Arizona Solar Electric Roadmap Study

Executive Summary

January 2007

ARIZONA DEPARTMENT OF COMMERCE
Our Job is JOBS!

Prepared by

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Table of Contents

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List of Figures

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1. Background

The Arizona Department of Commerce (ADOC) has the legislated responsibility to develop a 10-year economic plan for the state of Arizona (AZ). In its role as AZ's strategic economic research and initiatives entity, the Commerce and Economic Development Commission (CEDC) commissioned this project to help inform the strategy for future business development in the solar industry. Solar (along with water and sustainable manufacturing) was identified in the 2004 "Sustainable Systems Prospectus" as an "economy defining" industry opportunity for AZ based on the R&D strengths of its university system and building on its presence as one of three solar labs in the world.

Several international solar energy companies have recently expressed interest in AZ due to the number of days of sunshine and the existing solar electric infrastructure. AZ 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. The two primary goals of the project were to provide a framework that would:

- Accelerate the use and adoption of solar technologies in the market and applications to increase energy self-reliance, enhance energy security and protect the environment in AZ, and
- Describe the conditions that could enable AZ to move toward a leadership position in the research, development, manufacturing and deployment of solar technology by adopting the recommendations and potentially designing a series of demonstration activities.

The project objectives were to:

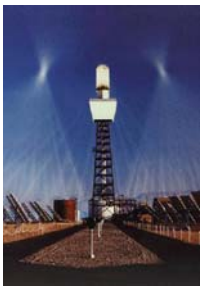
1. Describe the necessary conditions for the solar electric industry to make investments in AZ that will result in widespread solar electric deployment of:
   - centralized generation, distributed generation, building practices, local infrastructure support, workforce development, manufacturing and research
2. Describe and recommend the environmental conditions and policy options that will assist AZ in choosing the optimal portfolio of solar electric energy options
3. Review the potential to increase jobs in solar energy

2. Existing Solar Policies

Solar electric technologies are in various stages of development and require various incentives levels to be competitive. Navigant Consulting, Inc. (NCI) was hired by the ADOC to first assess the compositeness of several solar options. NCI reviewed five central station solar technology options: parabolic trough, solar Dish, power tower, concentrating photovoltaics (PV) and flat plate PV, Figure 1 and two customer sited technology option: residential building and commercial building applications, Figure 2.

Parabolic Trough

Solar Dish



Power Tower

Concentrating Photovoltaics

Flat Plate Photovoltacis (single-axis tracking)

Figure 1. Central Station Solar Power Options Reviewed

Residential

Commercial

Figure 2. Customer Sited Solar Power Options Reviewed

The PV options convert sunlight directly into electricity, whereas some of the other central power options concentrate solar energy onto heat transfer fluids to generate heat for use by a turbine generator or heat engine.

NCI assessed both state and Federal policies that would impact the economic viability of each of these solar technologies from 2006 through 2025. As shown in Figures 3 and 4, there are many Federal, state, and utility incentives for solar technologies.

