other industries). These include:

- Identifying large subsurface saline aquifers, or areas of salt caverns, in which cavities can be drilled, and surplus electricity can be used to pump in compressed air. When electricity is needed, air is released, spinning turbines and producing electricity to meet load demands. However, systematic surveys are needed to identify where these locations exist in Arizona. TEP is particularly interested in this possibility, because there are large saline aquifers with carbon dioxide deposits underneath Southern Apache County, where the Springerville Generating Station Solar System is located. Also, Dr. Ben Sternberg of the University of Arizona is looking into doing a statewide survey to identify such energy storage location opportunities.

- A related idea is to use water pumped to a great height and stored, with gravity used to run turbines with the water as it flows downward. This method would require a lake or water catchments at both the top and bottom of the landform.

- A very different storage method was proposed for study involving the use of electric plug-in vehicles as batteries to store surplus energy produced

from solar cells. Plug-in hybrids can stimulate renewable energy growth by making solar generated electricity a transportation fuel. What is needed are models with a 20 - 60 mile battery range that can be charged from PV arrays on parking areas and residential rooftops (*EPRI, NRDC)*. Lithium batteries will be used and are not as toxic as conventional automobile batteries. Plug-in hybrid vehicles can be a viable part of the solar demonstration projects planned for Arizona. Growth of the use of these hybrids depends on increased funds for research into making these batteries more efficient and recyclable, creating advanced metering system set-ups, securing tax credits, and promoting the use of these vehicles by the government.

Energy Transmission:

It has been estimated that the Southwest, with its many days of sunshine and clear skies, has the potential to create enough energy from the sun to support the electrical needs of the entire country. For this to occur, several large impediments must be overcome.

Transmission of energy with a minimum loss is essential to the future of solar energy if it is to play a significant role in our energy use. One of the major purposes of any electrical grid is moving power from the point of generation to where it will be consumed. It will require new Ultra High Voltage transmission lines to transmit energy over long distances. For rooftop photovoltaic cells, transmission is a minor problem. Utility scale large arrays could ultimately provide the majority of the power for a city that is 100% solar powered. (Rooftop systems are projected to supply 30% of total energy generation.)

Another significant barrier to creating a national transmission grid is the need to acquire rights of way across private property as well as federal and state lands. Research could be conducted to study the best routes across the country for building the lengthy transmission lines required to move vast amounts of electricity from Arizona to remote loads.

The possibility of the federal government declaring eminent domain was also mentioned (eminent domain for the federal government was granted in 2005 to designate National Interest Electricity Transmission Corridors and approve permits for critical transmission lines under limited conditions). This project would need to be on the scale of the creation of the interstate highway system. Researchers at the University of Arizona are discussing how to address this problem.

Permitting and Codes:

Residential and non-residential solar permitting needs to be consistent and timely throughout each permitting agency, as well as across jurisdictions. Currently, an installer of solar systems who submits a similar application to the County and the City permitting departments will encounter considerably different results. Throughout Southern Arizona, the regulations and permitting time varies considerably. In addition, departmental responses can vary based on differences in regulations, lack of familiarity with new technology and procedures, and differences in the level of staff expertise needed to accomplish certification inspections.

Research is needed to determine how to coordinate the many different permitting agencies in Southern Arizona so that each one has resources, experience, and regulations consistent with other jurisdictions to deal with an increasing number of solar and green building applications. Moreover, safety considerations must always be the most important consideration.

Pima County and the City of Tucson are working to address this situation. A group of local installers has been meeting with permitting officials, and TEP offers training for city and county officials. The County has recently hired Susan Buchan to manage the Green Building Program, and Chief Building Official Yves Khawam provides a high level of experience in renewable energy and green building.

When a successful model is developed, it will be important to also coordinate with other cities and towns in Arizona. Experts point out that the process should not be rushed. They note that there is a steep learning curve associated with any new technology, and it will take time for permitting departments to develop a full understanding of the technologies and their characteristics.

In addition to permitting, national green building standards that were created in a different climate and environment than Southern Arizona may need review. The National Association of Home Builders (NAHB) Green Checklist is excellent but needs specific tailoring and adaptation for Southern Arizona. Since members of NAHB build about 80% of all homes nation-wide, national acceptance should grow. In addition, it may be worthwhile to review LEED standards as they relate to Southern Arizona commercial building as well.

Utility Scale Systems:

TEP has identified areas related to inverters, power factor support, and other ancillary services that impact the successful integration of utility scale solar energy generation into the existing generation portfolio.

Lifecycle cost estimates for solar generation technologies will need to continually be improved. Intelligent Grid technologies are needed to provide management tools for reliable integration of large quantities of solar generation into the grid. Additional funding may become available in late 2007 from the Department of Energy. TEP and other local electricity utilities, the University of Arizona, and DOE all have opportunities for research in these areas.

Intelligent Grid Research:

Concentrated solar collectors can harness very large amounts of energy in the form of heat, which is used to make electricity by boiling water and producing steam that runs turbines. One drawback to this method is the small energy loss that occurs through transmission over long distances. Energy produced from rooftop photovoltaic cells has a lower loss rate because the energy is not transmitted over long distances. Excess solar power is transferred back to the grid and used locally. This is known as distributed generation. Achieving this on a large scale in urban areas will require the development of a sophisticated grid unification system.

Southern Arizona currently is home to the majority of research into the development of management tools for reliably integrating large amounts of solar generation into the grid. TEP has been developing these tools for nearly a decade and currently has been awarded a Department of Energy grant for additional study. Many participants believe this is just a starting point. One suggestion from the Working Group was to create and study an urban project.

Microgrids:

An important strategy related to distributed generation is the microgrid. Micro-grids are self-contained grids within the power distribution system, connected to it, but with the ability to operate independently of the larger system. Microgrids could allow substantial deferrals of new generation, transmission and distribution infrastructure, while simultaneously enhancing the reliability and security of the existing power system network. This requires the use of energy storage, high-performance power electronics, load management, and real-time communication with the larger-scale grid.

Summary of Research and Development

As discussed above, there are many different solar energy research projects underway in Southern Arizona, particularly in the area of higher efficiency and lower cost energy generation. Since cost is one of the biggest barriers to widespread deployment of solar energy technology, not just in residential, but

also in commercial and utility scale, this research has enormous implications for market growth.

Although worldwide current sales of solar modules are increasing, the general public will need cost reductions that provide a shorter term return on investment. The market is dependent on this.

There is current and proposed research on efficient, inexpensive and reliable energy storage, which is a needed to support long-term market growth. Though research on this need is underway, it appears that a solution is still several years away. Efficient storage must become a central priority, supported and coordinated among the private sector, utilities, government, and university research. Additional research is needed into the storage of electricity from photovoltaic generation systems and for thermal energy from concentrated solar collection.

Other areas identified for study include green building and permitting, utility scale systems, Intelligent Grids and microgrids. As the solar energy sector of the nation's energy supply grows and becomes more complex, these areas of solar development support will become increasingly important. A proactive approach is the only chance for success.

Finally, the need for enhanced communication and collaboration is enormous. Utility companies, government entities at all levels, the private sector, and universities are too often working on separate tracks with priorities that do not mesh. This is among the most serious barriers to solar energy development progress.

In particular, solar industry leaders and utility companies often find themselves at odds on key issues, including net metering, integration standards, underlying motivation, and more. At the same time, a lack of awareness by some players of what others are working on can inhibit useful collaboration.

