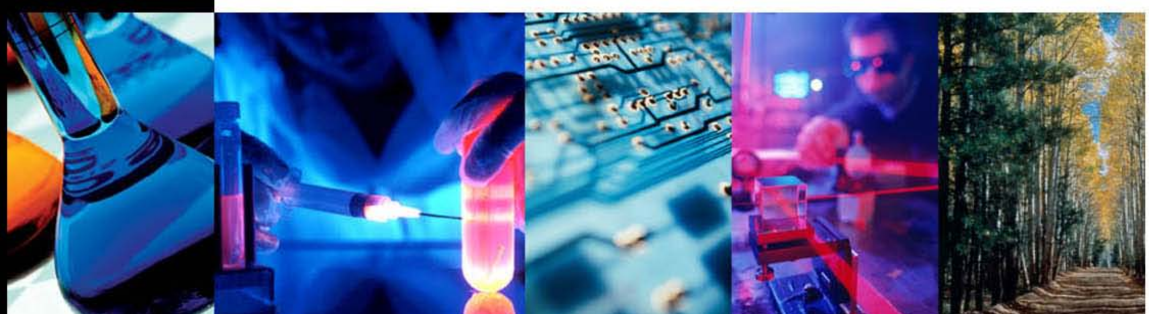
Arizona Solar Electric Roadmap Study

Full Report

January 2007



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The Arizona Department of Commerce (ADOC) has the legislated responsibility to develop a 10 year economic plan for the State of AZ.

Project Background

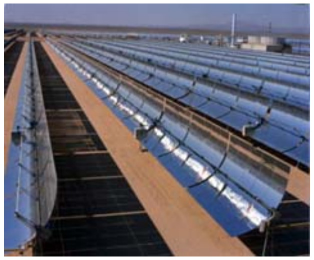
In its role as Arizona's strategic economic research and initiatives entity, the Commerce and Economic Development Commission (CEDC) commissioned this project to help inform the strategy for future business development in the solar industry. Solar (along with water and sustainable manufacturing) was 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. This roadmap is intended to provide a framework to make AZ a world leader in the research, development, manufacture and deployment of next generation solar electric technologies.

AZ wants to accelerate solar adoption, and develop a solar electric industry within AZ that would provide economic development.

Roadmap Goals

- 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 Arizona.
- Describe the conditions that could enable Arizona 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.





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There are three main objectives of the overall solar roadmap project.

Project Objectives
1. Describe the necessary conditions for the solar electric industry to make investments in Arizona 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 Arizona in choosing the optimal portfolio of solar electric energy options 3. Review the potential to increase jobs in solar energy

There are significant incentives available for solar at both the Federal and state level that can be leveraged to help stimulate solar adoption.

Key Federal Policy Incentives for Solar

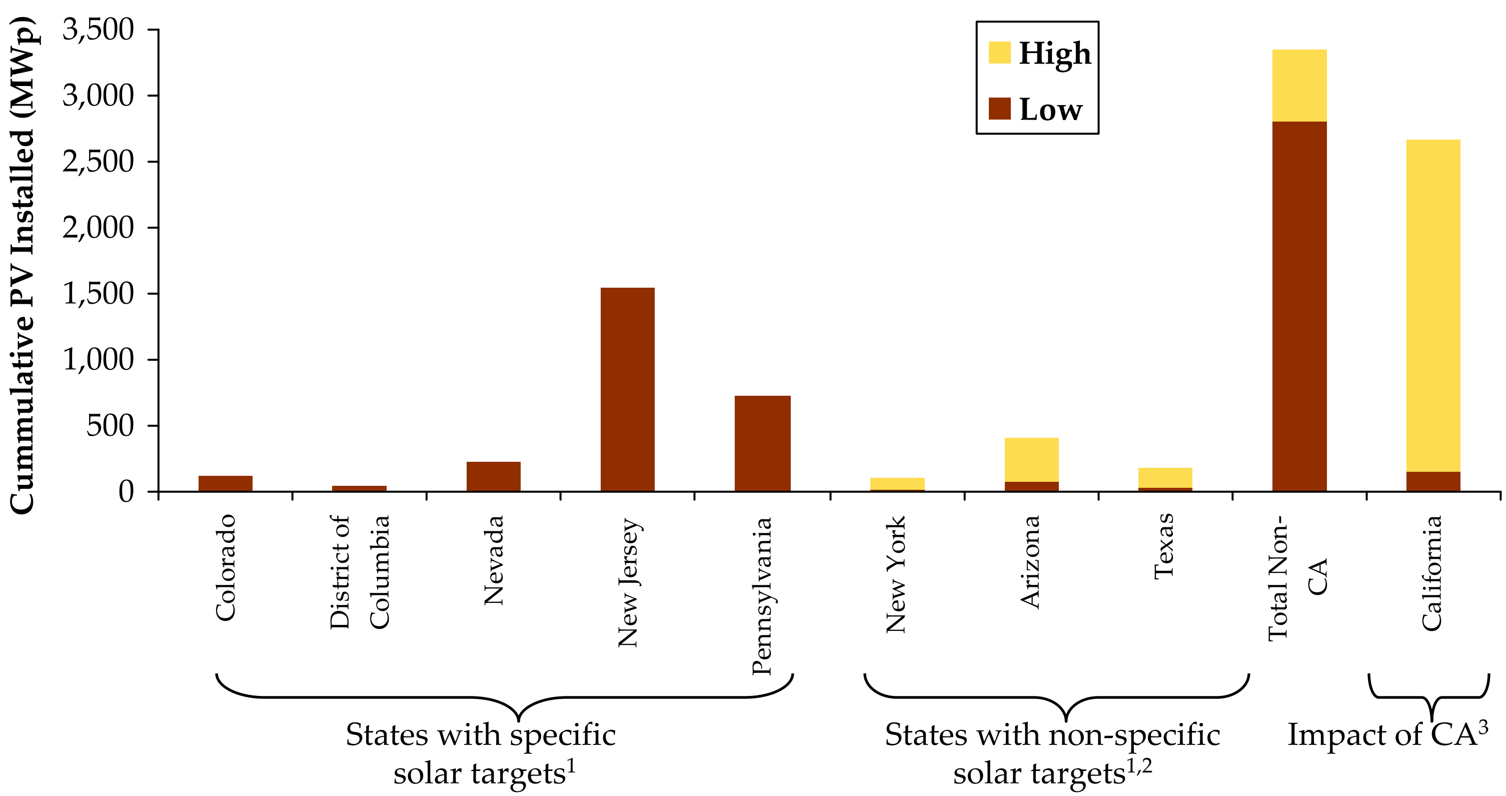
- Solar is often provided incentives compared to other renewable options. EPACT 2005 provides a 30% Investment Tax Credit for commercial installations through 2007 that will revert back to 10% at the end of 2007, unless it is extended.
  - There is also a residential tax credit of 30% (with a maximum cap of $2,000)
- For commercial installations, there is also the 5 year accelerated depreciation
- As of May 2006, the Solar America Initiative (SAI) has been funded $148 million at the President's request.

Key State and Tribe Policy Incentives for Solar

- As of June 2006, 20 states plus DC have renewable portfolio standards (8 with solar or non-wind set asides), and two additional states have renewable goals.
- Tribes are eligible for incentives from a variety of sources and are trying to leverage Renewable Energy Certificates (RECS) as well.
- CA Million Solar Roofs Bill became law in August 2006 providing significant solar incentives for solar development in CA.

RPS demand from solar set asides could result in 3,000 - 3,500 megawatts (MW) of solar without CA, and up to 6,200 MW with CA by 2020.

Estimated Solar Set Aside Capacity Targets by 2020 (MW)



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.

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Arizona incentives for solar are mostly provided by the utilities.

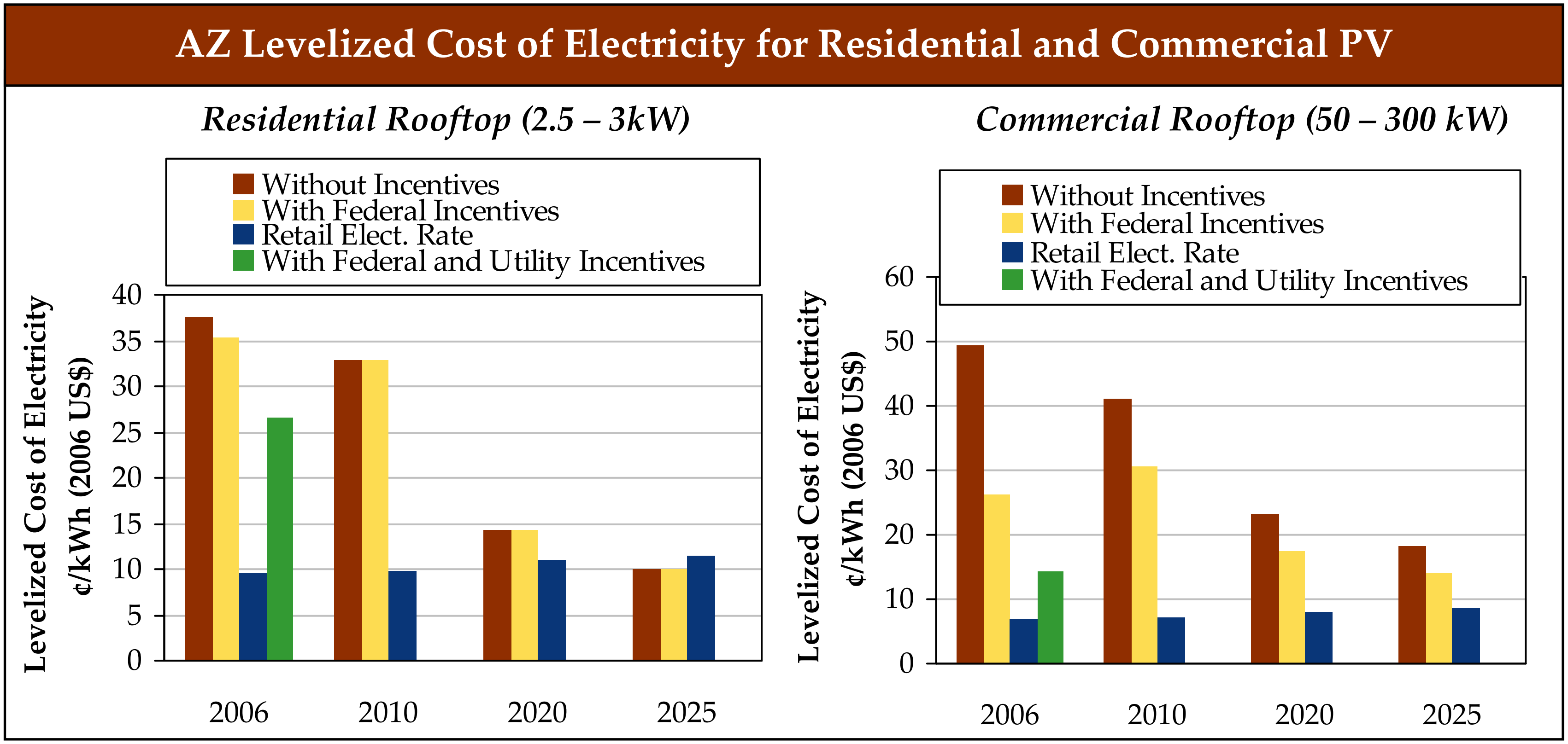
Key AZ Utility Solar Incentives		
Utility Incentive	**Incentive Amount**	**Comments**
APS Solar Partners Incentive Program **(PV and SHW)**	• $3/W for residential and $2.50/W for commercial grid connected • $2/W for off-grid <5 kW • $.50/kWh for SHW	• Total cap per customer per year is $500,000 • $8.5 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)	

The regulated utilities are currently discussing a uniform credit purchase program for solar through the ACC.

Some additional incentives are available at the state level.

Additional AZ State Level Solar Incentives and Other Related Programs		
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	

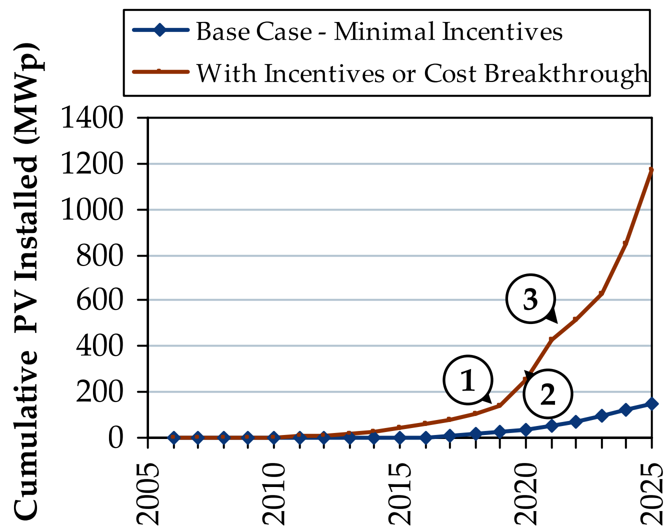
Currently, customer sited PV is more expensive than retail electricity, but future expected cost reductions will close the cost gap.



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.

With significant subsidies or cost breakthroughs, cumulative installations of rooftop PV by 2020 can be substantial.

AZ Rooftop PV Market Penetration (Residential + Commercial)



- Significant market penetration does not begin until payback rates drop below 10 years. This occurs in 2020 in the incentive/breakthrough case
- Installed PV could increase more rapidly after 2025 if prices relative to the grid continue to drop

Source: Navigant Consulting, Inc. analysis, September 2006.

Key Market Dynamics

1. Installations cross a tipping point as the payback period drops below 10 years. However, not all customers adopt immediately. Current payback levels are 35 years for commercial and 32 years for residential, with incentives.
2. Installations accelerate as 1) the payback period decreases – causing more customers to want to buy PV systems, and 2) time passes and adoption increases (the slow adopters actually adopt).
3. Installations decelerate slightly as the slow adopters have already adopted, and new installations are driven primarily by those who have waited for the price to continue to come down.