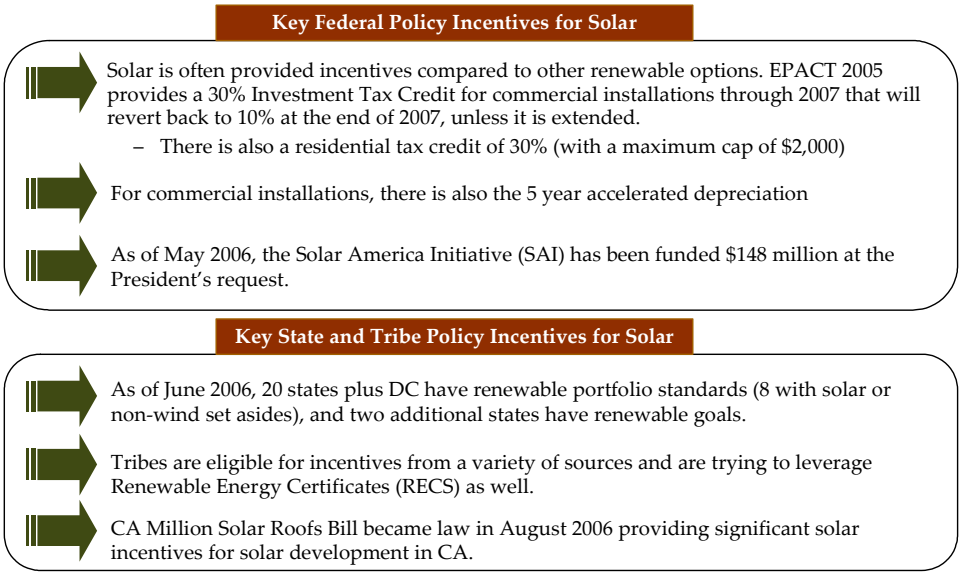


Figure 3. Key Federal, State and Tribe Solar Incentives

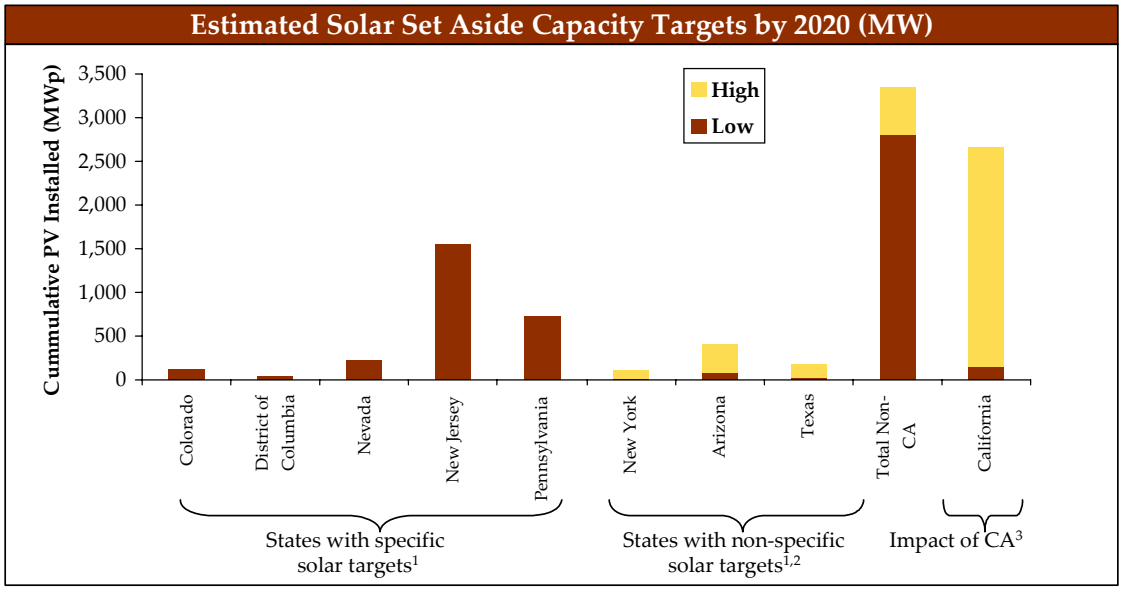
Utility Incentive	Incentive Amount	Comments
APS Solar Partners Incentive Program (PV and SHW)	• $3/W for residential and $2.50/W for commercial grid connected • $2/W for off-grid <5 kW • $.50/kWh for SHW	• Total cap per customer per year is $500,000 • $8.5 million total available for 2006
SRP EarthWise Solar Energy (PV and SHW)	• $3/W for residential and commercial PV up to 10 kW • As of July 5, 2006 the incentive level will be $2.50/W for PV systems >10 kW • $.50/kWh for SHW	• Maximum size for PV residential is 10 kW • Maximum amount of credit is $30,000 for residential and $500,000 for commercial
TEP SunShare PV BuyDown	• $2/Wpac Option 1 customer purchase • $2/Wpac Option 2 if purchased from TEP • $2.4/Wpdc Option 3 if customer purchased and operational within 180 days after receipt of agreement	
UES SunShare PV BuyDown	• $2.4/Wpdc for 1 – 5 kW if installed in 2006 for residential and commercial systems	• Incentives available for up to 50 kW of solar per year
Net Metering	• 10 kW for SRP • 10 kW for TEP (500 kW in aggregate)	

Figure 4. Key AZ Utility Incentives

Arizona Incentive	Incentive Amount	Comments
State Income Tax Credit	• 25% up to $1,000	• For residential only • Applies to all solar technologies (PV, SHW, and CSP)
Sales Tax Exemption	• Full sales tax exemption for solar energy systems	• Part of the recent HB2429 bill
Commercial Tax Credit	• 10% commercial tax credit capped at $25,000 per system and $50,000 per company annually	• Program capped at $1 million. Part of the recent HB2429 bill
AZ Enterprise Zone	• $3,000 for each net-new qualified employee over a 3-year period for a maximum of 200 employees in any given tax year. • A reduction of assessment ratio from 25% to 5% of all personal and real property for primary tax purposes for 5 years	• An effort to improve economies of designated areas in AZ by enhancing opportunities for private investment.
Property Tax Exemption	• Full property tax exemption for property owners installing solar energy systems	• Part of the recent HB2429 bill
Interconnection	• ACC is developing a statewide interconnection standard, but this is still in progress	
Job Training Program	• Provides grant money to companies creating full time permanent new jobs or training for existing worker within AZ	
AZ Workforce Connection	• Provides free services to employers who seek access to skilled new hires or existing worker training resources	

Figure 5. AZ State Level Incentives Applicable to Solar

As shown in Figure 3, there are 20 states that have renewable portfolio standards (RPS) and eight with solar or non-wind set asides. These RPS require that a certain percentage of new or existing generation come from renewable energy resources. NCI estimated the impact of the eight solar or non-wind set-asides could result in between 3,000 – 6,200 MW of new solar installed capacity by 2020, Figure 6.



Source: Navigant Consulting Analysis, 2006

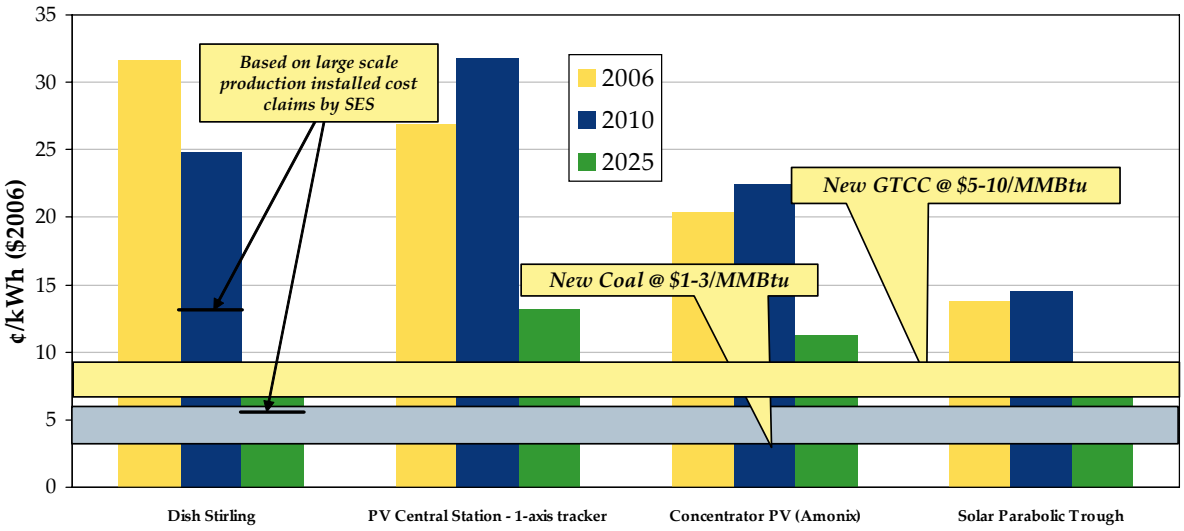
1. States have either specific solar targets as a % of generation or MW, or solar can be part of a non-wind set-aside or a DG set-aside. 2. Solar assumed to capture the following % of the state's RPS target: 0.2%-1.0% for NY, 1%-5% for TX, 3%-15% for AZ. For AZ, the 15% RPS target is assumed to have passed. 3.Lower bound for CA assumes installations stall at the 2005 installed capacity level. Upper bound assumes latest CA solar initiative is met.