There is a need for an accurate, authoritative and respected “solar energy commons” where ideas and resources can be freely shared, meaningful priorities established, and where interested parties know to go for accurate information. In Southern Arizona nothing exists that truly fulfills this need. *The Solar Energy Center of Excellence* has much potential in this area, and Congresswoman Giffords' Community Solar Initiative could be an important catalyst. Equally important, each individual must be mindful of our shared goal – increasing the use and availability of solar – and work collaborative to make it a reality.

EDUCATION AND COMMUNITY OUTREACH

Overview

Solar energy educational resources, in the schools and the community, are limited in Southern Arizona. A review of the educational and community programs in existence reveals a wide range of programs, but there is little coordination or communication among different entities.

Work group members agree that education and community awareness are critical building blocks on which the success of solar energy growth rests. The need for greater conservation of resources underlies the importance of expanding solar energy use, both economically and for the health and viability of the globe.

Moreover, demystifying solar energy is a critical step towards widespread community understanding. Students who learn how solar power works tend to share this information with the adults in their lives. In addition, expanded knowledge about the availability of tax and utility incentives can lead to higher demand, which in turn can translate to a greater amount of resources directed toward research and market development. In short, broad community understanding of the resources available and the positive reasons for converting to or building with solar will broaden the market further.

The committee gathered information in the following areas:

- Solar education programs in the K-12 school system;
- College, internship and job training programs;
- Business related solar education programs; and
- Community and Homeowner Association initiatives.

K-12 Education Programs

K-12 education is guided by the Arizona State Standards and all teachers, including the science classroom teacher, must comply with these guidelines for their classroom curriculum. Math, English, reading, social studies and science must be taught in compliance with these standards. Solar energy is not explicitly included in these standards. However, there are a number of concepts within the standards where solar energy could be included. Some schools offer environment and ecology electives which provide the opportunity to present information about solar energy if the instructor chooses to do so.

The state of Arizona has developed a set of standards for teaching academic subjects and a high stakes test, the Arizona Instrument to Measure Standards

(AIMS) to comply with the requirements of the *No Child Left Behind Act.* These standards require that instructors "teach to the test" by adhering to six science strands, multiple concepts and performance objectives. These serve to limit severely time in the science classroom since teachers and students are being held accountable for a broad scope of specifically delineated topics.

Existing Resources

Text book and Educational Science Materials: Newly published science textbooks include information on renewable energy sources and solar energy; however, many middle school and high school classrooms in Southern Arizona use older textbooks without this information. Textbooks are adopted at the discretion of individual school districts and new textbooks are only purchased every six to eight years.
Most elementary schools in the region do not use text books, and rely instead on kits, sets of hands-on material, or information from the Internet. Each teacher has the discretion to select the topics based on the Arizona State Standards. While these could include solar, it is unknown as to the number of teachers who include solar instruction in their classroom. Presentation of anything on solar energy is dependent on the interest of the individual teacher because it is not specifically prescribed within the performance objectives of the standards.

Tucson Unified School district does have a well-developed Regional Science Resource Center. The Center provides professional development courses for teachers on how to use the FOSS (Full Option Science System) instructional kits. The Center also includes materials for students and serves 44,000 in the region. (The Sunnyside School district also contracts with the Center.)

The Resource Center promotes the state and national science standards in the preparation of instructional materials and kits which are delivered to 97 classrooms, ranging from kindergarten through 8th grade throughout the region.

There is a FOSS kit for Solar Energy education, but it is offered as an optional mini-unit. However, it is not regularly provided to teachers as part of the resource program because of the demands to teach to the AIMS test. We were unable to determine how many teachers request the FOSS Solar Energy kit.

Supplemental materials also serve as valuable resources for educators, but no data is available on the extent to which these are used. A number of solar-related books are being published for K-12 schools and libraries. The school library is often a source of more up-to-date information than textbooks; however the purchase of these books is dependent on the demand and interest of educators in that school and need as related to the standards.

Currently the Tucson Public Library catalogue contains a limited number of titles listed for children on solar energy and about a dozen for adults. In a search of *Amazon.com*, 100 solar energy titles were found for children and adolescents. Most were published within the last 8-10 years. 70 titles were listed for children's books on Alternative Energy. As demand for information on Solar Energy education increases, it is expected that availability of texts and material will follow. Again, there is no clarity on the extent to which these are used, or the quality of the information they provide.

Current School Programs:

The Resources Efficiency Awareness Program (REAP), which was adopted by the TUSD Governing Board in 1991, has earned 52 TUSD schools a total of $22,750 in soft capital dividends in 2006. Dividends are awarded to individual school based on energy savings and recycling efforts. This program exemplifies a successful partnership among the school district, local and state agencies and corporations. The goals of the REAP program are to educate students and staff to conserve energy, water and resources, to demonstrate efficient technologies and the use of renewable resources, develop incentives to reduce utility consumption at schools and to champion resource-efficient design and operation of school facilities.

Smaller schools districts in Southern Arizona have less developed programs, although several districts have some type of energy saving programs. An example of this is the Vail school district's AP Environmental Science class which focuses on sustainability. Vail also has an Ecology Club and a Renewable Energy Club at the high school level. Finally, the *Envirothon* team from Vail's Empire High School, having won the statewide competition, recently competed in the North American Envirothon competition in New York. The students had to design a sustainable school campus as part of the competition.

Use of Solar Energy in Schools:

Solar energy powers Southern Arizona schools on a very limited scale. Information from Soltrex, a solar tracking company, indicates that six school districts in Arizona use some solar power, compared to Massachusetts where some level of solar energy is used in 112 school districts.

TUSD began the Tucson Solar Schools Project in March 2002, which has resulted in the installation of six kW of distributed photovoltaic systems on six schools. The project also promotes the integration of energy education into the curriculum at those schools. The project includes a Website that was cosponsored by TEP. This links teachers to lesson plans, special speakers, projects and presentations on solar energy. It is unclear how extensively this

information source is used in schools because usage is also based on individual teacher discretion.

In addition, TUSD has contracted with the Soltrex Company for use of a real-time resource tracker to monitor their school's energy use. This system provides clear information on the amount of money saved through solar. For example, Doolen Middle School produced solar energy that would meet the electricity needs of 509 average American homes in a single day, and that offsets the equivalent of 24,104 lbs. of CO2 emissions, the main cause of global warming.

The Vail School District has taken advantage of TEP's Green Watts solar donation program at Empire High School and Civano Community School. At Empire High School, which opened in 2005, TEP's *GreenWatts* customers funded a 7.5 kW DC photovoltaic system. The system's inverter and meter are located inside a science classroom, where they are used to help educate students about solar energy. At Civano School, sixty 50-watt PV panels generate electricity from the roof, and energy efficiency is a regular part of their curriculum.

Six schools and two additional district projects in TUSD were sponsored by *GreenWatts* funds contributed by TEP customers. The schools include Safford Middle School, Hohokum Middle School, Project MORE, Doolan Middle School, Palo Verde High School, Davidson Elementary School and Camp Cooper as well as one of the district's portable Facilities Offices.

Davidson Elementary school was completed in December of 2006 with a solar energy system which has a generating capacity of 9.6 kW DC. This school is the first in TUSD to qualify for the U.S. Green Building Council's (USGBC) Leadership in Energy and Environment Design (LEED) certification. At present 300 schools nationwide are on the waiting list for certification, a telling measure of the movement's rapid growth. In 1998, the U.S. Green Building Council established the LEED rating system, which certifies and grades new building projects according to their level of sustainability. In the spring of 2006, the USGBC officially launched LEED for schools, which was tailored to meet the specific needs of K-12 classrooms and to provide a barometer for better building performance.