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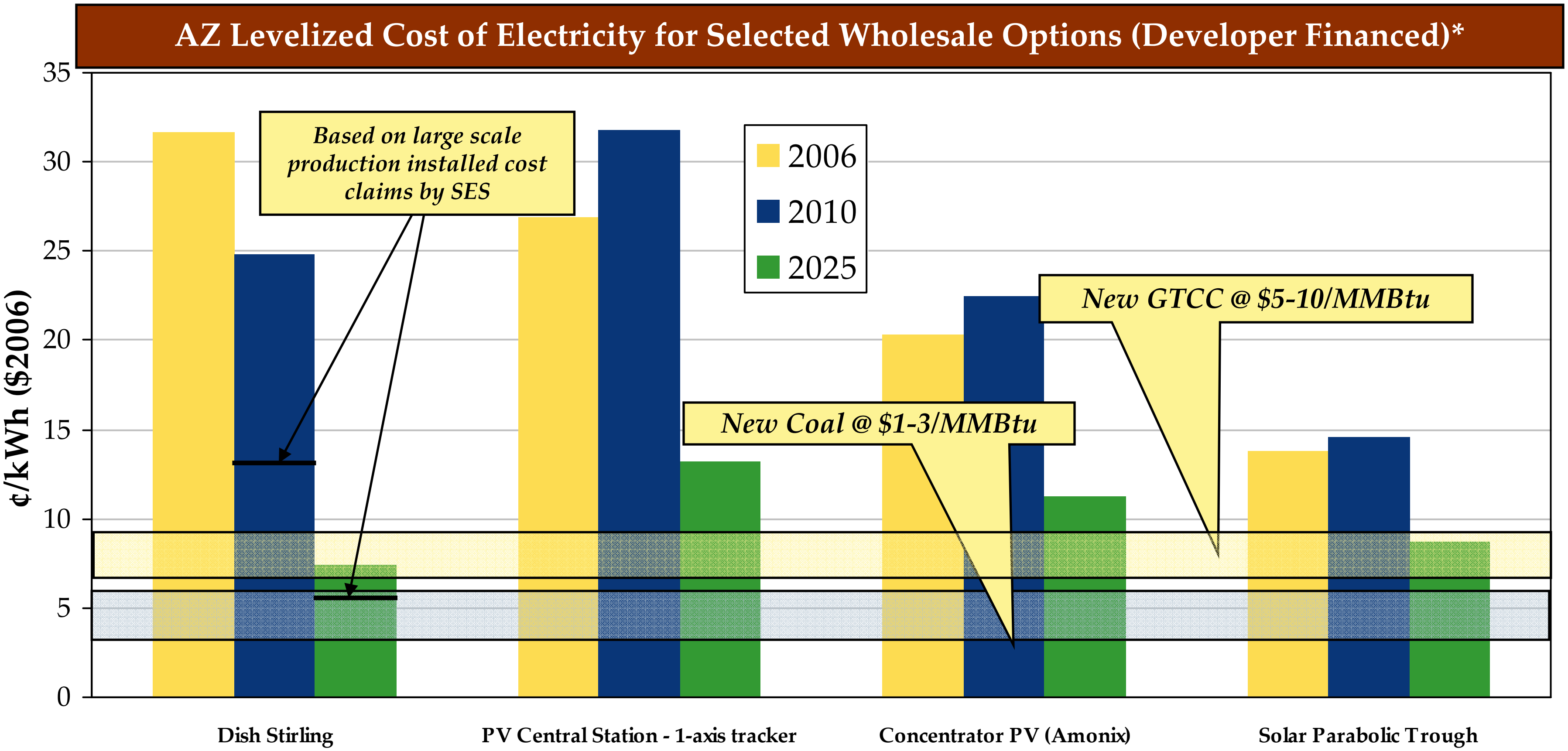
Technology improvements/cost reductions will allow central solar to compete with conventional baseload and intermediate generation.



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.

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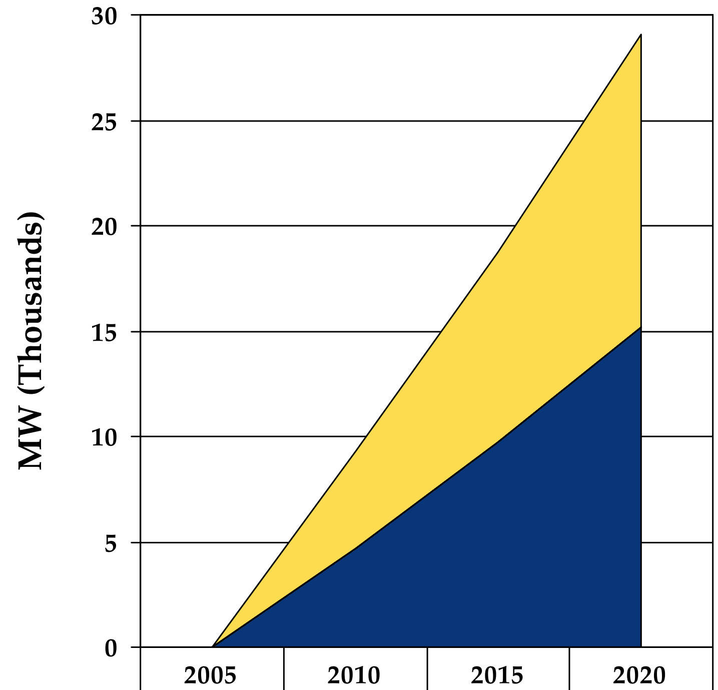
Peak loads in the desert southwest states and California are forecasted to grow by nearly 2,000 MW per year for the next 15 years.

	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.

Peak Load Growth (MW)

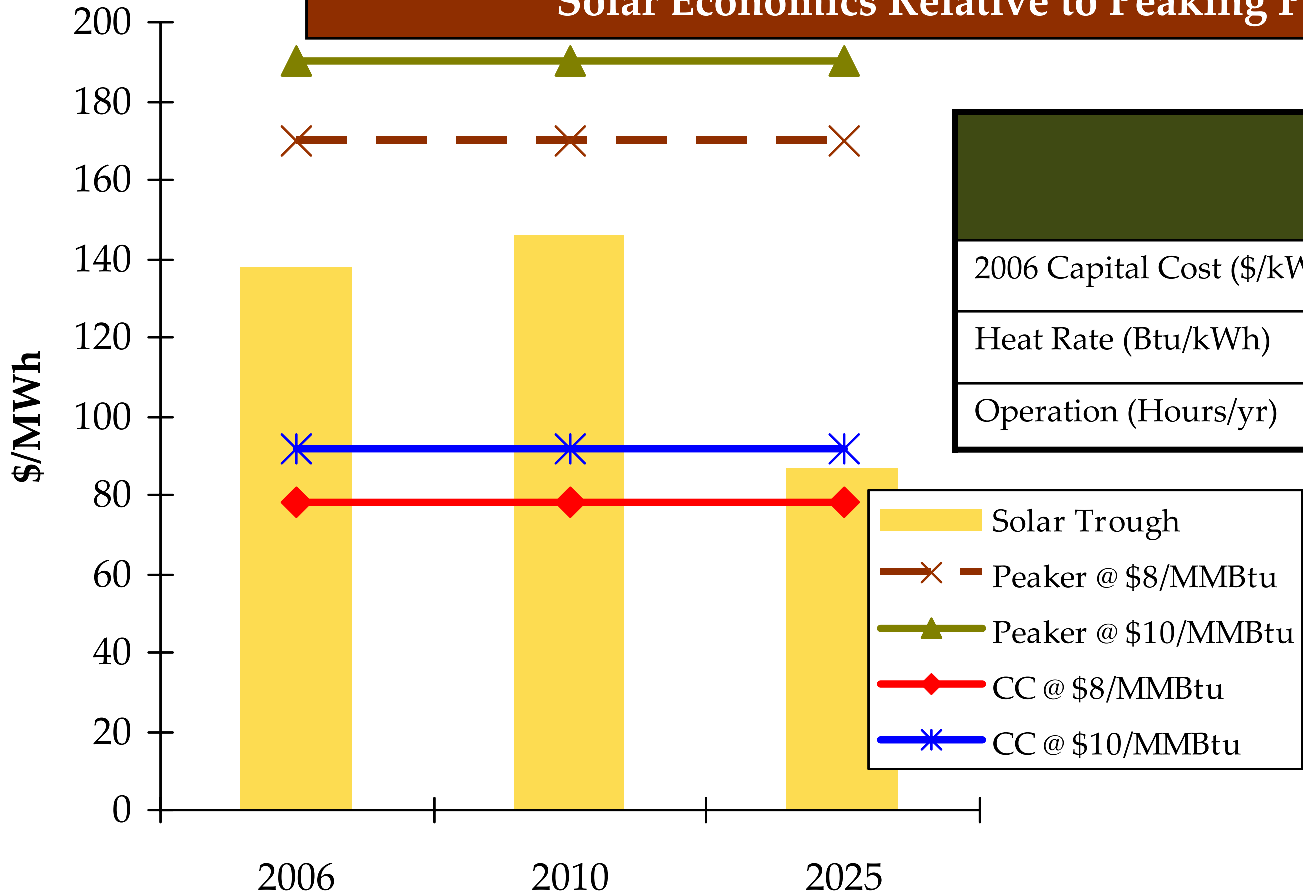


	2005	2010	2015	2020
AZ, NM, & So NV	0	4,652	9,000	13,925
California	0	4,661	9,707	15,169

Source: WECC, CA Energy Commission, NCI Analysis

Cost of electricity from parabolic trough is near the cost of peaking power today, with costs expected to decline by more than 50% by 2025.

Solar Economics Relative to Peaking Power



	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.

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However, the cost of electricity of solar is not directly comparable to the cost of electricity of peakers or combined cycle plants.

Discount Factors for Gas

- Solar output is comparable to a mix of peaker and combined cycle
- Peaker capacity has added flexibility to generate when needed
- Peaker capacity may still be required to address:
  - Intermittency
  - Non-coincidence of system and solar peak

Discount Factors for Solar

- Hedge value against gas price volatility
- Impact of lower gas usage upon average gas prices
- Value/compliance costs for emissions reduction
- Six hour storage capability built into post 2010 costs mitigate intermittency and non-coincidence issues

Two scenarios were developed for deployment of central station solar power through 2020.

	Base Case	Accelerated
Key Assumptions	• Business as usual • Central solar costs decline, but no breakthrough • Average gas prices remain in the \$7.00 to \$8.00/MMBtu range • Siting and transmission issues result in minimal export capability • Solar trough has 6 hour storage after 2010	• Early central station solar technology projects perform as planned, and costs decline as forecast • Average gas prices in the \$9.00 to \$10.00/MMBtu range • Greenhouse gas and other emissions add \$5/MWh to combined cycle costs • Transmission capability developed by 2020 to support an additional 200 MW of exports
Through 2015	Only modest deployment of central station solar in AZ under both scenarios, driven primarily by the state's RES	
Post 2015	• Central station solar continues modest deployment driven by RES	• Central solar captures 20% of the AZ capacity additions

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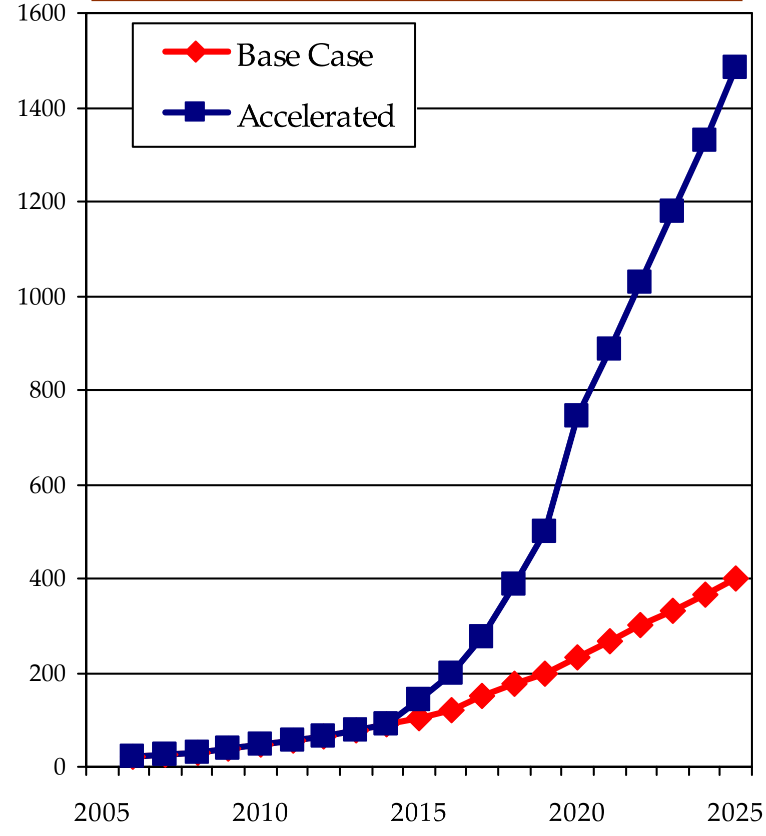
In the breakthrough scenario, central station solar deployment expands dramatically after 2015.

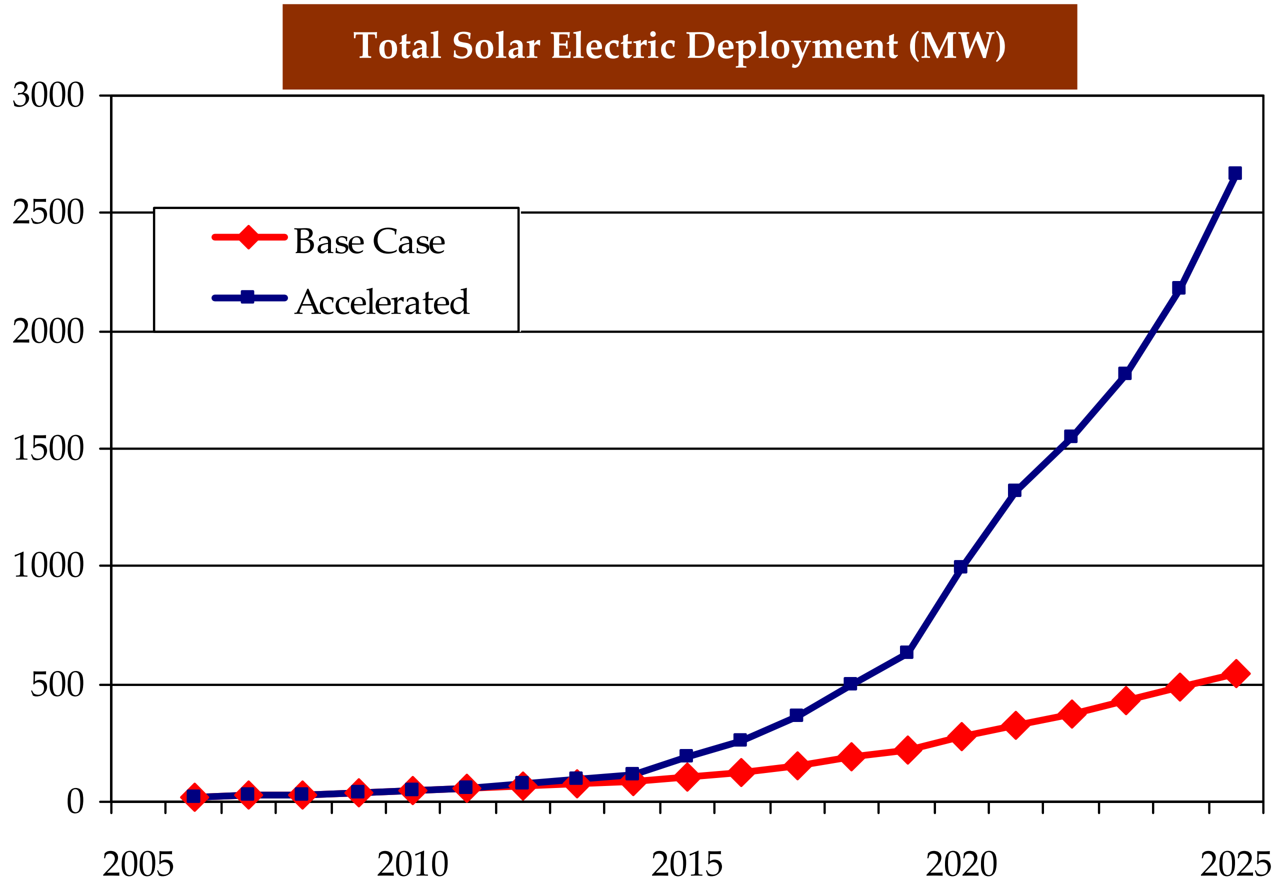
- Through 2015, central solar captures about 10% of the RES requirements in both scenarios
- For the Base Case, central solar continues to capture about 10% of the RES applied on a state-wide basis (~ 400 MW by 2025)
- In the Accelerated scenario about 10% of 2015 capacity are central solar, ramping up to 20% of capacity additions by 2020. In addition, slightly more than 20 MW is developed for export annually

Central Station Solar Deployment by Scenario (MW)



Source: Navigant Consulting, Inc. estimates, 2006.