Figure 6. Solar Set Aside Capacity by 2020

3. Likely Market Penetration of Solar in AZ

Central Station Solar System Economics

NCI estimated the likely market penetration of solar for customer and central station applications. NCI reviewed the economics of each of the technology options from 2006 through 2020. From conversations with experts in the field, NCI and the Steering Committee[1] for the project determined that the Power Tower options were unlikely to be competitive in the timeframe of interest and that the development risks were currently too high to be considered for detailed analysis. NCI therefore focused the central station analysis on the four other central station power options. As shown in Figure 7, central station power options are not currently competitive with a new gas turbine combined cycle (GTCC) plant (assuming $5 – 10/MMBtu gas prices) or a new coal plant (assuming $1 – 3/MMBtu coal prices).



Note: All cost estimates exclude additional revenue from renewable energy certificates. New Coal will generate electricity at 3.7 to 5.6 cents/kWh and new Gas Turbine Combined Cycle (GTCC) at 5.7 to 9.2 cents/kWh. LCOE includes 10% ITC and accelerated depreciation, and 30% ITC for 2006. NCI analysis using data from NREL in 2006 and Bob Liden, Executive VP and General Manager, Stirling Energy Systems, for Dish Stirling, September 19, 2006.

Figure 7. Comparative Economics of Central Solar Power Options

The levelized cost of electricity[2] (LCOE) for many of the central station options ranges today from about $.14 - .20/kWh with Federal incentives. This compares to the cost of a new GTCC

[1] The Steering Committee members are listed in the Appendix of this report

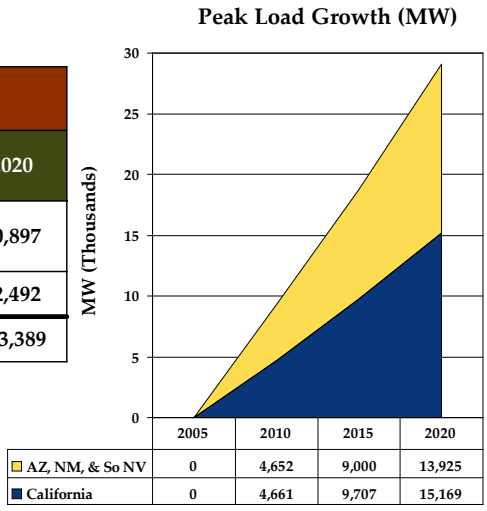
[2] The LCOE is the required selling price to cover all project cost over the project life, expressed in constant dollars (i.e., the revenue requirement). LCOE focuses on costs, not market prices and is the busbar cost of electricity and does not include transmission or distribution costs.

at $.057 – $.092/kWh. By 2010, the costs are shown to increase, as one of the major incentives for solar, the 30% Investment Tax Credit (ITC) is due to revert back to its previous 10% level at the end of 2007. Dish Stirling technology is the only central station application noted to reduce in price, as there have been significant claims about increases in production volumes that could help to provide economies of scale. Stirling Energy Systems (SES), a leading manufacturer of the technology has Power Purchase Agreements (PPAs) with two leading utility companies in California. One is with Southern California Edison (Edison International) for 500 MW with a 350 MW option and the other is with San Diego Gas & Electric (Sempra) for 300 MW with a 600 MW option. Using installed cost estimates provided by SES for 2010, NCI calculated the LCOE for the Dish Stirling technology at $.13 - .14/kWh in 2010.

Peak loads in the desert southwest states and California are forecasted to grow by nearly 2,000 MW per year for the next 15 years. As shown in Figure 8, there is significant peak load growth. Electric transmission is a critical link, however and under the current infrastructure, potential exports of solar to other markets are limited.

	Expected Peak Load (MW) 2005-2020			
NERC Sub-Region	2005	2010	2015	2020
AZ, NM, South NV	26,972	31,624	35,972	40,897
CA	57,324	61,985	67,031	72,492
Total	84,296	93,609	103,003	113,389

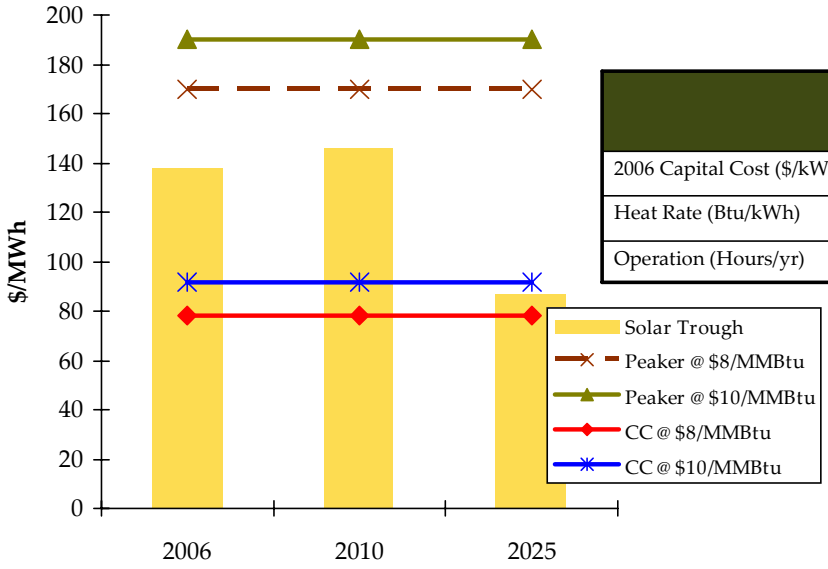
Peak growth in the desert southwest is forecasted to be nearly the same as CA.