Impediments

Installation of Solar: The major impediment for the installation of solar in schools is the initial capital outlay and the almost 20-year return on the investment. Superintendents agree that a payoff of 5-7 years would make the installation of solar a more reasonable option. Financing options are available but state laws and procedures restrict a school's ability to effectively contract with solar finance-design-build-maintain companies.

Curriculum: The need to follow the strictures of the Arizona State Standards limits the inclusion of solar energy education in current science and social studies curriculum. Since solar energy is not listed as a requirement under any of the performance objectives it is up to the discretion of the individual educator to include solar energy in the curriculum. Only anecdotal information is available on the degree to which individual teachers are electing to teach about solar energy.

Lack of Professional Development: Professional development for teachers on solar energy education is not widely available. In addition, teacher time is severely limited due to the demands of teaching material specific to the state standardized tests.

Opportunities

Given the lack of communication, coordination and focus on solar education, there is significant possibility for growth and improvement is broad. Moreover, organizations such as the *Arizona Foundation for Resource Education*, the *Arizona Association of Environmental Education* and the *Arizona Science Teacher's Association* exist to fill the gaps.

In addition, the TUSD Regional Science Resource Center could include more school districts and could more widely develop materials focused on Solar Energy. The Center could be an excellent central professional development location for training on solar energy.

University, Community College and Job Training Courses

Universities: Solar-related coursework is offered at the state's three major universities. The University of Arizona offers a course in Silicon Processing in the College of Engineering and the College of Architecture offers courses in Basic and Advanced Computer Energy Analysis and Solar Utilization in the Built Environment**.**

Some of the individual engineering departments include solar in their design courses. For example, the Introductory Course, Engineering 102, provides the students the opportunity to design a solar oven.

Community Colleges: While there are community colleges across the nation that provide Renewable Energy Certification Programs to train and certificate solar installers, such as San Juan College in New Mexico, community colleges in Southern Arizona have lagged behind. Occasional courses are offered, but there are currently no courses specifically designed to train solar installers.

Both Pima Community College and Cochise College offer classes for Electrical Utilities Technicians, Environmental Technology and Electrical Codes, wiring and heating and cooling systems. Solar energy was not mentioned specifically in any of the class descriptions.

JTED (Joint Technical Education District): JTED provides career and technical education programs for students in 11 school districts at the high school level in Pima County. These schools work in conjunction with business and industry to prepare a skilled workforce. At present, solar energy installation is not included in the planned curriculum.

Job Corps: Job Corps is the nation's largest residential and education training program for economically challenged youth, ages 16 through 24. The Fred G. Acosta Job Corps Center in Tucson offers a wide variety of training in technical and construction related job, but solar installation as an individual course is not offered.

International Brotherhood of Electrical Workers (AFL-CIO): The Tucson-based Local 570 of the IBEW has a five-year "wireman" apprenticeship program for individuals entering the field. At the present time, it does not include any training for installation of solar panels or other alternative energy equipment. In addition, curriculum materials for solar and alternative energy installations are not available at this time from the union's headquarters in Washington D.C.

Solar Energy International: Solar Energy International (SEI), which provides education and training to decision makers, technicians and users of renewable energy sources, offers a one-week course on solar installation in Tucson during the month of February. SEI, based in Colorado, also provides the expertise to plan, engineer and implement sustainable development projects.

Government, Community, Civic and Business Organizations

City of Tucson: The City of Tucson's Office of Conservation and Sustainable Development oversees the City's sustainability program, including solar. It coordinates the efforts of City departments, partners with other jurisdictions and public and private institutions, provides technical support to neighborhoods, organizations, and businesses, and provides outreach and education for both the general public and target audiences.

Pima County: Pima County recently hired a Green Building Manager, and is developing guidelines for new buildings in Pima County. One goal is to localize existing building standards such as Leadership in Energy and Environmental Design (LEED), for example, by requiring solar on new buildings. This is not currently required for LEED certification. The County hopes to exceed existing best practices and U.S. Green Building (USGB) Guidelines. The County also is

one of three pilot sites selected nationwide for facilitating LEED certification. This effort offers an opportunity to strengthen the emphasis on solar energy as part of Pima County's green building future. All county buildings that begin construction after July 1 and are larger than 5000 square feet must be LEED certified.

Pima Association of Governments (PAG): PAG established the Greater Tucson Strategic Energy Plan working group in 2006 to explore concepts related to energy as a guide for development in the greater Tucson region. Recommendations in the draft plan fall into several main categories, one of which is Energy Generation. This includes actions that government can take to encourage and promote solar and renewable energy usage. The plan has not yet been formally adopted.

Tucson Clean and Beautiful: This nonprofit organization is a public-private partnership formed in 1985 to encourage community-based and quality of life in the Tucson and Pima county metropolitan area. The organization sponsors a *Hot Topics/Cool Solutions* program that has included several conferences and community fairs related to sustainability, solar energy, energy efficiency, green building, urban heat island effect and cool/permeable pavements. These programs are aimed at students in grades K-12, neighborhood and civic organizations and workshops for teachers and industry/government professionals. The programs also include special events and program information available online.

Tucson-Pima Metropolitan Energy Commission (MEC): This is a citizen advisory body appointed by the Mayor and Council of the City of Tucson and the Pima County Board of Supervisors. In existence since 1980, its mission is to serve as a "catalyst for the City of Tucson and Pima County to build a more sustainable energy future in the region." Many of the solar energy achievements of the last 20years in the region, including the Civano project, the Sustainable Energy Standard and the Greater Tucson Coalition for Solar Energy, were supported by the MEC.

Greater Tucson Coalition for Solar Energy (GTCSE): The coalition formed in 1997 as a public-private collaboration to develop strategies and raise funds to support the strengthening of the local solar energy industry and solar energy demand. GTCSE facilitated over a dozen U.S. Department of Energy grants for the benefit of the community.

Sustainable Tucson Networking: *Sustainable Tucson* is an emerging network of networks that consists of more than 100 organizations, with an overriding goal of facilitating and accelerating Tucson's transition to sustainability through community-wide education and action. Representatives attend monthly meetings, and the organization strives to connect all of Tucson's sustainable assets, resources and best practices.

The Environmental Education Exchange: The Exchange was established to increase environmental literacy. It has developed a wide variety of conservation and environmental education programs and materials, available to educators and others. This group offers expertise in curriculum development and training to a wide range of public agencies, private organizations, school districts and businesses.

Citizens for Solar: The nonprofit organization hosts a Solar Potluck and Exhibit, a one-day educational event annually for the past 25 years, making it the longest running solar potluck in the U.S. Held at Catalina State Park, up to 2,500 people attend each year to observe solar ovens cooking food as well as other solar equipment in use.

Tucson Electric Power: TEP sponsors numerous educational and environmental programs. The *Sunshare* Program offers incentives to home and business owners to install photovoltaic solar systems. These customer-owned systems, combined with TEP's own utility-scale solar generation resources, produced just under 9,400 megawatt-hours of power in 2006, which is equivalent to the energy needed annually to power 880 average Tucson homes. The *Sunshare* program reimburses customers for installing photovoltaic systems.

The TEP sponsored GreenWatts program enables supporters who are TEP customers to invest directly in the creation of "green" power. For each Green Watt that is "adopted" for $2, TEP will create 20-kilowatt hours per month of electricity from renewable energy resources. Solar technology is donated to schools, non-profits and other community locations using the funds collected from GreenWatts participants.