Total solar deployment could exceed 2,600 MW in the accelerated scenario with rooftop PV accounting for about 45% of the capacity.



The accelerated scenario for solar could add over 3,000 jobs 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.

Total 2020 employment = 3,047 jobs for solar in an accelerated scenario

Emission reduction is estimated at 400,000 tons per year in an accelerated scenario in 2020.

Emission Reduction Potential in AZ (Accelerated Scenario in 2020)				
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.

There are many unique attributes in AZ that were identified in the interviews that were incorporated into the roadmap.

AZ Uniqueness & Strengths

- AZ Corporation Commission proactive leadership on its Renewable Energy Portfolio Standard
- AZ population and economic growth
- The excellent solar resource (high direct and diffuse solar radiation which is excellent for concentrating and flat plate PV)
- AZ high dependence on gas and its volatile price
- The ideal and central location of AZ to key nearby solar markets (TX, CA, NV, CO, NM)
- State Trust Lands and tribal lands could be used for large scale solar developments
- Competitive labor costs and tax rates
- ASU Poly PV certification capability is only one of three in the world (other 2 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
- Availability of funds close to $1.2 billion from RES through 2025 ($60 million per year)
- ASU assets (e.g. clean room, monitoring and evaluation equipment)
- UA assets (R&D on 3rd generation solar cells, clean rooms and characterization equipment)
- STAR facility for evaluating emerging technologies (only 2 others in world: Weizmann Institute in Israel and Australian National University)

Several barriers were also identified for large scale development of customer sited and central station solar.

- Capital cost
- Technology immaturity
- Significant solar incentives in other countries
  - 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 market (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
- Homeowner associations and restrictions on solar installations

Key Barriers

Many threats were also identified through an interviews process.

- A natural gas price collapse would reduce the competitiveness of solar
- Public concerns about NIMBY, aesthetics etc., may influence and limit the siting and large-scale deployment of central plants
- The planned use of central station or next generation PV systems that have not been fully proven may weaken the initiative
- Sustained economic recession results in concerns about investments in initially more expensive solar options
- Module shortage persists so systems can not be obtained to be installed

Key Threats

If some barriers can be overcome, there is potential for annual installations > 250 MW/yr in 2020, resulting in close to 3,000 new jobs.

Opportunities

- MWs in 2020 (Accelerated Scenario):
  - Central Solar: 145 per year
  - Rooftop: 115 per year
- Jobs in 2020 (Accelerated Scenario):
  - Direct Manufacturing: 510 per year
  - Installation/Construction + O&M: ~2,535
- Emissions Reductions in 2020 (Accelerated Scenario):
  - Central Solar: ~338,200 Tons of CO_2/Year
  - Rooftop: ~60,000 Tons of CO_2/Year
- Spin-off value of R&D development
- Additional economic development e.g. tourism to visit solar "centers of excellence" and deployment centers
- Enhanced sustainable AZ: maintaining AZ's quality of life

NCI's road-mapping process identified actions/recommendations based on analyses of the market opportunities, competition, and barriers.

- Research & Development
- Manufacturing
- Distributed systems deployment
- Central station development & operation

- Jobs
- Supply security
- Electricity prices and stability
- Reduced emissions
- Image

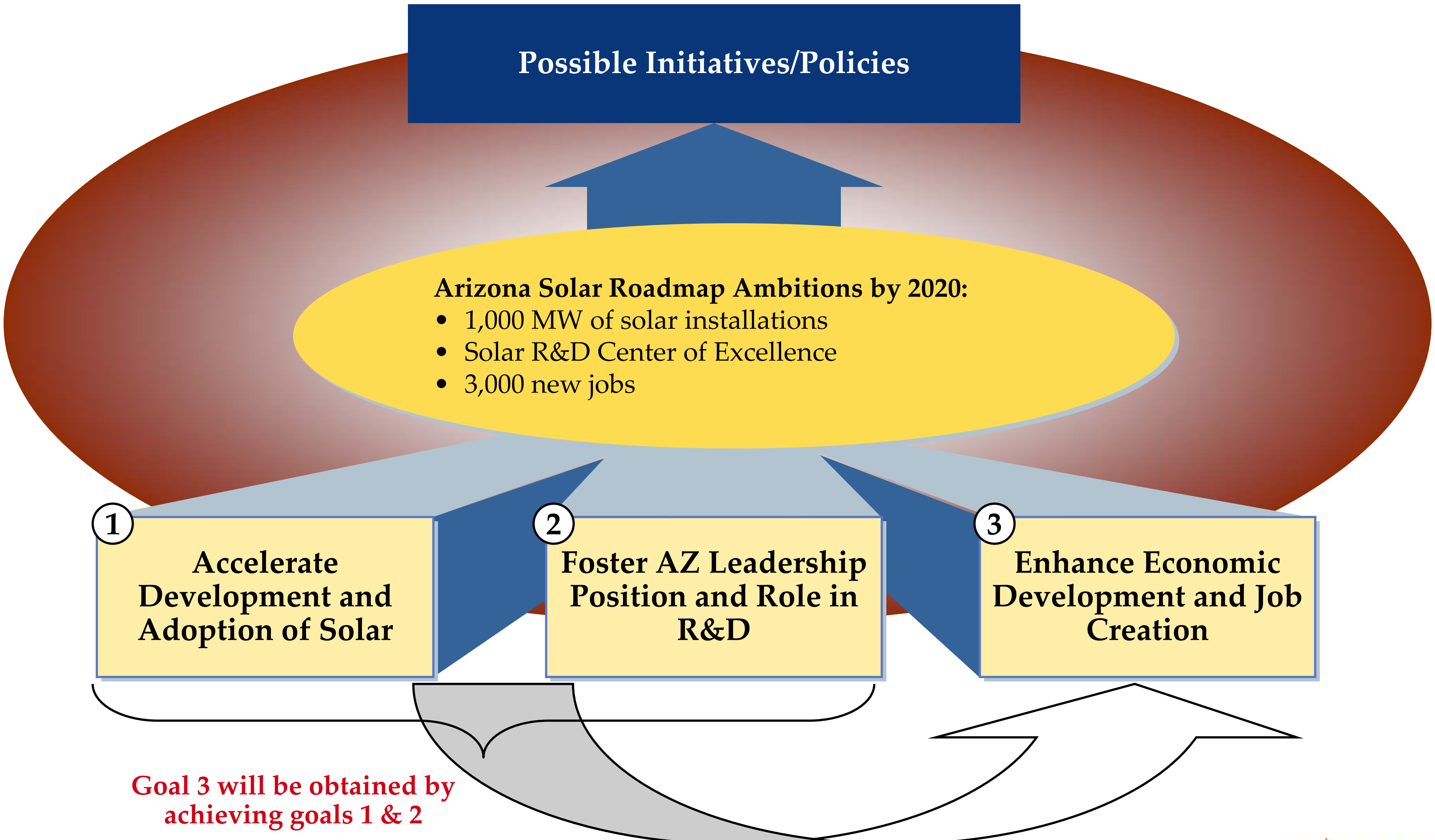
- Strengths
- Weaknesses
- Threats
- Areas of competitive advantages

- Financial
- Institutional
- Infrastructure
- Availability
- Wholesale markets
- Transmission
- Siting
- Other

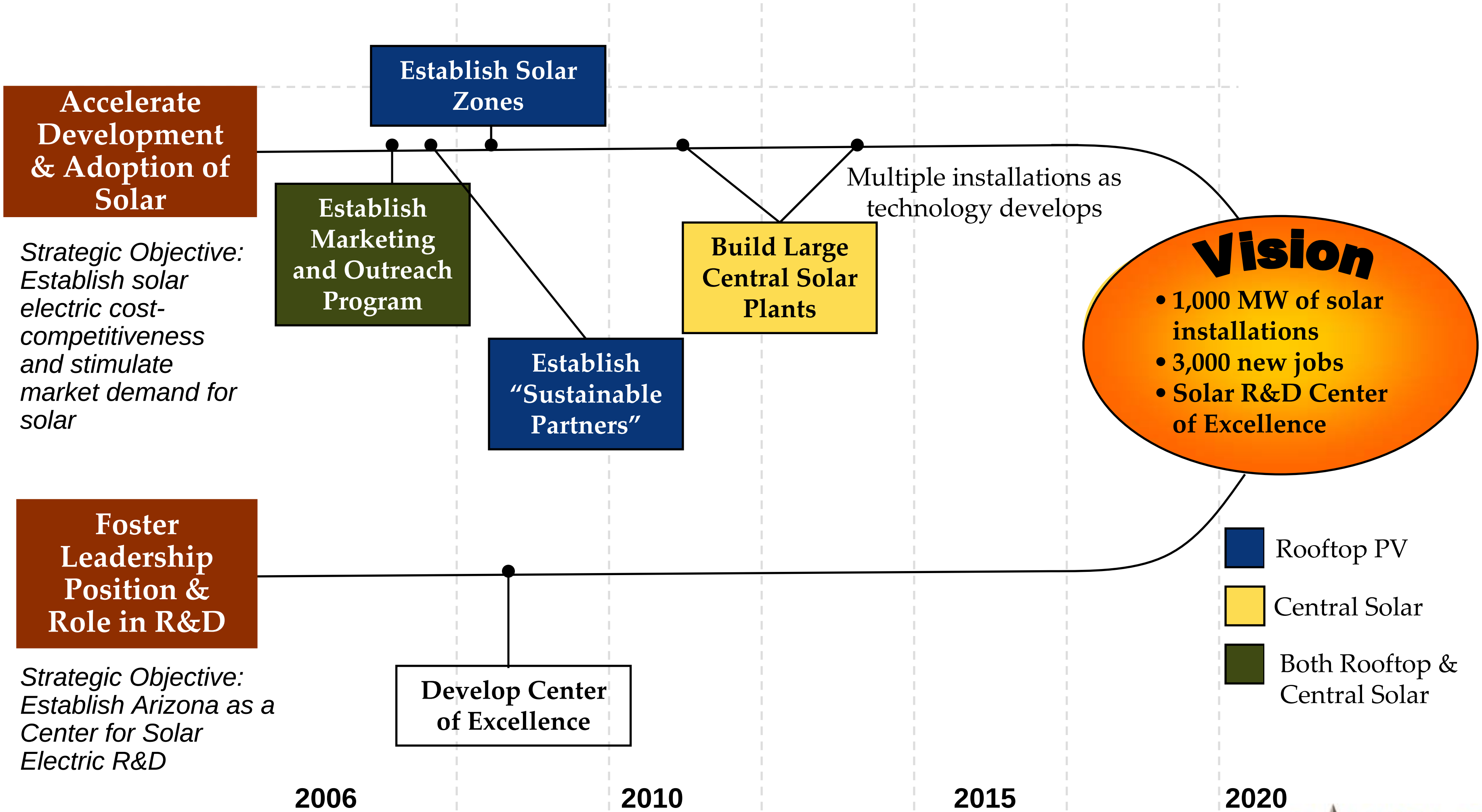
Policy and program recommendations and action items for:

- Near–term
- Mid-term
- Long-term

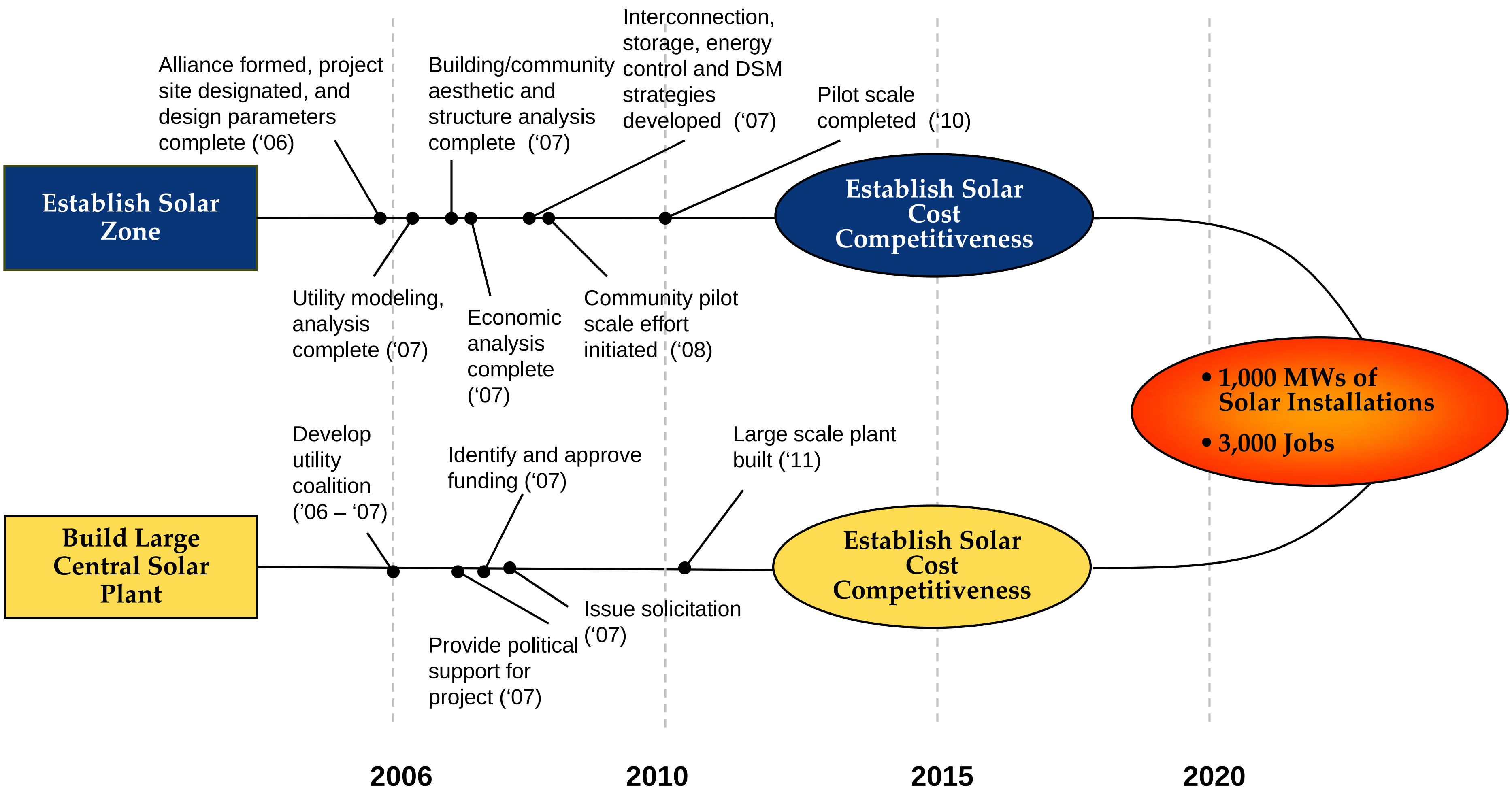
NCI along with the Steering Committee identified initiatives and policies that would address three goals and ambitions.