Source: WECC, CA Energy Commission, NCI Analysis

Figure 8. Peak Load Growth in the Southwest

One of the main advantages of solar technologies is that they often generate power that is coincident with utility peak loads that are more costly. As shown in Figure 9, the cost of parabolic trough solar technology (as shown in the yellow bars in Figure 9) is less than the cost of peaking power today (the top two peaker solid and dotted lines in Figure 9). Trough technology costs will only become more cost effected relative to peaking unit costs as the cost of trough units are expected to decline by more than 50% by 2025.



	50 MW Peaking Plant	260 MW Combined Cycle
2006 Capital Cost ($/kW)	$500	$650
Heat Rate (Btu/kWh)	10,000	7,200
Operation (Hours/yr)	1,200	7,500

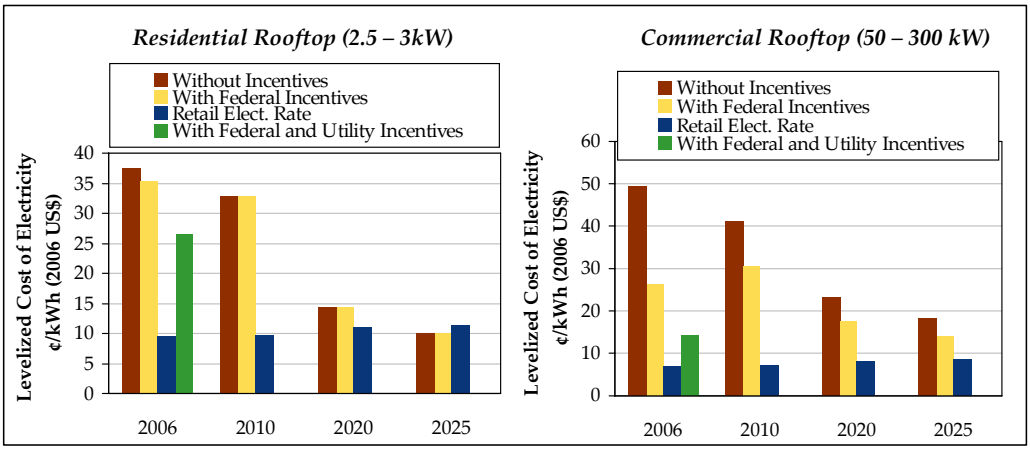
Note: LCOE for solar includes Federal Investment tax credit, and accelerated depreciation. 2010 and 2025 assumes 6 hours of storage.

Figure 9. Solar Trough Economics Relative to Peaking Power Options

Some of the disadvantages of solar are that it is an intermittent resource and the sun does not always shine. Peaking capacity may therefore still be needed to address the intermittency and some of the non-coincidence of solar output. On the other hand, solar provides a hedge against gas price volatility, allows the gas plant to use less gas and may therefore result in lower gas prices, reduces emissions, and by 2010 the trough technology may be able to have cost effective storage to provide six hours of storage.

Customer-Sited Solar System Economics

Residential PV economics, as shown in Figure 10, are currently 2 – 3 times more expensive than retail electricity rates provided by utility companies in AZ. Commercial PV economics on the other hand are currently more competitive as a result of the 30% ITC, 5-year accelerated depreciation, and other state incentives discussed in Section 1. Flat plate PV costs are expected to decline as shown in Figure 10 and the economics in the figure assume a business as usual cost reduction scenario. NCI also conducted an analysis assuming a cost breakthrough or incentives scenario that would result in more aggressive system price reductions.



Key residential assumptions without incentives: 100% debt, cost of debt = 6.25%, Insurance = 0.5%, Loan period = 10 years. Project economic life (for property tax calculations) = 25 years. Property tax rate of $11.70/$100 of assessed value. Electricity cost of .095$/kWh growing at 1%/yr. Key commercial assumptions (without incentives): Debt equity ratio: 55%:45%, cost of equity = 15%, cost of debt = 8%, Marginal federal + state income tax = 41%. Insurance = 0.5%, Depreciation under Modified Accelerated Cost Recovery System (MACRS): Depreciation period considered is 15 years. Loan period = 10 years. Project economic life (for property tax calculations) = 25 years. Property tax rate of $11.70/$100 of assessed value. Electricity cost of $.07/kWh growing at the rate of inflation. Retail elect. rates assume constant (real) 2006 dollars and a 1%/yr real increase through 2025. See more detailed discussion in Section 3 for with incentive assumptions. Note: The LCOE for residential is lower than for commercial building installations primarily as a result of cost of capital assumptions.

Figure 10. Customer-Sited Solar Economics

Market Penetration

In the accelerated cost reduction scenario, solar can result in 1,000 MW by 2020 and close to 2,600 MW of power by 2025, Figure 11, with rooftop PV accounting for 45% of the capacity.