TEP also sponsors *The Solar School* program with Tucson Unified School District. The TEP website provides resources and lesson plans on solar energy for the community. TEP speakers are available for schools and community groups, as available. At present, TEP educational materials and solar programs are widely used as resources for community and school on solar energy education.

AZURE (Arizona Utilities Renewable Energy): AZURE is an education-outreach partnership sponsored by Arizona's electric utility companies to educate Arizonans about Renewable Energy resources. AZURE provides educational experiences and information about renewable energy, including solar energy, on its Website, *AZUREeducation.com*. Although AZURE is just over a year old, it continues to grow. Offerings include lesson plans, opportunities for tours, guest speakers and classroom resources for educators as well as professional development training.

Arizona Public Service: APS, which serves much of Southern Arizona outside of Pima County, offers three educational programs that address renewable

energy and offer tools, experiments and in-depth information on solar energy including how it works, current and future use and real life projects from the company. The programs focus on providing educators the tools and background they need to teach this information in the classroom. The programs are:

- ***Teachers' Energy Workshop:*** A two-week workshop during the summer for 4th and 6th grade educators geared toward learning new and exciting ways to teach energy including solar and sustainability that meet state standards in science.
- ***Road to Renewable Energy***: Offers teachers an in-depth resource of information and guides to teach renewable energy including solar as well as displays and activities. Teachers can obtain materials through APS to help explain the technologies, current and potential uses, and realities of renewable energy within Arizona - this includes solar, geothermal, wind, bio-mass and bio-gas.
- ***Power Posse***: Offers teachers kid-friendly activities and tools to reinforce conservation and environmental education in the classroom. The program also offers unique experiments and projects for educators to teach solar.

Trico Utility Company: Trico, via its relationship with Arizona Electric Power Cooperative, actively participates in AZURE, the Arizona Utilities Renewable Energy Education initiative. This group, made up of representatives from Arizona Public Service, Tucson Electric Power, Salt River Project and Arizona Electric Power, compiles educational materials for use by elementary, middle and high school teachers. Trico offers grants to encourage renewable energy curriculum to schools in it service areas, and is in the process of designing that grant process to roll out early in the 2007-2008 school year.

Environmental Technology Industry Cluster (ETIC): ETIC is a membership-driven organization that represents about 300 Arizona companies in the renewable energy and environmental technologies sector. These companies are involved in such areas as carbon management, distributed power generation, environmental law, pollution control, resource recovery and water management. ETIC sponsors and organizes an annual resource event every January that focuses on the latest technologies and regulations dealing with clean air, mercury, global warming and renewable energy. The *Energy and Environment Conference (www.euec.com)* attracts 1500 attendees and 700 companies

Davis-Monthan Air Force Base: DM has a commitment to energy conservation and renewable energy and that they are actively working on identifying opportunities.

Neighborhood and Homeowner Associations

Neighborhood and Homeowner associations are most often called upon by community organizations and local businesses for information on environmental issues. However, there is not comprehensive information available on the involvement of these groups in solar education.

Homeowner Associations: Some Homeowners Associations (HOA) have been very protective of their "roof lines," particularly in using roofs for solar panels. Arizona legislation ARS-33-439 was enacted in 1979 to nullify this restriction, but the issue has continued to meet with opposition. However, just this year Governor Napolitano signed into law Senate Bill 1254, which prohibits HOAs from restricting the installation of solar energy devices. It allows associations to adopt "reasonable" rules governing the placement of solar devices, but they can't restrict function and efficiency.

Individual Homeowner Associations have provided educational sessions for their members, using some of the community and business resources listed above. Anecdotally, there appears to be a growing interest in solar energy programs for neighborhood and homeowner associations.

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ACTION STEPS

This section summarizes the steps that have been recommended by Working Group members in each of the three areas of focus:

Market Growth:

State:

- Encourage full implementation of the REST.

- Advocate for state incentives to attract solar businesses and engage business community support of the incentives.

- Assure implementation of a state net metering standard.

Federal:

- Extend Federal investment tax credits, through 2015, at the rate of 30% of investment value to utility owned solar generation to allow utility owned solar generation to compete with tax subsidized utility owned wind generation.

- Extend Federal solar income tax credit for individuals and sole-proprietorships at the present rate of 30% of total cost to a maximum of $10,000.

- Support current legislation, *The Solar Energy Research and Advancement Act,* introduced by Congresswoman Giffords. These bills would:

    - *Establish a solar industry workforce training and internship program to ensure that current and future employees obtain the necessary skills to install, operate and maintain solar energy products;*

    - *Launch a nationwide initiative for private industry and public agencies to demonstrate advanced solar PV technology. All states that submit proposals can receive funding for advancing commercial applications of solar technology;*

    - *Create a research and development program within the Department of Energy focusing on thermal energy storage technologies for CSP to focus on how to improve storage technology so that solar energy consumers can obtain electricity at night and on cloudy days;*

    - *Support research and development for solar lighting technology, such as solar light pipes.*

- Support a federal carbon tax.

Regional:

- o Standardize building codes and permitting requirements used by the City of Tucson, other municipalities and Pima County for PV installation.

Marketplace:

- o Encourage partnerships with the retail industry and large-scale commercial organizations;

- o Encourage solutions such as:

    - Orient buildings on land to assure optimum solar exposure as an element in building codes;
    - Promote use of solar ovens;
    - Promote wide-scale usage of solar water heating systems for all homes;
    - Light buildings at University of Arizona with solar lights.
    - Encourage and grow what is already a large market in thermal heating of swimming pools.
    - Support the expansion and use of hybrid and solar vehicles.

- o Initiate a study of how the Southwest could serve other areas of the country via solar energy farms located in Southern Arizona, coupled with new transmission to export the power from the region. Examine also the ways in which Arizona's solar resources could connect with the Midwest's wind resources;

- o Initiate a study on eliminating the inhibitors that delay the implementation of large scale solar on Southern Arizona's vast tribal lands;

Research and Development:

- o Increase efficiency and reduce the cost of energy generation for both photovoltaic and concentrated solar.

- o Develop efficient, economic and reliable short term and seasonal storage of power, including battery storage of electricity, converting electricity into some form of potential energy, and storage of concentrated solar thermal energy.

- o Research the potential of and need for a large-scale solar transmission system.

- o Explore possibility of implementing, at the regulatory level, incentives for PV and solar hot water storage.

- Identify the best locations in Arizona for large-scale solar energy generation, in terms of weather, proximity to urban centers (to limit power losses due to transmission), and jurisdiction (private and public lands).

- Create utility-scale generating algorithms and control mechanisms to manage the reliable integration of large scale solar generation systems.

- Research grid integration and microgrids. Create a project to analyze and evaluate the factors involved.

- Create a coordinated system for permitting and green building.

- To further all of the above, create a nationally recognized solar center for research, outreach, and as a central point of contact for all solar entities. This would be an authoritative and respected "solar energy commons" where ideas and resources can be freely shared, meaningful priorities established, and where interested parties know to go for accurate information.

Education and Outreach:

Community

- Organize and coordinate information about solar and renewable energy for distribution through existing networks—environmental associations, school districts, library interconnections, science teacher organizations, neighborhood and homeowner's associations and faith-based communities.

- Create Federal grants for community, city and county programs that promote solar energy use and educate the public on solar energy as part of conservation education.