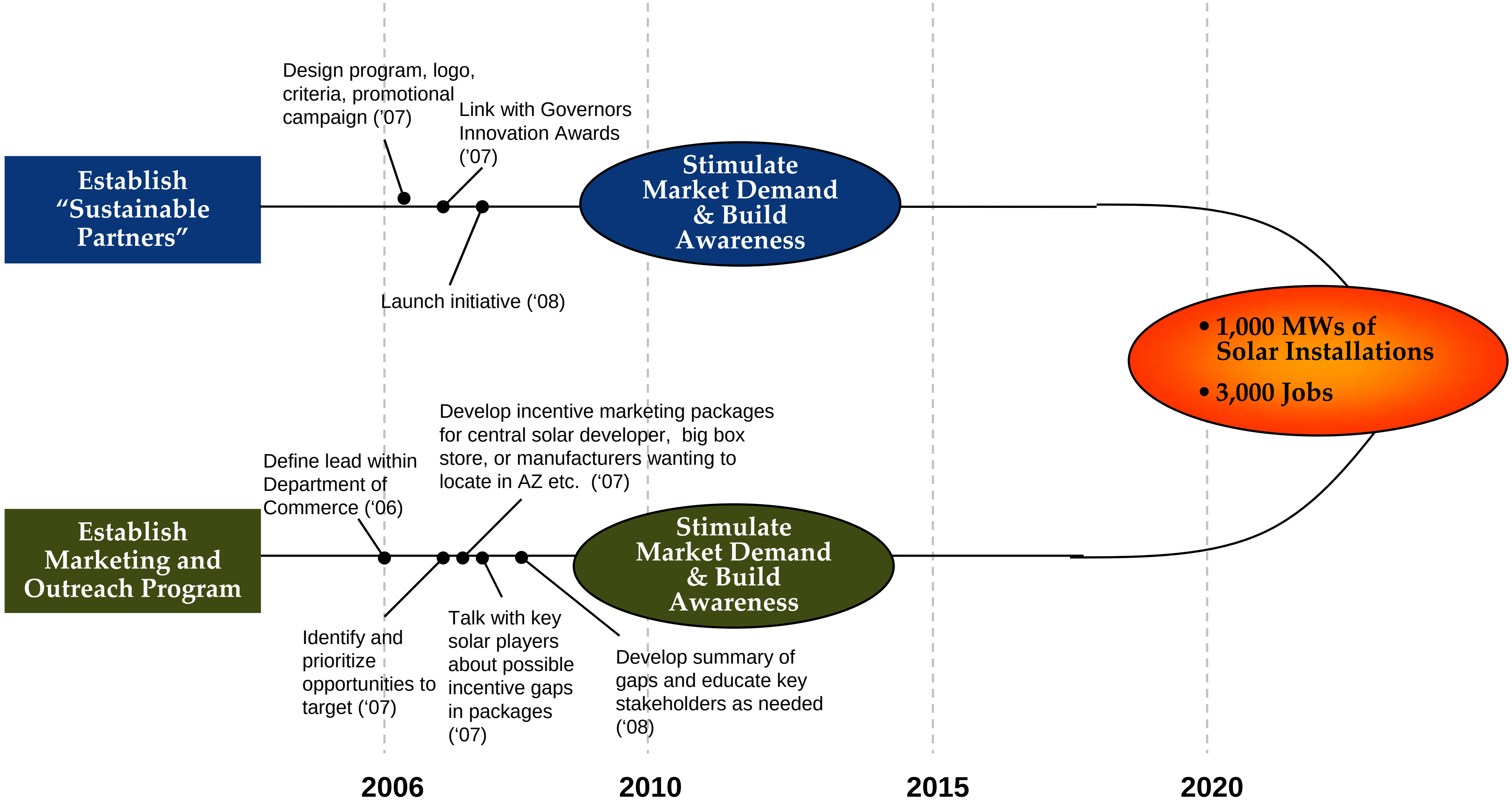
The vision and ambitions are achieved through integrated initiatives that build upon established policies and incentives.



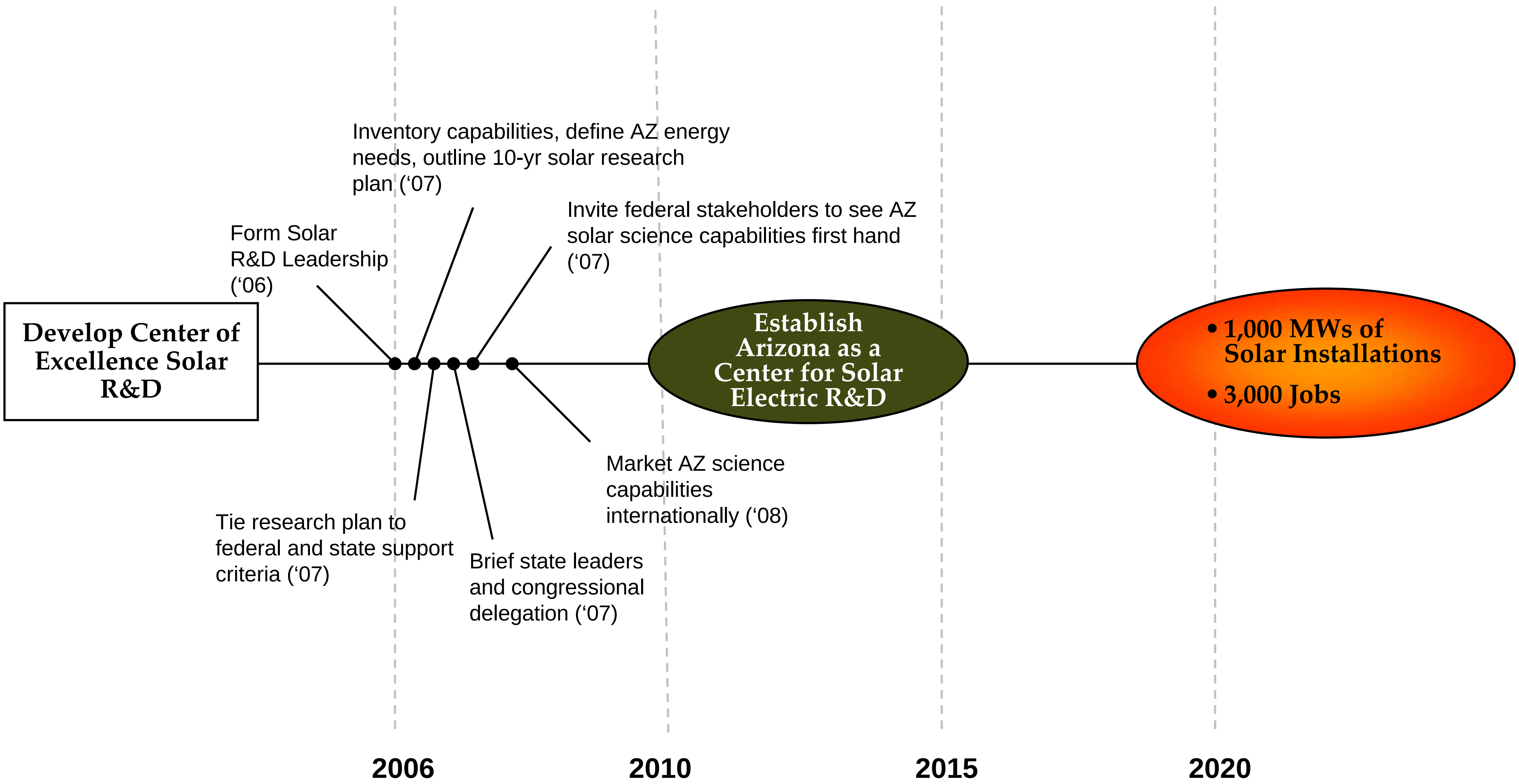
Below are key milestones to help accelerate the development and adoption of solar.



Below are additional key milestones for development and adoption of solar through stimulating market demand and building awareness.



Below are the key milestones for building knowledge to support the development of a Center of Excellence for Solar R&D.

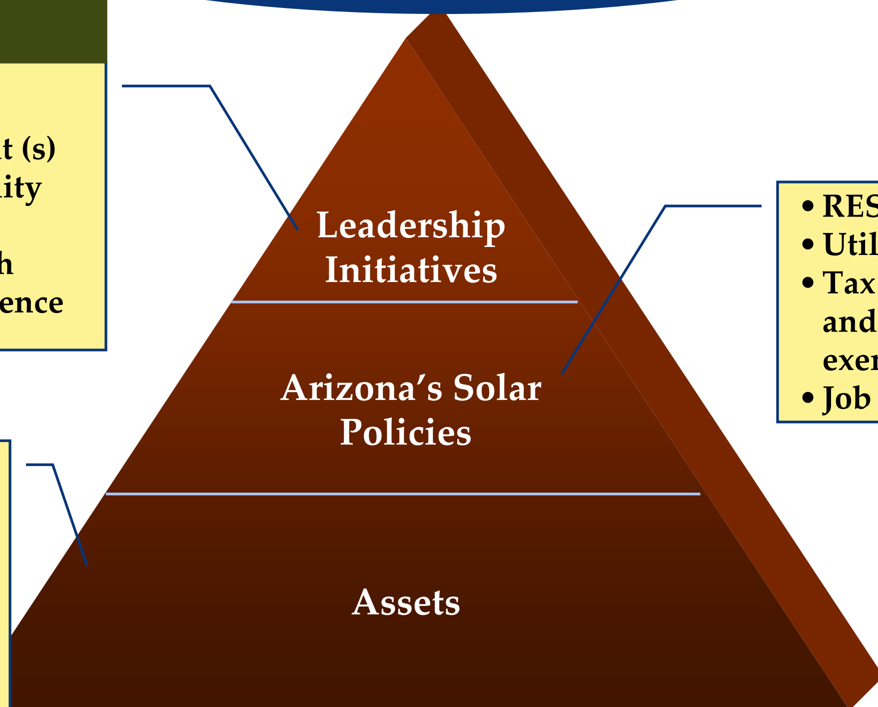


Implementing the roadmap initiatives will allow AZ to build upon its assets and policies to establish a leadership position in fostering solar.

Arizona Solar Roadmap Ambitions by 2020:
- 1,000 MW of solar installations
- Solar R&D Center of Excellence
- 3,000 new jobs

Roadmap Initiatives

- **Establish solar zones**
- **Build large central station plant (s)**
- **Establish "Arizona Sustainability Partners"**
- **Establish marketing & outreach**
- **Develop Solar Center of Excellence**



- **RES requirements**
- **Utility programs**
- **Tax credits (including sales and property tax exemptions)**
- **Job training funds**

- **Best solar resource in nation**
- **Rapidly growing markets**
- **Region committed to sustainable development**
- **Pro-business environment**
- **Opportunity for Tribal partnerships**
- **Intellectual capital at post-secondary institutions**

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Roadmap Goals

- 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 Arizona.
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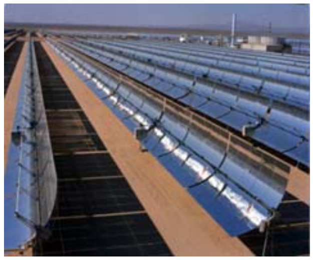



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NCI used a six-step approach to help AZ develop a solar electric roadmap.

Policy Strategy	Technology and Deployment Strategy	Local Barriers	Existing Business and Industry Status	Economic and Market Analysis	Recommend-ations
• Attend kick-off meeting in AZ to: – introduce NCI team and meet Steering Committee, – confirm project scope and deliverables, – define appropriate communication channels and frequency, and – establish priorities for selecting policies to support the roadmap objectives • Review existing policy/incentives for solar in AZ and U.S. – identify best practices of utility, state, Federal, tribal, and local stakeholders • Define the best policies to meet the AZ objectives (Task 6 Recommendations)	• Determine levelized cost of energy (LCOE) for parabolic trough, dish Stirling, concentrator PV, central station flat plate PV, residential rooftop PV, and commercial building rooftop PV for 2006, 2010, 2020 and 2025 without state incentives – Use NCI proprietary LCOE model and provide AZ with key technology and performance assumptions • Identify benefits and challenges for each of the technology options • Estimate the market potential and market penetration rates for rooftop PV • Identify centers for expertise and areas of core competency in AZ	• Conduct 5 – 8 interviews with AZ manufacturers, regulators, utilities, developers, tribes, and other key players to identify barriers to entry/deployment • Assess significance and likely persistence of the barrier • Identify and evaluate options to overcome significant barriers • Analyze advantages, disadvantages, and feasibility of overcoming barriers through 5-8 interviews with industry, regulators, utilities, tribes, and government • Recommend actions and policies to overcome barriers	• Review key utility, industry, investor, and developer solar activity • Interview 5 – 7 key players to obtain their opinions about local, national, and international opportunities • Define potential technology strategies for each solar technology option	• Summarize generation capacity additions of conventional power through 2025 within AZ and WECC under two scenarios • Synthesize publicly available data on electricity price forecasts and transmission capacity for export of solar • Provide electricity price forecasts for two scenarios • Describe WECC vulnerabilities and estimate impact on electricity price forecasts for WECC, California and Arizona • Review AZ utility resource plans through 2020 • Discuss possible risks and uncertainties in resource plans • Review solar plans and capacity additions through 2025 (conduct 3 - 5 interviews with staff at APS, TEP, and SRP) • Estimate solar technology LCOE for 2010 and 2025 • Estimate market potential for solar thermal electric and rooftop PV for 2010 and 2025	• Develop roadmap and recommendations from synthesis of previous tasks • Work with Steering Committee to develop policy objectives and goals, and to refine the recommendations • Assess AZ competitive position relative to strengths, weaknesses, and threats • Conduct workshop with Steering Committee for roadmap and action plan development • Provide recommendations for three time frames: – near-term (1 – 5 years) – medium-term (5 – 10 years) – long-term (>10 years)

NCI used a six-step approach to help AZ develop a solar electric roadmap.

			Page
1	Project Scope and Approach	Discusses the background, scope and approach of the project	31
2	Policies and Best Practices	Presents information about the policies that exist at the Federal, state, utility, and tribal level to support solar. Also presents information on best practices for solar development in other states.	36
3	Solar Technology & Deployment Issues	Presents information about a variety of solar technology options: economics (2006 – 2025), advantages and challenges.	61
4	Opportunities	Presents information about unique attributes of AZ as well as the energy, job, and emission reduction potential for rooftop and central solar application (2006 – 2025).	95
5	Barriers and Risks	Discusses the barriers and risks associated with solar energy development based on a interviews with a variety of key stakeholder groups.	141
6	Solar Roadmap	Identifies five major roadmap activities along with key milestones needed to achieve the roadmap goals for solar.	149
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2 Policies and Best Practices

3 Solar Technology and Deployment Issues

4 Opportunities

5 Barriers and Risks

6 Solar Roadmap

Appendix

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Compared to other renewable technologies, solar is often provided incentives at the national level.

Incentive	Description	Applicability					
		PV	Solar Thermal Electric	Wind Power	Biomass/ LFG	Low-Impact Hydro	Geo-thermal
Production Tax Credit (PTC)	• 1.9 ¢/kWh, after tax, for first 10 years of operation. PTC is indexed to inflation and is good through 12/31/2007. • Full value applies to wind, solar, geothermal and "closed-loop" biomass • Credit value is reduced to 0.9¢/kWh for "open-loop" biomass, small irrigation power/qualified hydro production, cogeneration and waste-to-energy			✓	✓	Small irrigation power only between 150kW and 5MW	✓
Investment tax credit (ITC)*	• 30% of the investment purchase/installation on income tax for commercial installations. Good through 12/31/07, then reduces back to 10%. PV also has a residential tax credit of 30%, but with a cap of $2,000	✓	✓				✓
Accelerated Depreciation	• Eligible technologies are classified under Modified Accelerated Cost Recovery System (MACRS) property class 5, allowing 5-year vs. 15 year depreciation	✓	✓	✓			✓
Renewable Energy Production Incentive (REPI)	• Rough equivalent to the PTC but for municipal utilities and other public entities • 1.50¢/kWh (1993 $) adjusted for inflation for the first 10 years of operation.[1] • EPAct 2005 reauthorized this program through 2026 (i.e., for project installed through 2016) • 60% of available funding to wind, solar, geothermal, biomass or ocean in shortfall years	✓	✓	✓	✓[1]		✓[2]

1. The REPI is subject to annual appropriations such that it may not be fully funded from year to year. 2. Contains restrictions on the type of geothermal reservoir.