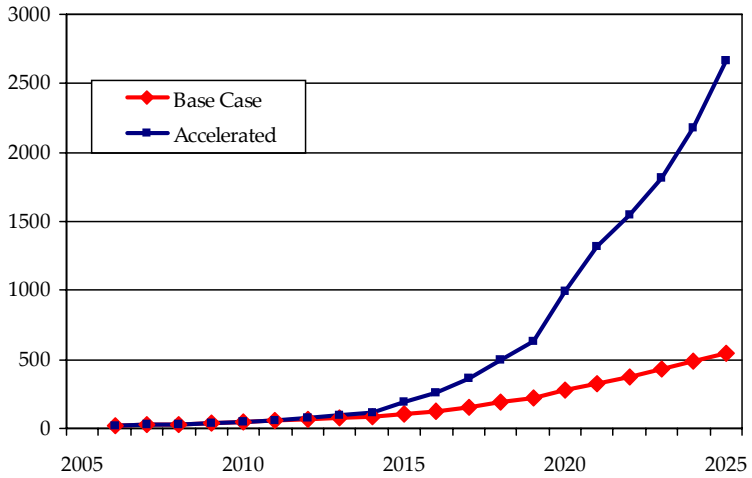


Figure 11. AZ Solar Deployment in MWs

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4. Potential Barriers and Opportunities for AZ

NCI conducted a series of interviews with key stakeholders in the state to determine the strengths and uniqueness of AZ for solar development. Below are some of the key points identified:

- AZ Corporation Commission provides proactive leadership on its Renewable Energy Portfolio Standard
- There is population and economic growth in the state
- AZ has an excellent solar resource for central and customer sited PV along with large areas of land for potential development
- AZ has high dependence on gas which has a volatile price
- The location is ideal and central to key nearby solar markets (TX, CA, NV, CO, NM)
- State Trust Lands and tribal lands may be used for large scale solar developments
- There are competitive labor costs and tax rates
- ASU Poly PV certification capability is only one of three in the world (the other two are in Northern Italy and Germany)
- ASU hosts the Power Systems Engineering Research Center, a consortium of 13 universities and 39 companies which is funded by the National Science Foundation
- There will be funds available for solar close to $1.2 billion from the Renewable Energy Standard (RES) through 2025 ($60 million per year)
- ASU has very good assets that can be leveraged such as its clean room, and monitoring and evaluation equipment
- UA has very good assets that can also be leveraged such as its R&D on 3rd generation solar cells, clean rooms and characterization equipment
- The STAR facility evaluates emerging technologies (there are only two others in world: Weizmann Institute in Israel and Australian National University)

There are however, many potential barriers to solar development in the state:

- The capital cost of the solar technologies are very high
- Some solar technology immaturity
- Other countries provide significant solar incentives that could draw solar development elsewhere
    - Tax holidays (personal and corporate); free land; reduced power rates; access to water and plant cost subsidies of 30 – 45% in locations such as Germany
- Lack of PV educated human capital and infrastructure
- Low utility rates relative to other nearby states
- Lack of local strong markets (relative to other some other U.S. states)

- Competition from neighboring states (e.g. NM manufacturing incentives)
- Perception of the need for gas back-up with solar to address intermittency
- Local building codes that restrict solar develop
- Homeowner associations and restrictions on solar installations

If many of these barriers can be overcome, there is tremendous potential for jobs and emission reductions in the state. As shown in Figure 12, the accelerated development scenario for solar can potentially result in over 3,000 jobs in AZ in 2020.

Accelerated Scenario In 2020	Cumulative Capacity (MW)	Installations in 2020 (MW/yr)	Direct Manufact. (# Jobs*)	Installation/ Construction (# Jobs)	O&M (# Jobs)	Installation Labor Expenditure (Million $)	O&M Labor Expenditure (Million $)
Rooftop PV	250	115	450	1,800	75	243	4
Central Solar	742	143	60	429	233	54	26
TOTAL	992	258	510	2,229	308	297	30

*Assumes none of central solar components are manufactured in AZ, except for PV where 20 MW were assumed to be manufactured in state. Assumes that an additional 150 MW plant is in AZ for the rooftop PV market (some in state and some exported).

Source: Navigant Consulting, Inc. estimates, June 2006.

Figure 12. Potential Jobs from Solar Development

Emission reductions are also estimated at 400,000 tons per year by 2020 in an accelerated development scenario.

Accelerated Scenario	Cumulative Capacity (MW)	Average Capacity Factor (%)	Energy Delivered (MWh)	Total CO_2 Reduction (Tons)
Rooftop PV	**250**		**388,075**	**60,000**
• Residential	187	18.3%	299,775	
• Commercial	63	16%	88,300	
Central Solar**	**742**		**2,182,500**	**338,200**
• Trough	519	38%	1,728,000	267,800
• Dish Stirling	148	23%	299,000	46,300
• PV	37	25%	81,000	12,600
• Concentrating PV	37	23%	74,500	11,500
TOTAL	992	26.3%	2,570,575	**398,200**

*Assumes .31 lbs/kWh of CO2 are displaced for a Combined Cycle Gas Turbine in 2020.
** Assuming market shares of: 70% trough, 20% dish Stirling, 5% concentrating PV, and 5% flat plate PV based on economics.

Source: Navigant Consulting, Inc. estimates, August 2006.

Figure 13. Emission Reduction Potential in Accelerated Scenario in 2020

By 2020, the opportunities for solar can be significant in an accelerated development scenario. As shown in Figure 14, there can be >250 MWs per year of solar being installed that can result in close to 3,000 new jobs.

Figure 14. Opportunities for AZ with Solar Development

5. AZ Solar Roadmap

NCI's road-mapping process identified actions and recommendations based on the analyses of the market opportunities, competition, and barriers to solar development, Figure 15. NCI and the Steering Committee used this information to develop initiatives and policies for achieving the three initial project goals and ambitions.