- Create Federal funding to support solar installation by non-profit organizations (churches, libraries, community and charitable groups).

- Work with media outlets to encourage solar programming and public service announcements.

- Encourage business partnerships with city, county and environmental groups in sponsoring events and programs on solar energy.

- Encourage the faith-based community to conserve and install solar in church related buildings (schools, sanctuaries, office buildings) both from a mission and an economic standpoint.

Schools

- Collaborate with the Arizona Department of Education and the State Superintendent on ways in which solar energy can be more directly included in the state standards at the time of re-adoption;

- Provide professional development for teachers on solar education.

- Encourage the U.S. Department of Education to proactively promote conservation and renewable energy within the national teaching standards.

- Promote federal funding to support the installation of solar technology in public schools, including charter schools, at the K-12, community college and university levels. (These installations could provide uninterrupted power availability in the case of a national emergency.)

- Create U.S. Department of Energy and/or Department of Education federal grants to train K-12 teachers and develop curriculum on renewable energy, conservation and solar use.

- Explore federal funding sources to provide job training and technical skills programs for solar installers, like those offered at community colleges, technical schools and high school programs such as JTED.

- Encourage the expansion of the Tucson Unified School District Regional Science Center to expand to a service offered to all of the southwest. Explore ways in which this Center could be included in the Rio Nuevo museum complex with solar energy education display area.

CONCLUSION

Enormous opportunity exists in Southern Arizona to emerge as the Silicon Valley of Solar Energy. As the report reveals, integrated actions are needed to:

- Jump start and maintain market growth:
- Encourage communication and cooperation among market experts and researchers;
- Coordinate and expand significantly the educational opportunities and outreach in the schools and the communities of Southern Arizona.

The optimism and enthusiasm of the solar experts participating in Congresswoman Giffords' *Community Solar Energy Initiative* indicate that the time is ripe for growing solar in Southern Arizona.

Research and Development
Appendix

The Research and Development Work Group catalogued two specific areas of research and development: research projects that are currently underway and additional areas of research that are needed. The following charts include brief descriptions in each of these areas.

Current Research – August 2007

Table 1 - *University of Arizona - Energy Generation Research*

Name	Company or Institution	Topic	Purpose/Uses	Status
Dr. Joe Simmons Dr. B. G. Potter	University of Arizona Materials Science	Sensitized solar cells Single junction	Nano-particle sensitizers can reduce efficiency loss due to design problems that plague many current cells. Target efficiency near 30%.	Demonstration expected in early 2008.
Dr. Joe Simmons Dr. B. G. Potter	University of Arizona Materials Science	Multijunction, nanostructured solar cells	Use “quantum dots” (functionalized cadmium-sulfide nanoparticles) to create sensitized solar cells. Target efficiency above 50%.	Pending funding, demonstration could be as early as 2009.

Name	Company or Institution	Topic	Purpose/Uses	Status
Dr. Roger Angel et al	University of Arizona Astronomy	Concentrating optics for multijunction photovoltaic cells	Low cost, high performance optics needed to exploit these very high efficiency cells	Prototype systems being made at Mirror Lab for tests generating power using a small sun tracker.
Dr Roger Angel et al.	University of Arizona Astronomy	Sun-tracking mounts for concentrator photovoltaic systems	Reliable, low cost mounts essential to realize concentrator PV potential.	Designs being developed to match new optics.
Dr. Neal Armstrong	University of Arizona Chemistry	Organic solar cells	Improve the function of the polymer interface to increase efficiency.	
Dr. Neal Armstrong, et al	University of Arizona Chemistry	Molecular-organic hybrid solar cells	Use “quantum dots” with built-in nanowire arrays to conduct electricity to external electrodes.	
Dr. Scott Savedra, et al	University of Arizona Chemistry	Biomolecular photosynthetic solar cells	Use supported lipid bilayers with incorporated “triad” photoreceptors. Use photosynthesis for efficient energy generation.	
Dr. David Lynch	University of Arizona Materials Science	Processing of crystalline silicon	Use a cold crucible method to reduce processing of silicon to a single step. Decrease cost of silicon.	

Name	Company or Institution	Topic	Purpose/Uses	Status
Dr. Kelly Potter	University of Arizona ECE	Testing and performance degradation – accelerated UV exposure	Use accelerated UV exposure to identify the source of solar cell efficiency loss due to exposure to sunlight.	
Dr. Douglas Loy and Dr. Kelly Potter Dr. Chris Cornelius	University of Arizona ECE Materials Sandia Laboratories	Environmental degradation of systems components	Identify sealants and adhesives that don't degrade due to exposure to sunlight and weathering.	
Dr. Herman Fasel	University of Arizona AME	Solar Tower Concentrators	Thermal load calculation. Large scale power generation.	
Dr. Neal Armstrong, Dr. Stanley Pau	University of Arizona Chemistry OSC	Direct solar hydrogen generation	Use “quantum dots” to separate hydrogen and oxygen upon sunlight exposure.	
Dr. Douglas Loy	University of Arizona Materials	Electrolytic formation of hydrogen	Membranes used in the formation of fuel cells are reversed and used for the separation of water in electrolizers.	

Name	Company or Institution	Topic	Purpose/Uses	Status
Dr. Richard Ziolkowski Dr. Hao Xin	University of Arizona ECE	Enhanced thermo-photovoltaics, Rectennas from THz to Visible	Metamaterial-based micro/nano structures to convert efficiently more of the solar spectrum to electrical power	Designs and testing of scaled versions of previous DARPA funded metamaterials and rectenna work on-going

Descriptions of University of Arizona Energy Generation Research

Sensitized solar cells (Simmons and Potter – Materials)
Today: Most solar cells are made of semiconductor single junctions that consist of (a) silicon, (b) cadmium telluride, or (c) copper-indium-gallium-diselenide. These materials have a theoretical efficiency near 30%. Yet, the best that can be achieved in practice is far below this limit due to inherent problems in the design.
R&D: New thin films using nano-particle sensitizers are being developed that avoid the design and operational problems of conventional solar cells. The promise is to reach, single junction efficiencies near 30%. Demonstration expected in early 2008. (DOE, TRIF)

Multijunction, nanostructured solar cells (Simmons and Potter – Materials)
Today: Multi-junction solar cells have the promise to reach efficiencies of 50-60%. The best 3-junction solar cells are made at Spectrolab (Boeing subsidiary) with an efficiency of 40% using a very expensive thin film epitaxial growth method.
R&D: Research is ongoing into stacking up “sensitized solar cells” that use special nano-particles called “quantum dots” to build multi-junction systems. Quantum-dot solar cells have been judged by DOE to have the greatest potential for reaching efficiencies above 50%. The materials developed at UA would not require epitaxial growth and have the potential

to deliver 50-60% efficiencies at much lower cost. With adequate funding, demonstration could be expected as early as 2009. (DOE pending)

Organic-organic heterojunctions (Armstrong – Chemistry)
Today: Organic solar cells have great promise for charge separation. However, existing organic solar cells have limiting problems that keep them at very low efficiencies.
R&D: New developments to improve the function of the polymer interface promise a removal of the limiting problems.

Molecular-organic hybrids (Armstrong, Pyun, Zheng, McGrath and Saavedra – Chemistry)
R&D: New nano-composite materials are being developed that use a porous sol-gel matrix as a host and contain functionalized cadmium-sulfide nanoparticles, known as "quantum dots" to absorb sunlight and generate electricity with built-in nanowire arrays to conduct the electricity to external electrodes. (DOE and NSF). Another design utilizes self-organized organic dyes in mesophase materials.