*The House and Senate have introduced the Securing America's Energy Independence Act to extend the ITC for solar and fuel cells through 2015.

EPACT 2005 provides a 30% ITC for commercial installations of solar through 2007, but this may be extended through 2015.

EPACT 2005

- An increase, through the end of 2007, in the Investment Tax Credit (ITC) for solar, from 10% to 30% of installed cost.
  - Eliminated the $25,000 cap
  - Reverts back to 10% after end of 2007
  - Covers all equipment and installation costs
- Creation of a residential solar tax credit of 30% (with a $2,000 maximum)
- Renewable energy purchase requirements for the Federal sector (reaching 7.5% by 2013, up from 2.5% in 2005). Is likely to result in 150 MW of PV
- A PV commercialization program for the procurement of PV systems for public buildings
- Clean and renewable energy bonds are established, but applications had to be in last April
- Increases solar R&D to $250 million annually
- Electricity provisions: net metering, interconnection standards, and time based rates

Securing America's Energy Independence

- House and Senate Bills both include:
  - Extension of 30% business credit for PV, CSP, and solar hot water until Dec. 31, 2015. Credit can be taken against alternative minimum tax (AMT).
  - Extension of 30% residential tax credit for solar water heating, PV and fuel cells
    - Changes maximum to $2,000 for each kW of solar (vs. flat $2,000 cap) and $1,000 for fuel cells. Credit can be taken against AMT.

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As of May 2006, the Solar America Initiative (SAI) has been funded $148 million at the President's request.

- In May 2006, the House Appropriations Committee approved the FY2007 Energy and Water Appropriations bill
- Total funding for the DOE Solar Program was $148.3 million
  - $134.3 million for PV
  - $8.9 million for CSP
  - $5 million for solar heating and lighting
- The Office of Science has additional funds for solar R&D
- Currently undertaking Technology Acceptance exchange meetings to obtain inputs to the SAI
  - The mission of SAI is to achieve cost-competitiveness of solar energy technologies by 2015 across all market sectors
  - The Technology Acceptance side of SAI is to reduce market barriers and promote market expansions of solar energy technologies through non-R&D activities

Source: Solar Energy Industries Association, Weekly Newsletter, May 19, 2006.

Tribes are eligible for incentives from a variety of sources. Tribes are also trying to leverage RECs.

Organization	Description	Examples
DOE Tribal Energy Program	• Provides financial and technical assistance to tribes for feasibility studies, and shares the cost of implementing sustainable renewable energy installations on tribal lands. • The financial assistance is done mainly through grants.	• In 2005, the DOE awarded grants between $100 - $250k • The Hualapai Tribe won a grant to establish a tribally operated utility-scale wind farm
USDA Renewable Energy Systems and Energy Efficiency Improvements Program	• This program currently funds grants and loan guarantees to agricultural producers and rural small business for assistance with purchasing renewable energy systems and making energy efficiency improvements.	• The Gila River Indian Community won a $500,000 grant to build a 500 kW PV power plant on tribal lands
National Rural Utilities Cooperative Finance Corporation	• Offers full-service financing, investment, and related services to its members, and offers a wide range of flexible, low-cost financing programs and interest rate options.	• Helped the Gila River Indian Community obtain a loan through the Clean Renewable Energy Bonds Program

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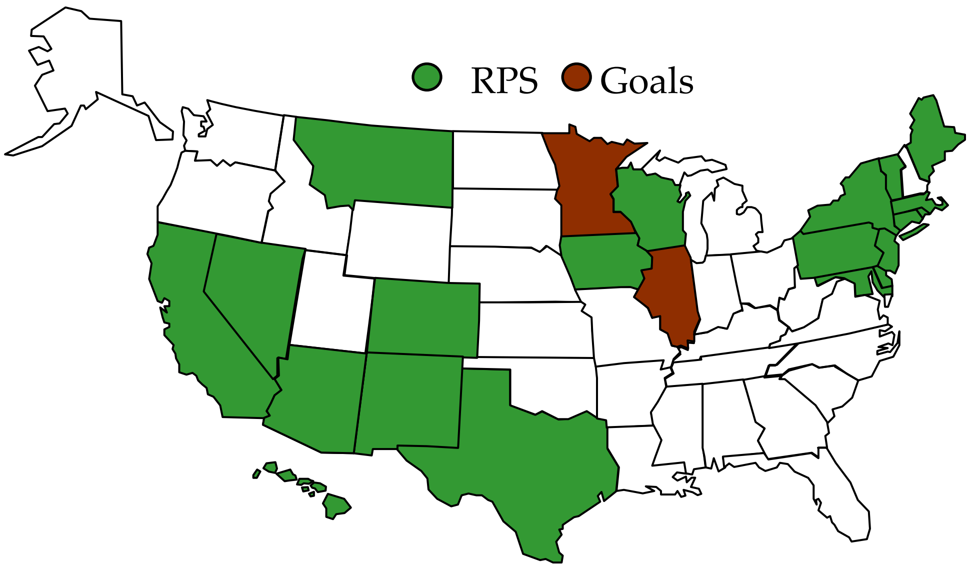
EPACT 2005 provides some additional incentives for tribes.

	Provisions Relevant to Indian Energy Under the Energy Policy Act of 2005
Title II: Renewable Energy	• Reauthorizes through 2023 the REPI (Renewable Energy Production Incentive) program, which provides renewable energy production incentive payments of 1.5 cents/kWh (adjusted for inflation and subject to appropriations) for solar, wind, geothermal, biomass and other renewable technologies • Adds Indian Tribal governments or "subdivisions thereof" to the list of qualified REPI participants • The use of biomass from Federal or Indian lands is encouraged by the creation of two grant programs to produce electric energy or heat from biomass and to improve biomass utilization technology
Title V: Indian Energy	• Provides grants, low-interest loans, loan guarantees and technical assistance, and streamlines the approval process for Tribal leases, agreements, and rights-of-way so that outside parties have more incentive to partner with Tribes in developing energy resources • Included in this title are provisions creating an Office of Indian Energy Policy and Programs within the Department of Energy to support the development of tribal energy resources • Makes Dine Power Authority, a Navajo Nation enterprise, eligible for funding under this title • Directs the Secretary of Housing and Urban Development to promote energy efficiency for Indian housing • Sections 2602 and 2603 instructs the Secretary of Interior to develop an Indian energy resource development program to provide grants and low-interest loans to tribes to develop and utilize their energy resources and to enhance the legal and administrative ability of tribes to manage their resources • Section 2602 creates a DOE loan guarantee program and directs the Energy Secretary to give priority to any project using new technology, such as coal gasification, carbon capture and sequestration or renewable energy-based electricity generation (no more than $2 billion at a time. • Section 2604 establishes a process by which an Indian tribe, upon demonstrating its technical and financial capacity and receiving approval of their Tribal Energy Resource Agreement, could negotiate and execute energy resource development leases, agreements and rights-of-way with third parties without first obtaining the approval of the Secretary of the Interior

Source: Red Mountain Energy Partners, May 2006 based on U.S. Senate Post Conference Bill Summary

As of June 2006, 20 states plus DC had renewable portfolio standards (8 with solar or non-wind set asides).



	Target	Other
AZ[3]	1.1% by 2007 thru 2012	0.66% solar by 2007
CA	20% by 2017	
CO	10% by 2015	0.4% solar by 2015
CT	10% by 2010 (7% tier 1)	
DC	11% by 2022	0.386% solar by 2022
DE	10% by 2019	
HI	8% by 2005, 20% by 2020	
IA	105 MW (2% by 1999)	
IL[1]	8% by 2013	
MA	4% by 2009 (+1%/year after)	
MD	7.5% by 2019	
ME	10% additional by 2017. Starts in 2007 and increases 1%/year	Above the 30% for 2000. Includes some non-RE.
MN[2]	10% by 2015 (1% biomass)	
MT	15% by 2015	
NJ	6.5% by 2008 (4% tier 1), 20% by 2020	0.16% solar (95 MW) by 2008, 2% by 2020
NM	5% by 2006, 10% by 2011	
NV	20% by 2015	5% of RPS solar
NY	24% by 2013	0.154% customer-sited by 2013; includes 1% via green power
PA	18% by 2020 (8% is RE)	0.5% solar by 2020
RI	16% by 2019	
TX	5,880 MW by 2015	Includes 880MW pre-RPS & 500 MW non-wind
VT	New generation 2005-2012 RE	10% cap
WI	10% by 2015	

1. The Illinois RPS is a goal with a cumulative 2% cap on rate increases resulting from compliance with the goal
2. In Minnesota the RPS is mandatory for the largest utility, Xcel, however, for the rest of the utilities and service providers it is a "good faith effort". Under a separate agreement, and in addition to the RPS requirements, Xcel is required to build or contract for 125 MW of biomass electricity, and must build or contract for 1,125 MW of wind by 2010.
3. In 2/26/06 ACC approved revised RES of 15% by 2025 and 30% from DG by 2025. Final decision expected 7/31/06.

Source: Navigant Consulting, Inc. 2006, Database of State Incentives for Renewable Energy (DSIRE) and California Energy Commission.

RPS standards vary by the size of the requirement, the allowable resources, dates, use of technology tiers/multipliers and other factors.

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The AZ RES is under review by the Administrative Law Judge.

AZ Renewable Energy Standard (RES)

On Feb 27, 2006, the Arizona Corporation Commission gave preliminary approval of a revised Environmental Portfolio Standard (now a Renewable Energy Standard – RES), which is currently under review by the Administrative Law Judge who will prepare a recommended order for adoption by the Commission. Provisions include increasing the portfolio mix to 15% renewables by 2025 and an additional requirement that 30% of the renewables come from distributed generation resources. A final decision is expected by the end of 2006.

Under Arizona's RES, regulated utilities in the state are required to generate a certain percentage of their electricity with renewable energy according to the following schedule:
0.2% in 2001; 0.4% in 2002; 0.6% in 2003; 0.8% in 2004; 1.0% in 2005; 1.05% in 2006; 1.1% in 2007-2012
Eligible technologies include solar electric, solar water heating and solar air conditioning, landfill gas, wind and biomass. Solar electric power must make up 50% of total renewables required in 2001, increasing to 60% in 2004-2012. Arizona Public Service, a utility, has requested and received a rule waiver allowing it to meet a portion of its RES requirements using geothermal resources.

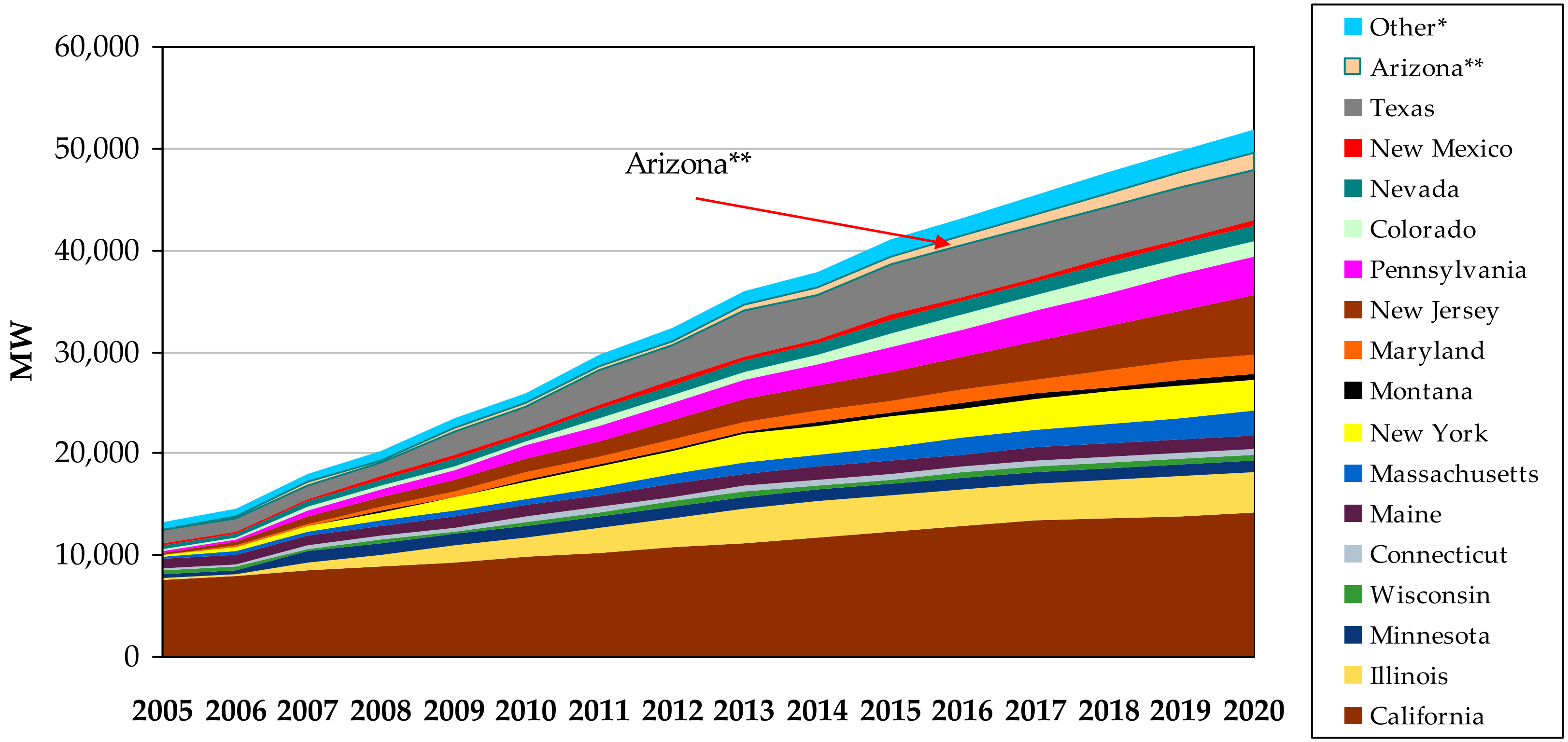
Funding for the RES comes from existing system benefits charges and a new surcharge to be collected by the state's regulated utilities. The existing surcharge is capped at $0.35 per month for residential customers, $13 per month for non-residential customers and $39 per month for customers with loads over 3 MW. At least $15 million-$20 million will be collected annually to support the RES.

Interestingly, the standard includes a caveat that if the cost of solar technologies does not decrease to a Commission-determined cost/benefit point by the end of 2004, the portfolio requirement will not continue to increase. On February 10, 2004, the ACC voted to allow the standard to continue increasing to 1.1% of electricity from renewables by 2007. Workshops will be held to determine whether the current surcharge on residential electric bills of up to $0.35 per month should be increased, and whether a requirement that 60% of the renewable energy come from solar resources should be modified or eliminated.

The RES requirement does not apply to Salt River Project, which is not regulated by the commission and has its own program to increase the use of renewable energy.

State RE standards are expected to support ~12,000 MW of existing capacity and result in ~52,000 MW of new capacity by 2020.