Figure 15. Roadmap Process

Figure 16 lays out the major five initiatives identified to help meet the vision of achieving 1,000 MW of solar development by 2020, 3,000 new jobs, and a Solar R&D Center of Excellence. The five initiatives include:

- Establishing a Marketing and Outreach Program;
- Establishing a Solar Zone;
- Developing a Solar Center of Excellence;
- Establishing "Sustainable Partners"; and
- Building Large Central Solar Plants.

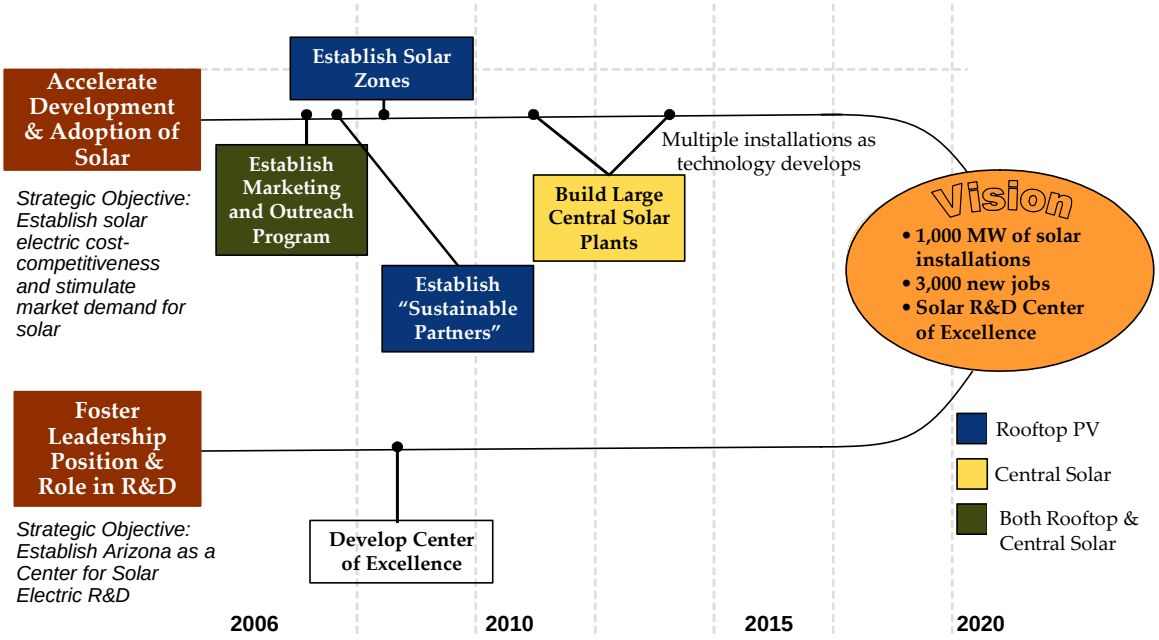

Figure 16. Five Key Initiatives for Meeting the Solar Vision

Four of the initiatives are focused on accelerating the development and adoption of solar, and one is focused on fostering a leadership position and role in R&D. The detailed milestones for each of the key initiates to help accelerate the development and adoption of solar are shown in Figures 17 and 18.

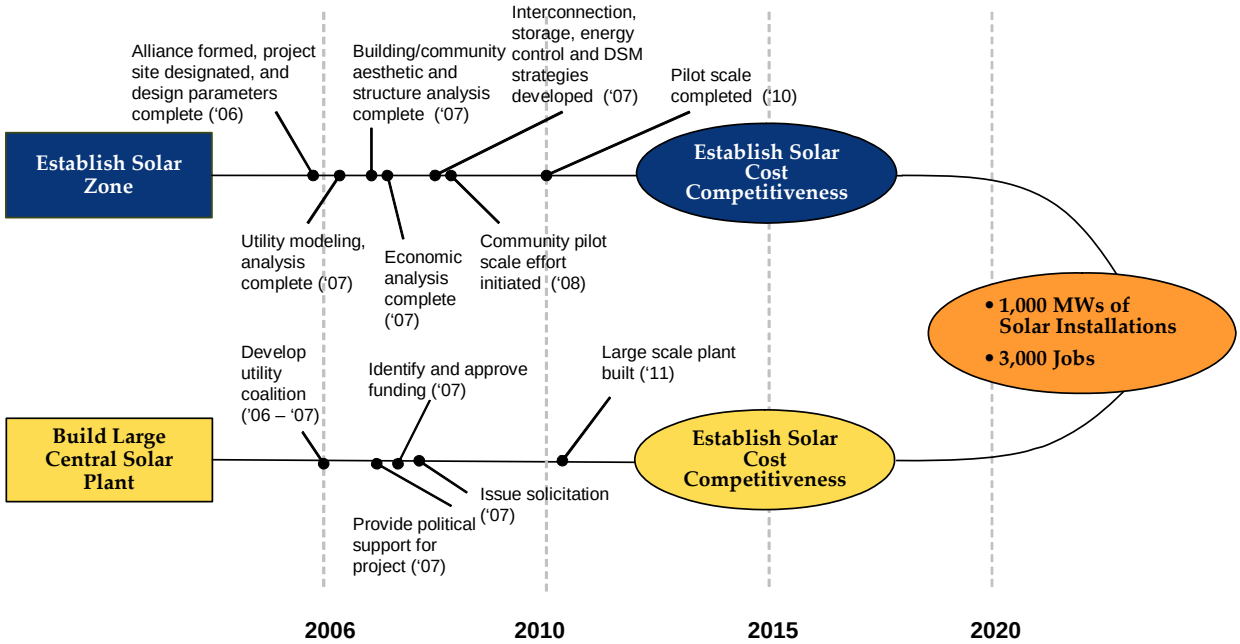

Figure 17. Key Milestones for the Solar Zone and Building Large Central Solar

The initiatives in Figure 18 that identify the milestones for "Establishing Sustainable Partners" and an Outreach and Education Program will help the development and adoption of solar through stimulating market demand and building awareness.