Biomolecular photosynthetic solar cells (Saavedra, Armstrong and Hall – Chemistry, and Gust, Moore and Moore – ASU Chemistry)
R&D: Biomimetic organic solar cells consisting of supported lipid bilayers with incorporated "triad" photoreceptors use the photosynthesis process for efficient conversion of solar radiation to electricity. (DOE)

Processing of crystalline silicon (Lynch – Materials)
Today: Solar-grade crystalline silicon is produced using a two step purification process to produce electronic grade silicon. Silicon determines about 40% of the cost of a PV unit.
R&D: Using a cold crucible method, the processing of solar-grade silicon can be reduced to a single step, reducing the cost of silicon conservatively by a factor of 2.

Testing and performance degradation – accelerated UV exposure (Potter – ECE)
Today: When solar cells are first exposed to sunlight, their efficiency decreases by 10%. Further decreases by as much as ½ percent are seen per year of use. This has a major effect on finances of buying solar cells.
R&D: Accelerated UV exposure will identify the source of the photo-activated defects. Experience with radiation-induced degradation of optical fibers (support from NASA and Sandia) will lead to the development of additives that can avoid or mitigate performance loss due to solar exposure (solarization).

Environmental degradation of systems components (Loy – Materials, Potter – ECE, and Cornelius – Sandia)
Today: Many solar cell components such as adhesives and sealants fail (de-lamination) within the first year of use or during presale proof-testing. This increases the cost of solar cells and strongly affects use of solar energy in developing nations.
R&D: Investigation of the degradation process of sealants and adhesives from accelerated UV exposure and weathering promises to identify improved materials for sealants and adhesives in solar cell systems.

Concentrating optics for multijunction photovoltaic cells (Angel, Olbert – Astronomy, Burge, Sasian - Optical Sciences)
Today: New, highly efficient (35%), multijunction cells are commercially available at ¼ the cost per watt of any flat panel photovoltaics, but their potential for low cost solar electricity has not yet realized.
R&D: The multijunction cells work best in highly concentrated sunlight. Using optics experience developed at the Mirror Lab for large telescopes, new optical designs and manufacturing methods are being developed to make prototypes of new concentrating systems that combine high efficiency and low cost. (TRIF)

Sun-tracking mounts for concentrator solar systems (Angel, Davison – Astronomy)
Today: Concentrator solar systems of both the photovoltaic and thermal types must be mounted on two-axis trackers to point at the sun. Tracker costs today are too high.
R&D Astronomical telescopes are designed using the most advanced engineering to realize very high tracking performance in the same buffeting wind environment as solar trackers. We are designing solar trackers with their required tracking accuracy and 100 mph wind survival, based on telescope experience. (TRIF)

Solar Tower Concentrators (Fasel – AME)
Today: Solar tower power plants have been constructed in several places, including a 30 kW system in Manzanares, Spain.
R&D: Calculations of thermal loads for a new design for larger power generation are being conducted in the AME Department.

Direct solar hydrogen generation (Armstrong, Pyun, Zheng, McGrath and Saavedra – Chemistry, Pau – OSC)
Same molecular-polymer hybrids as described above can use the nano-particles to separate hydrogen and oxygen upon sunlight exposure.

Electrolytic formation of hydrogen (Loy – Materials)
R&D: Membranes used in the formation of fuel cells are reversed and used for the separation of water in electrolizers.

Rectennas from THz to Visible (Ziolkowski, Xin – ECE)
Today: The previous DARPA funding on rectennas considered using microwave beams to remotely power communication and remote sensing systems, as well as the design and testing of metamaterials for a variety of electrically small antenna applications.
R&D: Now trying to combine the metamaterials, electrically-small antennas and novel micro-electronic devices to convert more of the solar spectrum to usable energy.

Table 2 - *University of Arizona - Energy Storage Research*

Name	Company or Institution	Topic	Purpose/Uses	Status
Dr.Olek Palusinski	University of Arizona ECE	High Capacitance Materials	Use electrochemical etching of metals to produce a large surface area that can store charge. Use for fast response energy storage needed to span the spin up time of gas turbines (10 min).	
Dr. Ben Sternberg	University of Arizona Geological Engineering	Compressed air energy subsurface storage	Use compressed air pumped into large subsurface salt caverns. Conduct geological surveys around Arizona for suitable locations.	

Name	Company or Institution	Topic	Purpose/Uses	Status
Dr. Roger Angel	University of Arizona Astronomy	Pumped hydroelectric energy storage	Photovoltaic solar energy generated during the day is stored for distribution at night.	

Descriptions of University of Arizona Energy Storage Research

High Capacitance Materials (Palusinski – ECE)
New materials are being developed with very large capacitance using electrochemical etching of metals. This method produces a large surface area that can store charge. Such materials could be used for fast response energy storage needed to span the spin up time of gas turbines (10 min).

Compressed air energy subsurface storage (Sternberg – Geological Engineering)
Today: Tucson Electric Power Utility is evaluating use of compressed air pumped into large subsurface carbon dioxide containing aquifers at Springerville, AZ to store solar-produced energy. This approach is effective for energy storage over many months to a year.
R&D: It is important to identify other potential compressed air storage sites (CAES) in the State of Arizona for setting up other solar cell power plants. Geological surveys will be conducted of various locations in Arizona to look for salt caverns or non-porous sedimentary or metamorphic rocks at depths 100m to 4km.

Pumped hydroelectric energy storage (Angel – Astronomy/Steward Observatory)
Today: solar electricity from Arizona fulfills less than 0.01% of the states needs; none is exported to other states.
R&D. Solar electricity from the Southwest has the potential to provide all the nation's electricity needs. For this to happen, overnight storage is required locally in the Southwest, so that transcontinental overhead transmission lines are used at capacity 24 hours a day. Arizona has excellent sites for pumped storage, with more than 1 km height difference and the potential for water storage at both upper and lower levels. A survey will be made of possible sites with potential for 100 GW-days of storage, and concepts for national distribution developed.

Table 3 - *University of Arizona - Weather Modeling Research*

Name	Company or Institution	Topic	Purpose/Uses	Status
Dr. Eric Betterton	University of Arizona Atmospheric Science	High Resolution Weather Modeling	Forecast solar irradiance, cloud cover, precipitation and temperature.	Currently able to forecast up to 36 hours in advance on a 1.8 km (1 mile) grid scale.

Description of University of Arizona Weather Modeling Research

The Department of Atmospheric Sciences runs a high resolution, cloud resolving model, daily, to predict many different types of atmospheric variables up to 36 hours in advance. Some work is ongoing in improving model predictions by improving model configuration and by improving model initial conditions. Cloud location and coverage are not always well initialized and these spin up errors can magnify into large errors with the model's forecast of solar irradiance and clouds. Future work needs to focus on improving the initial cloud location and coverage. In addition, work is needed with respect to model validation of clouds and irradiance, among other important parameters such as temperature and precipitation.

Table 4 - *University of Arizona - Solar Decathlon*

Name	Company or Institution	Topic	Purpose/Uses	Status
Dr. Dale Clifford, Dr. Jason Vollen and Dr. Joe Simmons	University of Arizona	Solar Decathlon competition	Build a 100% solar house which is taken to the National Mall in Washington DC. 20 teams compete. Points are awarded in 10 categories, including architecture, engineering, and energy balance, using only solar energy	Competition is every two years. U of A plans to compete in the next one in 2009. Sponsored by Department of Energy. www.solardecathlon.org The 2007 Solar Decathlon is Oct. 12 – 20, 2007.