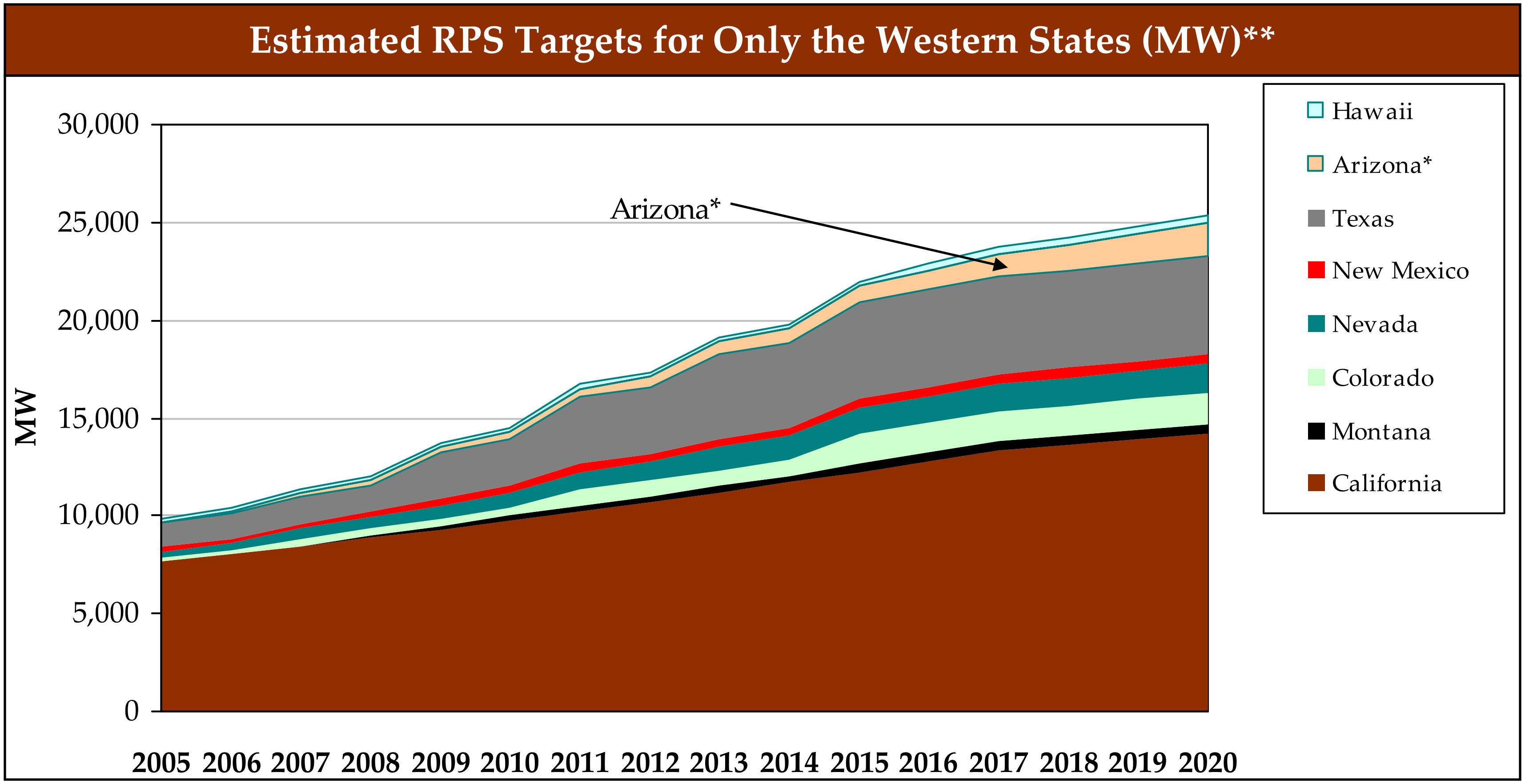
Estimated RPS Targets (MW)



Source: Navigant Consulting, Inc, February 2006.
- Other includes: Hawaii, Iowa, Rhode Island, Vermont, Delaware, and Washington D.C.
- ** The numbers for Arizona assume that the current resolution to raise the target to 15% passes

Note: Assumes maximum RPS target was achieved and held constant through 2020.

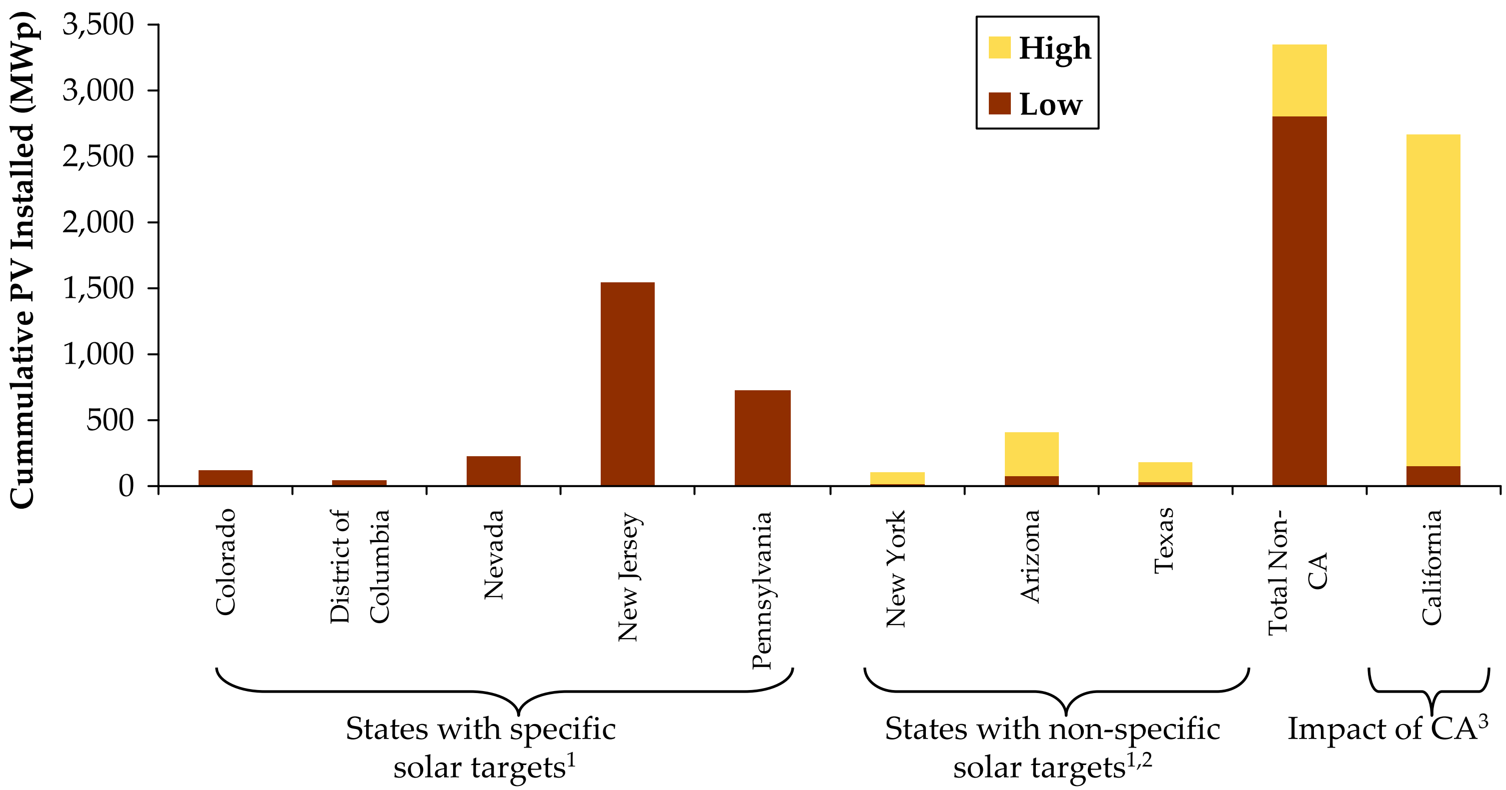
AZ will play some role in RPS growth in the western states.



Source: Navigant Consulting, Inc, May 2006.
*The numbers for Arizona assume that the current resolution to raise the target to 15% passes
**Assumes maximum RPS target was achieved and held constant through 2020.

The demand from RPS solar set asides could result in 3,000 to 3,500 MW of solar without CA, and up to 6,200 MW with CA by 2020.

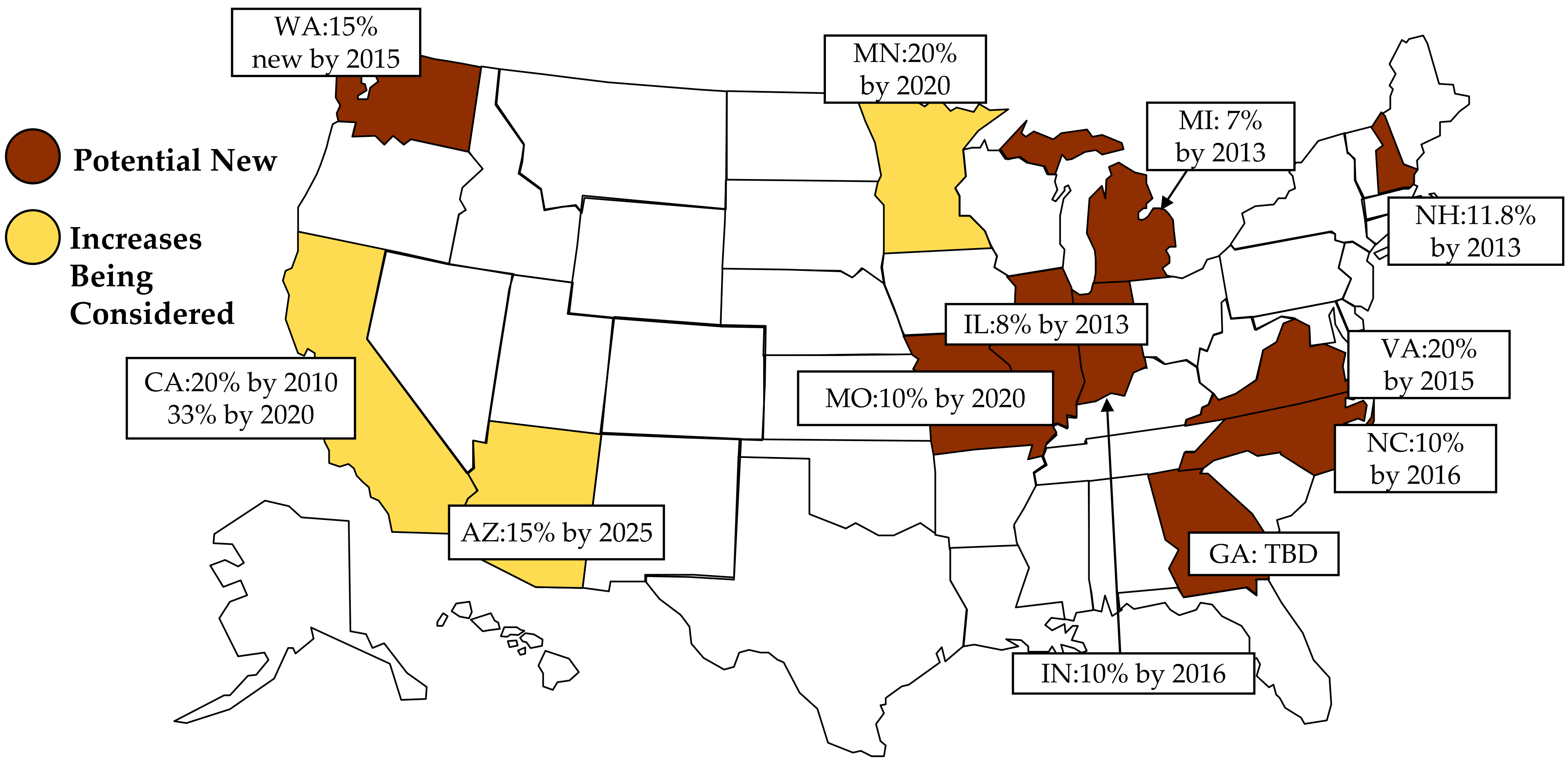
Estimated Solar Set Aside Capacity Targets by 2020 (MW)



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.

As of June 2006, nine states have RPS bills introduced and 3 are considering increasing RPS targets, including the AZ target.



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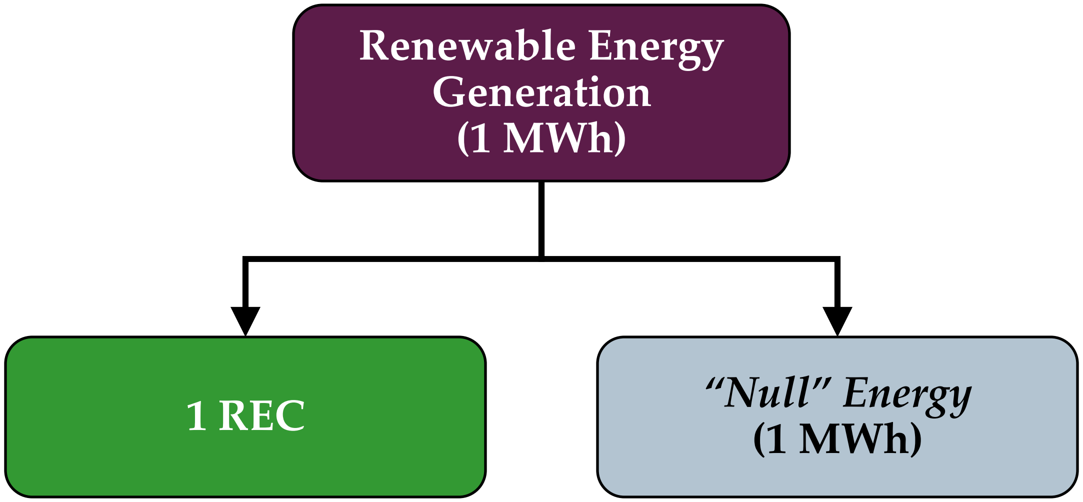
Renewable Energy Certificates (RECs) have emerged as a useful means for valuing the attributes of power sold to retail customers.



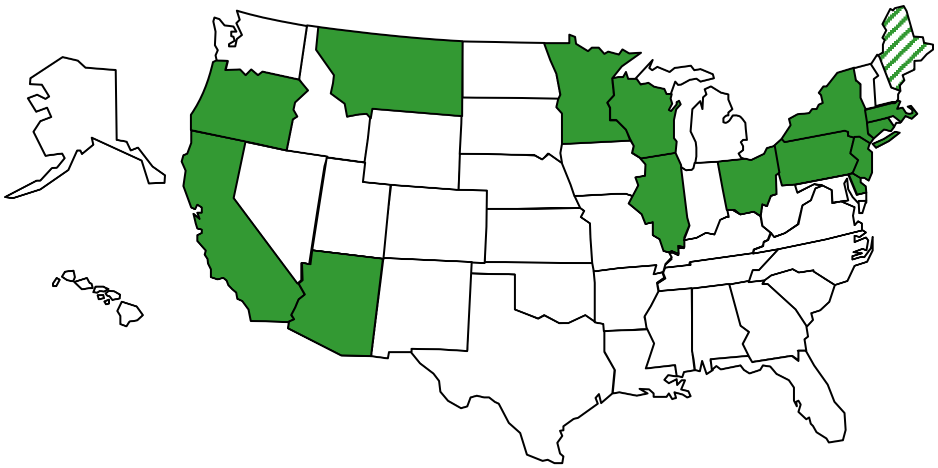
- Emission rate attributes
- Locational attributes
- Technology/fuel attributes
- Labor attributes
- Other

- Electrons without attributes (commodity electricity)

- RECs and the associated energy can be sold separately or together.
- A REC conveys the right to claim the attributes associated with electricity generated from a specific renewable facility.
- RECs are used to demonstrate compliance with RPS rules and also substantiate green power marketing claims. Certificates can also be used for labeling/ disclosure purposes.