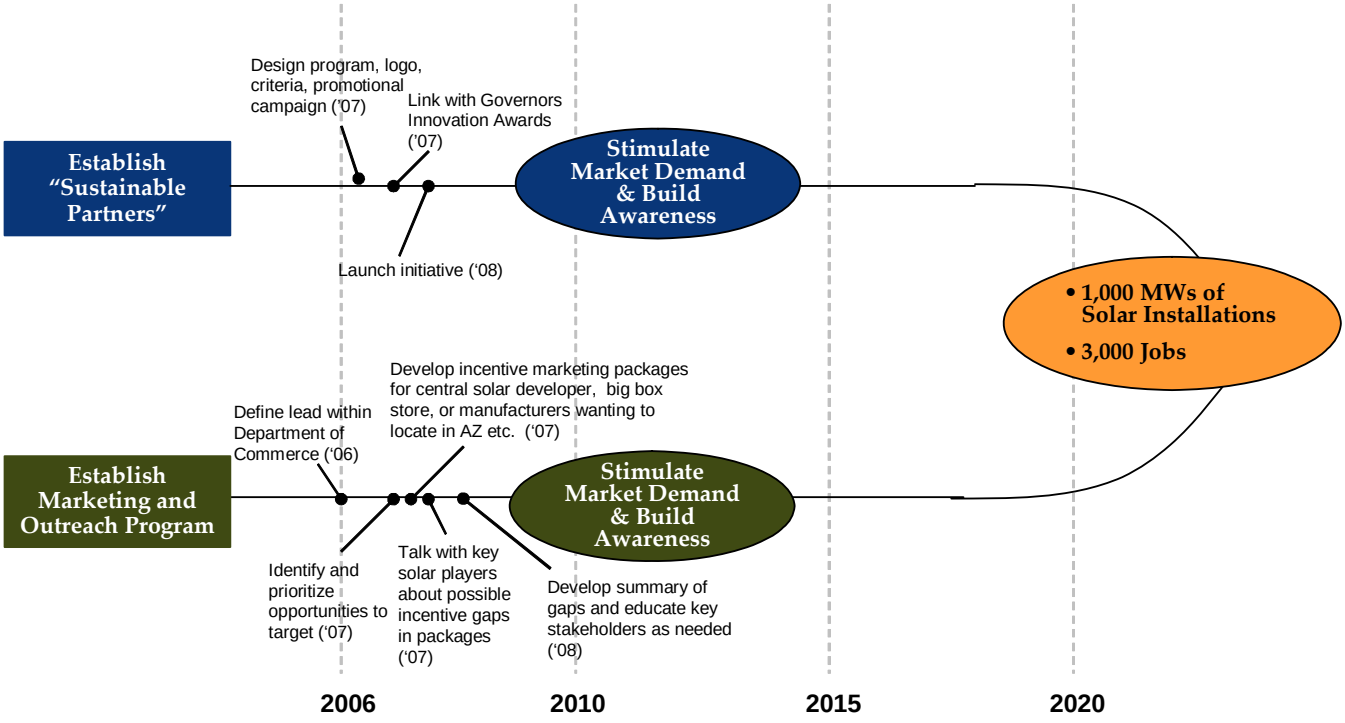

Figure 18. Key Milestones for Sustainable Partners and Marketing and Outreach

To foster a leadership position and role in R&D, the NCI team and Steering Committee members identified the milestones shown in Figure 19.

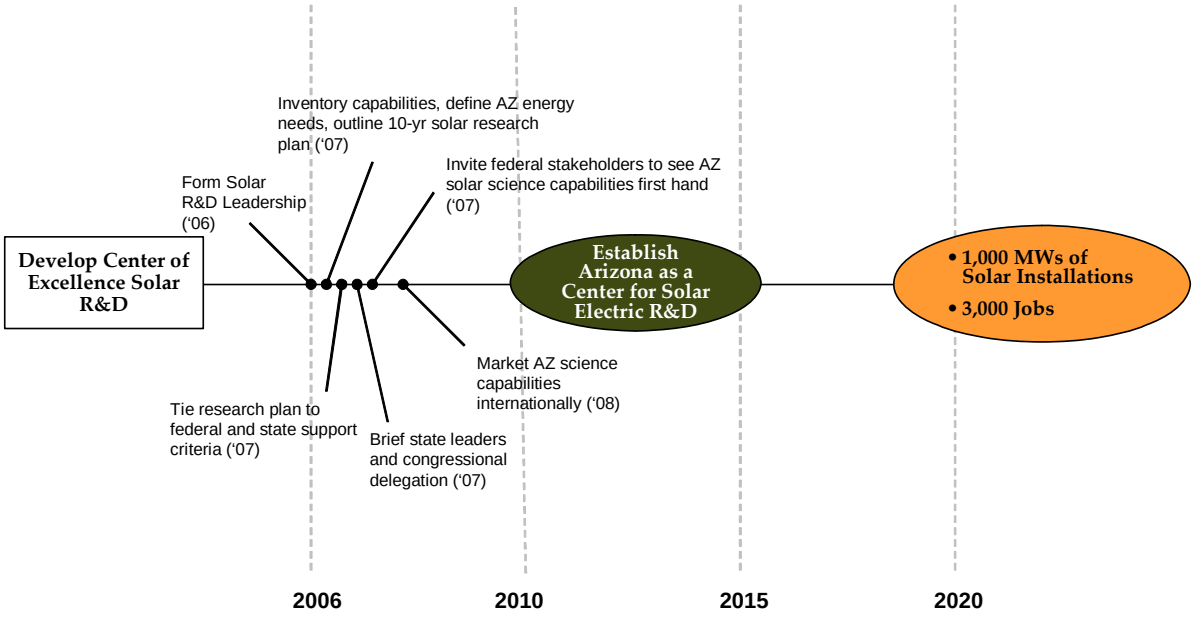

Figure 19. Key Milestones for Developing a Center of Excellence for Solar R&D

Implementing the roadmap initiatives above will allow AZ to build upon its assets and policies to establish a leadership position in fostering solar, Figure 20. The opportunities are significant if the state can take a leadership role in facilitating the activities that will leverage AZ's strong assets to help achieve the MW and job targets desired.