Table 5 - *Private Sector - Energy Generation Research*

Name	Company or Institution	Topic	Purpose/Uses	Status
Dr. Jeff Britt	Global Solar	Thin film solar cells using CIGS (copper-indium-gallium-diselenide)	Modulars for solar conversion Small portable devices Rooftop Large power modules	
Dr. Arthur Schneider	Raytheon	Enclosed solar cells	45% efficiency Reduce cost per kilowatt	Proposal to NREL for more funding is underway.
Dr. Terje Skotheim	Solar Technology Research Corp.	Silicon research	Reduce the cost of silicon Partnership with DOE	Manufacturing plant operational in possibly 3 years.
John Scheatzle	Brush Ceramics/Zentrix	Concentrated photovoltaic cell	Low cost, high output solar energy Uses Beryllium Oxide Monolithic optical concentration	In production.
Glenn Rosenberg Dr. Raymond K. Kostuk Dr. Stanley Pau	Prism Solar Technologies University of Arizona Electrical and Computer Engineering OSC	Holographic Planar Concentrator	Replace silicon and other PV cell material with a low cost holographic concentrator that is configured in a standard flat plate PV cell module. Efficiency equal or better than conventional flat plate modules but with much lower cost.	Proposals submitted to DOE and NSF. Collaboration with Prism Solar Technologies. Product possible by late 2008.

Descriptions of Private Sector Energy Generation Research

Concentrated photovoltaic cell (Brush Ceramic Products)
Brush Ceramic Products manufactures beryllium oxide (BeO) ceramic in a variety of shapes and sizes. BeO is useful due to its very high thermal
conductivity and low dielectric constant. This means that the material conducts heat without conducting electricity. BeO has the highest thermal conductivity of any commercially available ceramic. BeO also has very mature, reliable metallization systems. Recently, applications have been developed for photovoltaic concentrator systems which use less silicon and concentrate the solar energy into much smaller photovoltaic receivers. BeO is the only material that can handle the heat and temperature fluctuations.

Holographic Planar Concentrator (Prism Solar Technologies/University of Arizona)
Today: The cost of conventional silicon PV modules limits widespread deployment of solar energy. Much of the cost is due to the photovoltaic material.
R&D: Modeling, design, and fabrication of holographic concentrators are investigated that can be used in a planar module. The element selects spectral bands that the PV cell is most sensitive to and can work with either direct or diffuse sunlight. Processing in low cost dichromated gelatin layers is also studied.

Table 6 - *Tucson Electric Power – Current Research*

Name	Company or Institution	Topic	Purpose/Uses	Status
Tom Hansen	Tucson Electric Power	**(1)** Balance of System Integration/Cost Reductions.	Reduce the cost of the non-PV module components and installation labor. With Brookhaven National Labs	Begun in 1999, continued through design evolution at the Springerville Generating Station Solar System. Will complete in 2010.
Tom Hansen	Tucson Electric Power	**(2)** Low efficiency, very low installed cost utility scale solar modules.	For low cost utility scale PV generating stations competitive with fossil fuel generation. With a module manufacturing equipment maker.	Begun in 2002, funding has been intermittent. Will continue until 800 watt module manufacturing equipment is designed and functional.
Tom Hansen	Tucson Electric Power	**(3)** Reduction of solar generation maintenance costs.	To categorize and find methods for reducing the ongoing costs of maintaining and operating both distributed solar generation and utility scale solar generation systems. With Sandia National Labs.	Ongoing as long as TEP solar generation production facilities are functioning. Two reports have been published, more to follow annually

Name	Company or Institution	Topic	Purpose/Uses	Status
Tom Hansen	Tucson Electric Power	**(4)** Solar Output Intermittency Management.	Characterization of solar intermittency frequency and amplitude for comparison with dispatchable generation management tools. With Carnegie-Mellon University researchers.	Project completed; report to be published in late 2007.
Tom Hansen	Tucson Electric Power	**(5)** Methods for Evaluating Solar Capacity Value for Utilities.	Recently awarded DOE –SAI grant for proposing and evaluating new methods for the capacity value of solar generation to utilities. TEP received one of only two grants awarded for research in this important area of solar market transformation.	Evaluation method algorithms developed. Data for use in evaluation will be processed next. Report to be issued second quarter of 2008.

Name	Company or Institution	Topic	Purpose/Uses	Status
Tom Hansen	Tucson Electric Power	**(6)** Propose revisions to IEEE-929/1547 inverter protection standards.	Evaluate and propose new standards for low voltage and frequency deviation ride through to prevent unnecessary power output reductions from normally encountered voltage and frequency grid power deviations. With Xantrex.	Ongoing since 2003. Work with Sandia Labs and NEC officials. Ongoing data provided to Xantrex. Expect solutions to be implemented in 2010.

Descriptions of TEP Current Research

- As the cost of PV modules is reduced by other research, the cost of all components and labor needed to build a complete functional solar generation system will dictated by the Balance of System (BOS) costs. In some cases the current BOS costs are greater than the module costs and become the long term barrier to competitive lifecycle solar generation energy costs. This project is a design development project to incrementally reduce the installed BOS costs of utility scale solar generation. TEP was the first solar system designer to achieve BOS costs of less than $1.00 per DC watt at its Springerville Generating Station Solar System. DOE had for years supported research to achieve this low level of BOS costs, but it had not been done successfully before. The ongoing project also documents the long term costs of operation.

- The use of very large, low cost per watt DC modules could potentially reduce the installed cost of highly integrated utility scale PV generation systems. This project is to develop manufacturing equipment for the production in large scale of such modules. The project has considered the construction of a PV manufacturing facility to produce such modules at the solar generation site in Arizona.

- Long term maintenance costs can significantly impact the lifecycle cost of solar generation. Very little reliable data ahs been collected on the long term costs of operating and maintaining solar generation in real life conditions. TEP is providing data on both distributed solar generation and utility scale solar generation for evaluation and publishing into the public domain for use by solar developers.

- While solar generation output in a world without clouds is better than 99.9% predictable, clouds create output variations of very high magnitude in very short periods of time. The successful integration of large amounts of solar generation into the nation's electrical grid will initially require the ability to manage these intermittencies with fueled, dispatchable generation source. TEP provided short time frame, high resolution solar generation data for researchers to use in characterizing the frequency domain behavior of utility scale and large commercial scale solar generation. The conclusion was that solar generation is far more variable than wind generation and different tools for intermittency management will be needed to successfully integrate large amount of solar into the grid as compared to wind.

- Electric utilities must keep a balance between generation output levels and load requirements within very tight tolerances on very short time scales, continuously, in the absence of economic and reliable energy storage technologies. To perform this balancing act, utilities rely heavily on the controllable characteristics of dispatchable generation resources. These resources provide capacity value to electric utilities. Time variant generation resources such as wind and solar do not provide the same controllable characteristics as fossil fueled generation. A method for evaluating the capacity value of solar generation to utilities, that is acceptable to utilities, has not yet been proposed. This project is to develop a method of solar capacity value to utilities that is acceptable to utilities.