Currently, the sale of RE attributes can add $10-50/MWh to project revenue (more for solar projects, less for "voluntary" RECs).

State renewable energy funds are expected to provide approximately $318 million in 2006.



Public Benefit Funds allocated to renewable energy funds

Voluntary Public Benefit Funds allocated to renewable energy

Annual Funding Available in 2006 ($ million)			
AZ	$13.5*	**MT**	$2
CA	$135	**NJ**	$68
CT	$20	**NY**	$13
DE	$1.5**	**OH**	$1.25
IL	$5	**OR**	$11
MA	$24	**PA**	$5.5
ME	voluntary	**RI**	$3.0
MN	$16	**WI**	$1.3

* In 2005 Arizona will generate an estimated $8.5m from PBFs and an additional $11-11.5m from a utility bill surcharge for renewable energy. Funds are given to utility to comply with Renewable Energy Standard (RES) through green power purchases, development of renewable generation assets and customer PV rebates. Arizona is currently modifying RES rules which could result in the elimination of PBFs for renewable energy, and instead create a utility bill surcharge to generate ~$50 million per year.

** Amount represents both renewable energy and energy efficiency programs.

Also, D.C. raised $9.5 million in 2005 using a PBF for renewable energy, energy efficiency and low-income programs.

Note: Values show are annual amounts for renewable energy only, and do not reflect total state system benefits charges.
Source: Navigant Consulting, Inc. estimates, January 2006.

Typical uses of funds include: rebates, grants, loans, feasibility studies, market support for RPS and green power, and education/outreach.

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AZ incentives for solar are mostly provided by the utilities.

Key AZ Utility 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)	

The regulated utilities are currently discussing a uniform credit purchase program for solar through the ACC.

Some additional incentives are available at the state level.

Additional AZ State Level Solar Incentives and Other Related Programs

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	

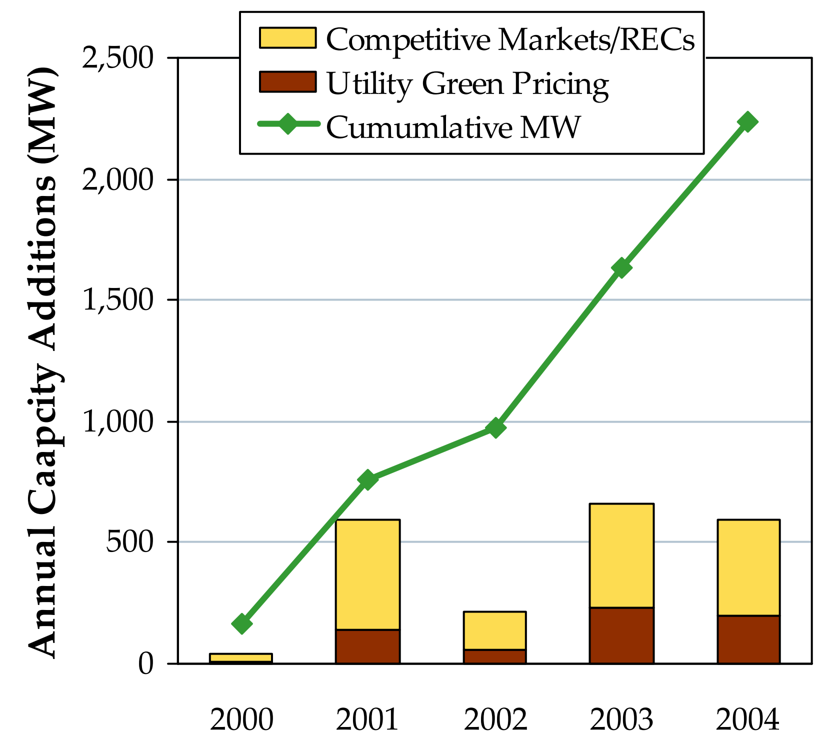
There has been a tenfold increase in capacity supplying green pricing programs since 1999, but wind represents about 80% of the capacity.

- Currently about 600 utilities, including investor-owned, municipal utilities, and cooperatives, have either implemented or announced plans to offer a green pricing option[1]
- Competitive green power products are available in 10 states and in DC, from more than 30 suppliers
- A growing number of REC-based products are also available
- Average premium is 2.45 cents/kWh
- Some of the most successful green pricing programs have experienced 3 – 5% market penetration

1. Because a number of small municipal or cooperative utilities offer programs developed by their power suppliers, the number of distinct green pricing programs is just more than 100.

Source: DOE - EERE Green Power Network; *Green Power Marketing in the United States: A Status Report,* Eight Edition Lori Bird and Blair Swezey, NREL, October 2005.

New Renewable Energy Capacity Serving Green Pricing Programs



Many policy options encourage widespread adoption of solar.

Objectives	Strategies	Tactics	Policy & Program Options
Provide financial incentives to stimulate market	Provide tax incentives	Federal incentives	• Extend 30% ITC (including IOUs) for 10 years • Continued support for accelerated treatment of depreciation
		State incentives	• Sales and property tax exemption • Tax credit for distributed generation investments • Manufacturing tax credits
	Provide direct incentives	Capital cost subsidies	• Up-front, declining buy-downs for PV and thermal that attain targeted payback periods for system owners
		Production-based subsidies	• Performance-based incentives such as per-kWh payments over guaranteed period of time
Facilitate easy access to solar	Maximize availability of solar resource	Solar access	• Solar enterprise zones • Statewide solar access rules/solar "rights" policies
	Expedite development	Permits & approvals	• Streamline siting, permitting, zoning
		Common interconnection standards	• Allow for the connection of pre-certified systems • Establish reasonable timelines for utility responses to applications • Eliminate undue fees and insurance requirements • Establish dispute-resolution process • Transparency and consistency among utilities and states

Source: WGA Solar Task Force Report, Clean & Diversified Energy Initiative,. Appendix II-3, January 2006.

Many policy options encourage widespread adoption of solar.

Objectives	Strategies	Tactics	Policy & Program Options
Provide ongoing support	Demonstrate leadership	Advocacy	• Encourage "Zero Energy Buildings" • Public education programs to promote efficiency, alt. energy
		Public purchasing	• Purchase distributed solar for public buildings • Purchase solar under long-term power purchase agreements
		Regulatory & market stability	• Establish stable, long-term programs (minimum 10 years) • Structure incentive programs to attract investment (e.g., 10-year payback for residential, 5 years for businesses) • Design programs to support self-sustaining markets • Encourage participation by publicly-owned utilities
		Low-cost capital	• Tax-free solar bonds for public projects • Long-term debt financing • Government guarantees (loan or performance) • Public-private partnerships
	Encourage optimized production	Net metering	• Credit customer for excess energy generated and supplied to the grid
		Alternative rates	• Encourage optional rate structures that incentivize PV, including time-of-use tariffs
		Create revenue stream	• REC trading and ownership

Source: WGA Solar Task Force Report, Clean & Diversified Energy Initiative,. Appendix II-3, January 2006.

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Several states have incentives specifically to lure solar and other renewable energy manufacturers.

State	Program	Description
WA	Tax Abatement for Solar Manufacturers	• 40% reduction of the Washington state Business and Occupation tax of 0.484% • This applies to manufacturers and wholesale marketers of PV modules or silicon components of those systems
TX	Solar Energy Business Franchise Tax Exemption	• Exemption from the Texas state franchise tax for corporations • This applies to solar electric and solar thermal manufacturers
NY	Renewable Energy Technology Options Program	• Up to $540,000 in funding awards • Specifically for individuals or corporations to develop, demonstrate, commercialize, market or improve manufacturing methods from solar electric, wind, biomass, and hydro technologies
NY	Renewable Energy Technology Manufacturing Incentive Program	• $1 million award per project • For renewable energy technology manufacturers to develop or expand facilities for production of systems and components related to solar electric, wind, biomass, and hydro technologies
VA	Solar Manufacturing Incentive Grant Program	• Between $.25 and $.75/W for PV panels sold in a calendar year for panels manufactured in VA • Program expires at the end of 2007
MI	Refundable Payroll Credit	• Business located in the NextEnergy zone may claim a tax deduction for their pay roll amount • Applies to most renewable and clean energy technologies
MI	Nonrefundable Business Activity Credit	• Partial state tax credit for manufacturers that locate to the NextEnergy zone in MI • Applies to most renewable and clean energy technologies

There are also several states that foster R&D in renewable energy.

Examples of State Renewable Energy R&D Activities		
State	**Organization**	**Purpose**
NY	New York State Energy Research and Development Authority (NYSERDA)	• NYSERDA is funded by a charge on the electricity transmitted and distributed by the state's investor owned utilities • Focuses on fostering R&D in energy that benefits NY citizens and economy
NC	North Carolina Solar Center	• State funded research institute for renewable energy research and development
MA	Massachusetts Technology Collaborative (MTC)	• MTC focuses on innovation to drive the renewable energy industry in Massachusetts • Provides funding for innovation
FL	Florida Solar Energy Center	• State funded research institute for renewable energy R&D
CA	California Energy Commission's Public Interest Energy Research (PIER) and Energy Innovations Small Grant (EISG) programs	• PIER provides funding to organizations involved in R&D that will improve the quality of life in CA • EISG provides funding of $50k to $95k to small businesses, individuals, and academic institutions for hardware and modeling projects to establish feasibility of new energy concepts
AZ	Solar Test and Research Center (STAR) and ASU	• STAR: Solar research for APS, solar equipment manufacturers, scientists, engineers, and students from around the world. STAR is the largest facility of its kind in the world. ASU also has significant resources for solar R&D and education

Note: Ohio is also currently seeking proposal for a solar center

In January 2006, CA passed a landmark resolution to foster the growth of the solar industry.

- The Commercial and Existing Residential Buildings (CERB) incentive for PV will initially be $2.50/W and will decrease approximately 10% per year until 2016.
- Incentives for solar thermal electric, solar heating, and solar cooling are included.
- 10% of the funds are tagged for low income and affordable housing.
- Incentives for the Residential New Construction Component (RNCC) portion are still in discussion, but they will focus on creating a market with builders and developers of new housing.

$2.9 Billion (2007 – 2016)

- **$2.5 Billion to CERB Program** → **Funded through surcharge on customer bills for CA's 4 investor owned utilities** → **Program administered by the CPUC**
- **$350 Million to the RNCC** → **Funded through a Public Goods Charge that will be collected from 2007 to 2011** → **Program administered by the CEC**

NYSERDA has focused on training/certification to build a credible installation and distributor network to support a sustainable market.

New York State Energy Research and Development Authority (NYSERDA) Business Development Activities for a Sustainable Renewable Energy Market

Qualified Installers and Market Tested Products/Systems → **Multiple Distribution Pathways** → **Informed Customers** → **"Reachable" Cost** → **Sustainable Market**

Accredited Training , Installer Certification
[Institute for Sustainable Power & North American Board of Certified Energy Practioners]

Photovoltaic Incentive Program
Small Wind Incentive Program

[RPS Customer-Sited Tier]

Innovative Business Development (stressing infrastructure development)
[PON 949 $2 million]

Targeted Outreach and Analytical Tools
Brochures, Clean Power Estimator, powernaturally.org

NYSERDA has also worked to support development of renewable energy technology and manufacturing companies that will add jobs.

Renewable Technology for Economic Development

R&D → **Initial Prototype** → **Demonstration** → **Market Entry/ Validation** → **Commercialization**

Entrepreneurial Business Networks and Incubators for Renewable and Clean Energy Technology

→ Two-Stage Funding Program to Assist with Technology Development
PON 945 $2.5 million

→ Custom Management Consulting Assistance for Solving Startup Problems

→ Financial Support to Expand Manufacturing Capabilities in New York State
PON 959 $4 million

NY is one of several states that have added incentives to specifically lure solar and other renewable energy manufacturers.

Program	Comments
Innovative Business Development	• $2 million solicitation (initial funding) issued for the first time this year. Proposals due May 3, 2006 from companies located in or wishing to locate in NY that will result in NY business to assemble, install, distribute, sell and/or service electric renewable energy. Focus on infrastructure development Greater impact on reducing PV costs and increasing manufacturing than mnf incentives. Cannot be used for manufacturing and development of products
Training/ Certification	• Goal is to expand qualified installer base which NYSERDA believes is key to any successful PV program
Technology Development	• $2.5 million initial funding, proposal rounds every 6 months. Proposals due May 30, 2006. This program is designed to share the risk of early stage technology and product development, e.g. technology development, prototype construction, demonstration and manufacturing improvements • Two stage program. Stage 1 is smaller award for things such as feasibility studies ($40 – 50k). Stage 2 helps commercialize the product or provides money for beta tests (~$250k). Idea is to have companies move from Stage 1 to 2 over the course of time.
Financial Support for Manufacturing	• $4 million initial funding, next round of proposals due June 1, 2006. Provides performance-based financial support to companies that want to expand the manufacturing of renewable energy technologies in NY. Funding to assist in expanding manufacturing capacity or for moving technology developed in above programs into manufacturing. • 2 years ago DayStar came in to NY with a $1 million award. 25% was used for capital purchases. The rest of the dollars were for sales or performance payments. – Also agreed to locate in STEP (Saratoga Technology Energy Park), a NYSERDA funded industrial park for alternative energy companies. – If they do not deliver, they do not get the money and they negotiate with NYSERDA regarding the time they can achieve the milestone (typically up to 5 years)
Business Support	• Contractors selected to help in oversight/evaluation of contracts. Provide business support to NY companies

Source: Interview with NYSERDA, May 2006.

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4 Opportunities

5 Barriers and Risks

6 Solar Roadmap

Appendix

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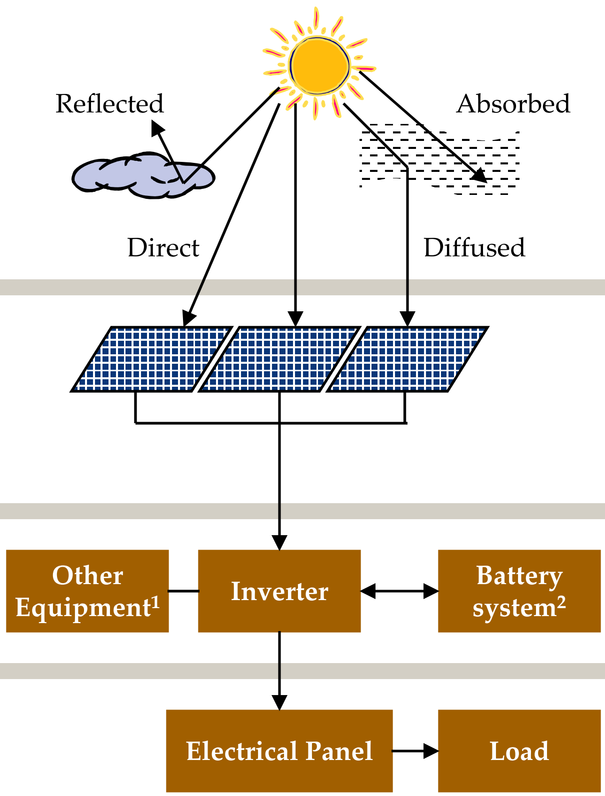
Photovoltaic technology converts solar energy into usable electrical energy.