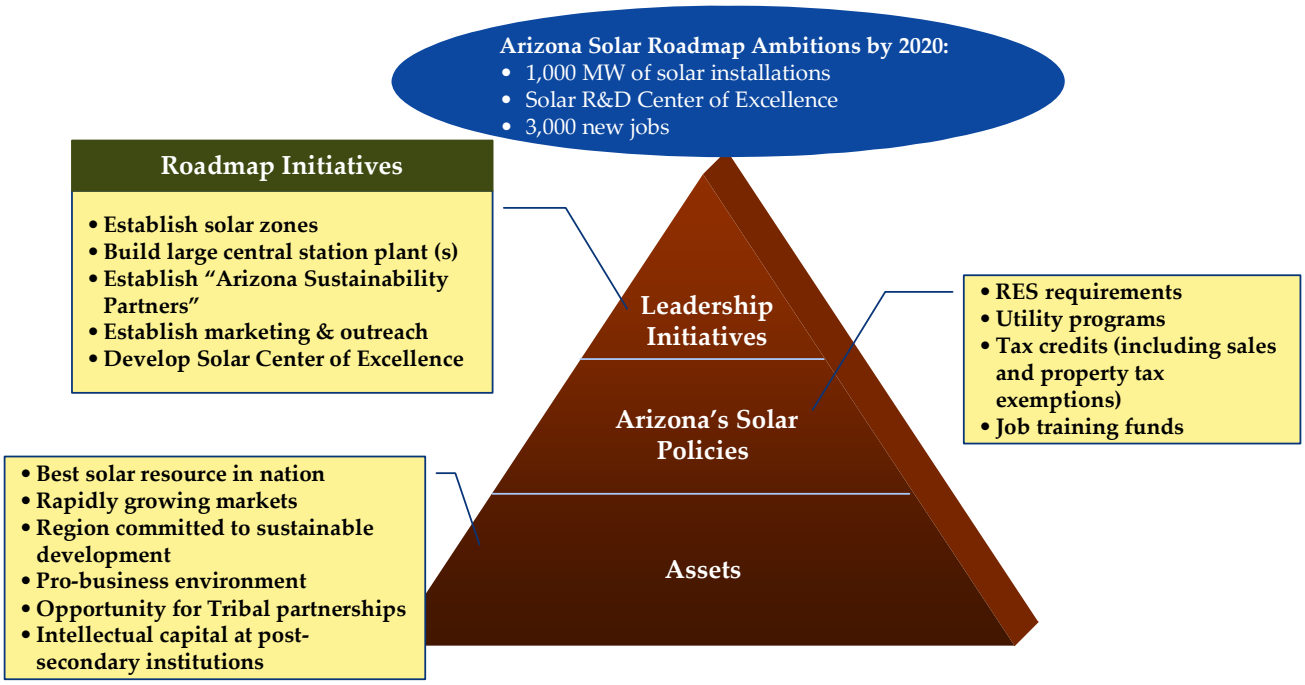

Figure 20. Foundation Elements for Achieving the Solar Roadmap Ambitions

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Appendix: Key Contributors to Report

There were four meetings that NCI held with the Steering Committee members listed in Figure 21. They provided valuable input throughout the process to ensure accuracy and completeness. NCI and the ADOC are thankful for their time and commitment to the project.

Name	Organization
Stephen Ahearn, Director	State Residential Utility Consumer Office
Bud Annan	Solar Energy Advisory Council
Chuck Backus, President	Arizona State University Research Park
Harvey Boyce, Director	Arizona Power Authority
Lee Edwards, CEO	BP Solar
Eric Daniels, President of Technology	BP Solar
Jonathan Fink, Vice President for Research & Economic Affairs	Arizona State University
Greg Flynn	The League of AZ Cities and Towns
Ed Fox, Vice President	Arizona Public Service
Barbara Lockwood, Renewable Energy Manager	Arizona Public Service
Peter Johnston, Manager Technology Development	Arizona Public Service
Chico Hunter, Senior Engineer	Salt River Project
Gail Lewis, Policy Advisor	Governor's Office

Figure 21. Steering Committee Members

Name	Organization
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Doug Obal, Director of Financial Analysis	Stirling Energy Systems, Inc.
Larry Lucero, Manager of Government Affairs	Tucson Electric Power
Todd Madeksza	County Supervisors Association of Arizona
Willis Martin, Vice President of Land Acquisition – Phoenix Area	Pulte Homes
Fred DuVal, Member	Commerce and Economic Development Commission
Leslie Tolbert, Vice President of Research	University of Arizona
Joe Simmons, Chair of Department of Materials Science and Engineering	University of Arizona

Figure 21. Steering Committee Members (continued)

In addition to the Steering Committee members, several staff from the Arizona Department of Commerce contributed their time and oversight on this project. Those key members are listed in Figure 22 along with the NCI contributors in Figure 23.

Name	Organization
Deb Sydenham, Assistant Deputy Director, Community Development	Arizona Department of Commerce
Lisa Danka, Assistant Deputy Director, Strategic Investment and Research	Arizona Department of Commerce
Kent Ennis, Research Manager, Strategic Investment and Research	Arizona Department of Commerce
Lori Sherill, Support Specialist, Community Planning	Arizona Department of Commerce
Jim Arwood, Director Energy Office	Arizona Department of Commerce
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Figure 23. Navigant Consulting, Inc. Contributors