- Solar inverters must currently meet the requirements of IEEE-929/1547 to be interconnected safely to the electrical grid. While the standard does provide for safe interconnection conditions, the standard also forces inverters to disconnect from the system at times of low voltage or frequency where additional reductions in generation pose an additional threat to electrical grid stability. While this is not a problem at current levels of solar generation penetration, as the number of solar generators installed increases over time, this is expected to result in reduced grid reliability. The solution is very easy to implement, but there is a need for reliable data for use in determining the changes to be proposed in the new standard and in proposing the inverter changes needed to implement the new standards.

Table 7 - *Identified Needs for Future Research*

Name	Need	Purpose	Status/Proposed solution/Relevant Party
Roger Angel, Eric Betterton, University of Arizona	Integrated plan for conversion of US electricity from fossil fuel to solar. Predict thermodynamic efficiency of coupled solar generating/ storage/transmission systems	In order for solar power to largely replace fossil fuel in the US, storage systems and high power transmission lines will be needed from Arizona and the Southwest across the nation. Calculate optimum combination of coupled source/ storage/transmission systems	Technical solutions need to be worked out, (UA, ASU) then State action to reserve sites, and Congressional action on transmission corridors, similar to the creation of the Interstate highway system.
Roger Angel University of Arizona	Low cost solar to electric conversion at scale of US electricity consumption	Research into concentrator optics and tracking systems as described in previous table	Research started at UA
Roger Angel, Eric Betterton, University of Arizona	Sunshine survey	Determine complementary sites in Arizona to ensure best uniformity through the seasons and weather, and proximity to pumped storage locations. Use cloud resolving model climatology to determine most efficient geographical locations for placement of systems of solar collectors to maximize solar electricity delivery from a geographic region.	The current U.S. Solar Map (NREL) is based on 15-year old data and has a maximum resolution of only 40km x 40km. We need to develop a high-resolution (2 km) solar climatology for Arizona to better select solar farm sites and associated storage systems. The UA runs high-resolution daily weather forecasts that could be used to generate a climatology.

Eric Betterton University of Arizona Atmospheric Science	Predict operational loads	Use weather model's temperature, solar irradiance, and humidity to drive a simple secondary power load model to forecast peak and total daily power needs. Prediction of solar output on short (minute to minute) and medium (day ahead by hour) as well as long term (month ahead by hour) time frames.	Discussions have begun between TEP and U of A regarding prediction methods.
Ardeth Barnhart C-Trade	Locations for solar fields	We need places to build solar generating stations	BLM land o Federal land – no need to buy it o Problem is there are no transmission lines *(Use the sites of existing power plants with available large open areas and existing transmission lines for utility scale solar generation stations. –TEP)*
Valerie Rauluk Venture Catalyst	Renewable energy grid integration	Identify the benefits of distributed PV generation Identify the dollar value	Create a project for Southern Arizona and get it funded, then study it. *(TEP has a DOE-SAI grant in 2007-2008 to perform such research. –TEP)* The TEP project is a good start but it only begins to scratch the surface of the value of DG. DG value assessment to the entire grid is essential to more appropriately set rates for partial requirements, buy-back rates, and more effectively assess any cost factors allocated to DG, netted by the benefits. (Vecat)

Valerie Rauluk & Bud Annan Venture Catalyst	Microgrid Research	Microgrids could allow substantial deferrals of new generation, transmission and distribution infrastructure, while simultaneously enhancing the reliability and security of the existing power system network when coupled with energy storage, high-performance power electronics, load management, and real-time communication with the larger-scale grid. (Vecat)	Formulation of suitable interconnect standards and their implementation techniques. Investigations of capacity value of PV with energy storage and methods to maximize this value. Design of digital control strategies for the power electronic system to implement the new interconnect requirements. Development of required communication techniques and protocols. (Vecat)
Tom Alston American Solar Electric	Dispel the myth that reliance on distributed generation could lead to blackouts	There is a common thought that if the power grid were widely supported by PV modules on residential homes, and there was a cloudy day while it was still very hot, that there wouldn't be enough electricity generated to serve the needs of the city. This is a barrier to the expansion of distributed generation.	Do research around the world to see if this has actually ever happened. *(TEP does not consider this an immediate <5 year> barrier to solar generation and is involved in research to find tools, including energy storage technologies, to prevent this from becoming a long term barrier. –TEP)*
Tom Alston American Solar Electric	Study using hybrid automobiles as batteries	This would change how distributive generation would work – many homes would now have batteries instead of pushing power back on the grid.	*(In progress by TEP and other utilities as part of an energy storage portfolio. Smart Grid technologies are needed to successfully enable this source of storage. –TEP)*

Dennis Dickerson Pima Association of Governments	Create a loan system for investing in solar energy	The main problem with installing solar systems is the upfront cost. It is easy to get a loan for a car – why not have a system that is just as easy for solar?	
Tom Hansen Tucson Electric Power	Ancillary Services	Solar generation should provide power factor support, droop support (frequency compensation with output delta control), spinning reserve and other ancillary services through additional software functionality and short term energy storage integrated into the PV inverters. Inverters should also support remote control of power output and protection characteristics.	Smart Grid technologies are needed to enable this goal. DOE is expected to issue additional grant opportunities in this area in late 2007. TEP, U of A and DOE all have opportunities for research in this category.
Tom Hansen Tucson Electric Power	Solar generation data	Needed to improve lifecycle cost estimates for solar generation technologies as they become competitive with fossil fueled sources.	Ongoing effort by all solar equipment manufacturers, utilities and solar owners.
Eric Betterton University of Arizona	Green building research and integration	Solar energy research should include investigation of the demand side, i.e., energy efficient buildings.	John Wesley Miller, UA Geography Department introducing new Planning degree.

Marshall Magruder Santa Cruz County Energy Commission	Green Building standards	Need to integrate residential and non-residential solar electric and heating permitting with building structure and equipment energy efficiency.	Take national standards such as National Association of Home Builders Green Building standards and LEED standards, and adjust them to fit the climate and environments of Southern Arizona. Integrate these and more effective permitting to create “total building synergy” with much better construction, better energy efficiency (lower demands), and less costly required generation needs.
Marshall Magruder Santa Cruz County Energy Commission	Solar Permitting	Need to make permitting procedures and specifications consistent across Southern Arizona.	Evaluate current permitting throughout Southern Arizona agencies and find a model program that can be introduced to the others. Plan a conference with all parties to provide resources and training.
Ardeth Barnhart C-Trade	Research into Compact Linear Fresnel Reflector (CLFR) deployment	Lower temperature, lower cost, minimum ground usage array that is not dependent on fossil fuel equipment and can be used as energy production for desalination plants	Currently being developed by Ausra Inc. in the United States with proven use in high solar radiation, low water resource areas such as Australia
Ardeth Barnhart C-Trade	Firming the Solar, increasing dispatchability (see Lane Garrett below)	Conduct research into the use of biodiesel and biomass generators, firefly and lithium-ion batteries and plug-in hybrids for storage and back-up systems	Partner with Federal research laboratories on research
Lane Garrett ETA Engineering	Make power firmer	“Firm power” means that power can be reliably provided.	The long term solution is cost effective, reliable, efficient direct electrical conversion energy storage.

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Global Solar – Host of April 27 Solar Energy Roundtable
Pima Association of Governments – Host of the June 1 Solar Advisory Council Meeting
Arizona Builder's Alliance – Host of the June 15 Work Group Meetings
Hon. Shirley Scott – Host, July 5 *Solarfest*
Hon. Karin Uhlich – Host, July 13 Work Group Meetings
Hon. Nina Trasoff – Host, August 17 Work Group Meetings
University of Arizona – Host, August 22 Solar Advisory Council Meeting

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