From Sun to Power Outlet



Solar Resource	**Solar energy falling on a PV module can be either direct or diffused.**
PV Panel	**DC electrical energy output from PV modules is a function of module operating characteristics and external conditions.**
Balance of System (BOS)	**AC electrical energy from PV system is a function of system efficiency. An inverter is required to convert DC power to AC**
Load	**AC electrical energy consumption by load**

[1] Other equipment includes mounting structure, switches & fuses, meters, wires & conduits, isolation transformers/ automatic lock-out switches, etc.

[2] Battery system is optional and include batteries, charge controller and battery enclosure

Flat plate PV were evaluated for three primary applications.

Residential

Central (single-axis tracking)

Commercial

Flat plate PV technology is well proven, but system economics require incentives to be competitive with retail rates.

Flat Plate PV Technology

- Crystalline silicon technologies have module efficiencies of around 14.5% and system efficiencies of 12.3%.
- The technology has over 25 years of proven and reliable performance in the field.
- Inverters, which used to be the main problem area for PV systems, have improved in performance and reliability over the past several years. Inverter efficiency is now about 95%.
- The PV industry is active in terms of R&D: several companies are developing next generation PV technologies such as thin films (CdTe, CIS, Spheral Solar) and there continues to be innovation with proven, crystalline silicon.
  - Sanyo has developed a very high efficiency solar cell (HIT) that results in about 35% increase in an annual output over existing crystalline silicon modules.

Economics

- A recent surge in demand and a shortage of silicon prices has caused the cost of installed systems to spike 5% to 20%, depending on the geographic market. Over the long-term, prices are expected to decline approximately 4 - 5% per year.
- Solar resources in AZ are very good and provide an effective capacity factor of between 18% to 25% depending on the angle and amount of tracking.

1. kWpac = kW peak, alternating current.

PV can be sited at customer premises to compete with retail power, but high first cost is still a major barrier to broader market penetration.

Advantages	Challenges
• Modular • Well suited to customer-sited applications, and can defer some T&D losses and upgrades • No land costs (if building mounted) • Proven reliability • PV output is a good match with peak demand, thus offsetting the most expensive power. • Minimal O&M costs (no moving parts), plus inverter replacement typical in year 10. • Cost-effective today in many off-grid markets such as telecommunications, water pumping, rural electrification.	• Polysilicon shortages, the raw material used to make 93% of 2005 PV modules, has resulted in a temporary module shortage • Very high capital costs relative to conventional power options • Intermittent resource – Need energy storage to be able to operate completely independent of the grid • Lack of infrastructure for sales/service (generally) • Poor consumer knowledge about the reliability of systems • Lack of simple interconnection standards (this is not a disadvantage of PV itself, but rather a barrier to more widespread adoption)

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Installed residential prices in 2006 were high due to the module shortage, but are expected to drop again starting in 2008.

	Residential PV Economic Assumptions for Given Year of Installation (2006$)			
	2006	**2010**	**2020**	**2025**
System Capacity (kW)	2.5 - 3	2.5 - 3	2.5 - 3	2.5 - 3
Total Installed Cost ($/kWac)[1]	$9,000	$7,900	$3,800	$2,650
Non-Fuel Fixed O&M ($/kW-yr)[2]	$15	$13	$11	$11
Capacity Factor (%) – Phoenix	18.3%	18.3%	18.3%	18.3%
Project Life (yrs)	25	25	30	30
CO2 (lb/kWh)	No air emissions			
NOx (lb/kWh)				
SOx (lb/kWh)				

1. kW peak alternating current. An 82% DC to AC rating factor is assumed that takes into account system losses (dust, wiring, module mismatch), system equipment efficiencies (inverter) and impact of temperature on PV system output.
2. Excludes inverter replacement, which is assumed to occur every 10 years.

Source: NCI estimates based on industry interviews, 2006. Capacity factor estimates based on discussions with Herb Hayden at APS and analysis using PV WATTS, May 2006. 2006 installed costs from AZ Department of Commerce, Installed Cost Survey for May 2006. 2006 install costs based on interview with Kyocera Solar, June 2006.

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Commercial systems are cheaper than residential as they are typically installed on large roofs and benefit from the economies of scale.

	Commercial PV (flat roof) Economic Assumptions for Given Year of Installation (2006$)			
	2006	**2010**	**2020**	**2025**
System Capacity (kW)	50 - 300	50 - 300	50 - 300	50 - 300
Total Installed Cost ($/kWac)[1]	$7,500	$6,200	$3,300	$2,500
Non-Fuel Fixed O&M ($/kW-yr)[2]	$30	$26	$22	$22
Capacity Factor (%) – Phoenix	16%	16%	16%	16%
Project Life (yrs)	25	25	30	30
CO2 (lb/kWh)	No air emissions			
NOx (lb/kWh)				
SOx (lb/kWh)				

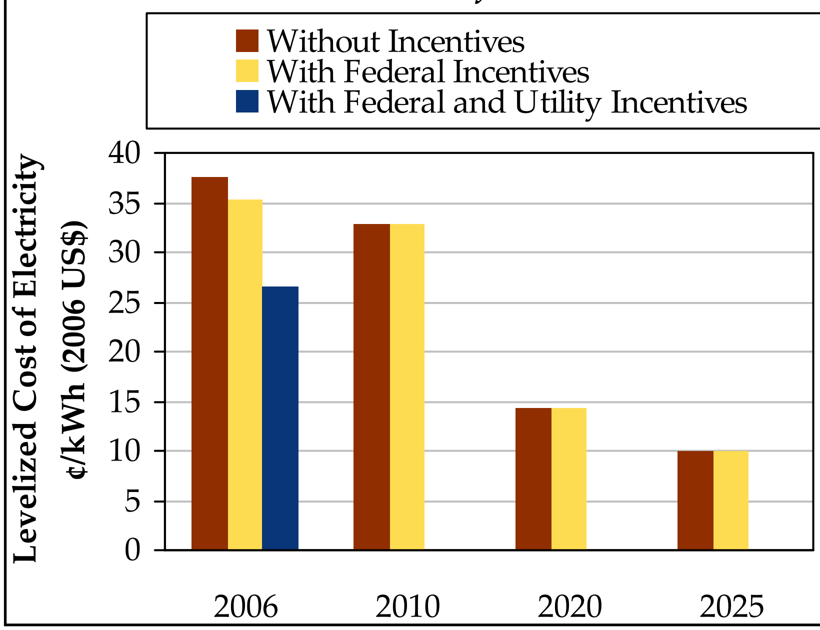
1. kW peak alternating current. An 82% DC to AC rating factor is assumed that takes into account system losses (dust, wiring, module mismatch), system equipment efficiencies (inverter) and impact of temperature on PV system output.
2. Excludes inverter replacement, which is assumed to occur every 10 years.

Source: NCI estimates based on industry interviews, January 2006. Capacity factor estimates based on discussions with Herb Hayden at APS and analysis using PV WATTS, May 2006. 2006 installed costs based on data from AZ Department of Commerce, Installed Cost Survey for May 2006 and NCI analysis.

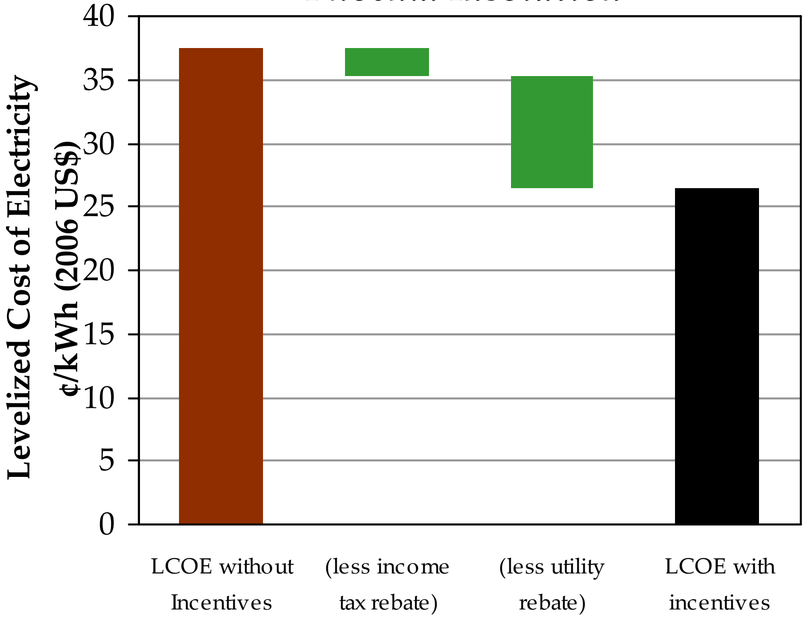
If PV prices continue to fall, residential PV will be affordable in the future.

AZ Levelized Cost of Electricity for Residential PV (2.5 – 3 kW in Size)

With and Without Federal Incentives for Given Year of Installation



With Incentives – 2006 Installation, Phoenix Insolation



Key assumptions without incentives: Debt equity ratio: 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 assumptions with incentives: Federal Tax Credit of 30% for 2006, capped at $2000. Assume that the Federal Tax Credit ends at the end of 2007. For the 2006 local incentive, assumed rebate of $3/Wdc, capped at 50% of the system cost This is the current APS incentive.

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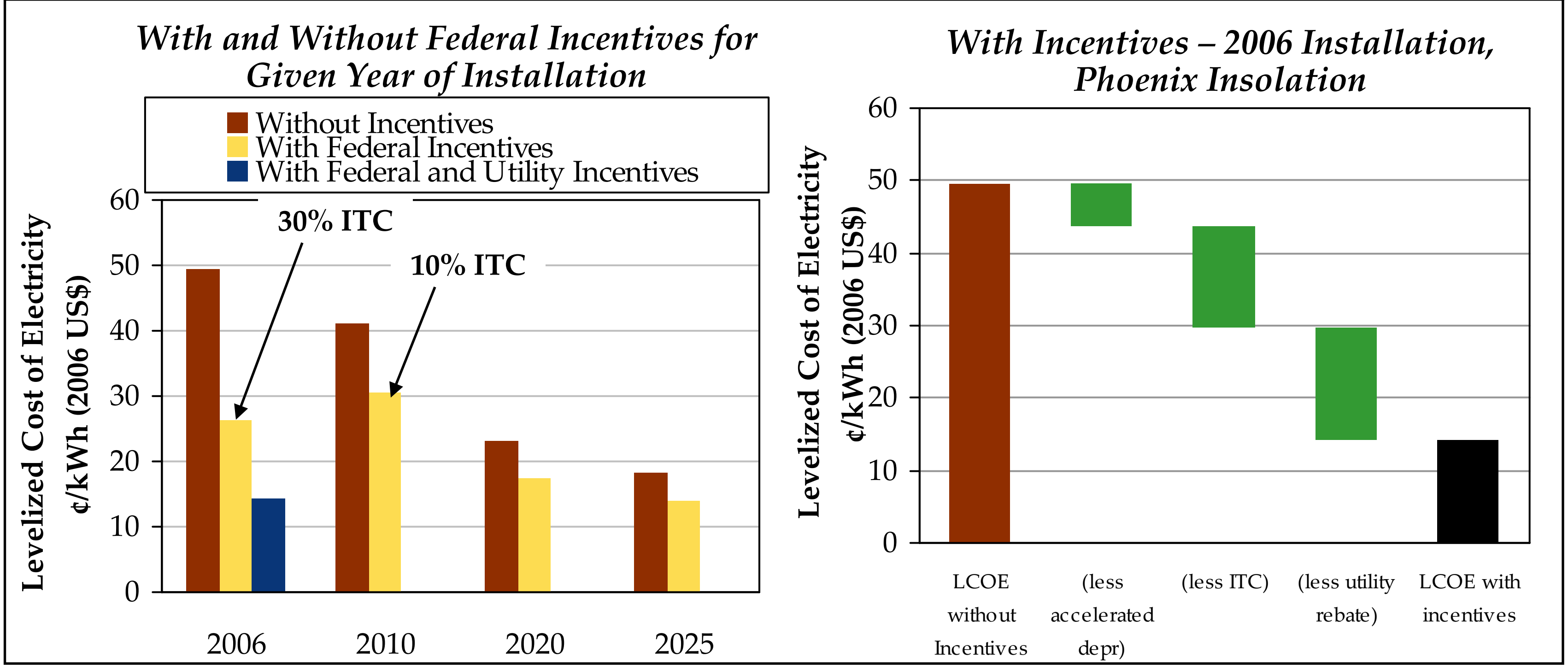
The 30% Investment Tax Credit (ITC) has a significant impact on project economics.

AZ Levelized Cost of Electricity for Commercial PV (50 – 300 kW in Size)



Key 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 $.07kWh growing at 1%/yr. Key assumptions (with incentives): Accelerated depreciation under MACRS 5 year schedule. Federal investment tax credit = 10% of **total installed** cost in year 1 after 2007. Currently the incentive level is 30%, but this is due to expire in 2007. Local incentives of $2.5/Wdc, capped at $500,000. This is the current APS incentive.

Central Station PV are expected to have similar cost structures to commercial systems.

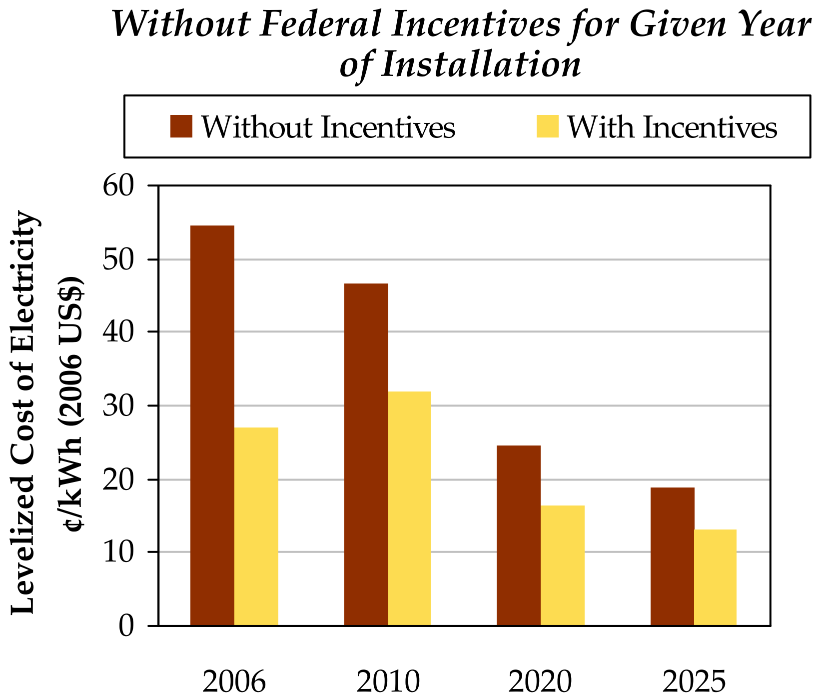
	Central Station PV – Single-Axis Tracker Economic Assumptions for Given Year of Installation (2006$)			
	2006	**2010**	**2020**	**2025**
Plant Capacity (MW)	5	5	8	8
Total Installed Cost ($/kWac)[1]	$8,000	$6,600	$3,600	$2,600
Non-Fuel Fixed O&M ($/kW-yr)[2]	$30	$26	$22	$22
Capacity Factor (%) – Phoenix	25%	25%	25%	25%
Project Life (yrs)	25	25	30	30
CO2 (lb/kWh)	No air emissions			
NOx (lb/kWh)				
SOx (lb/kWh)				

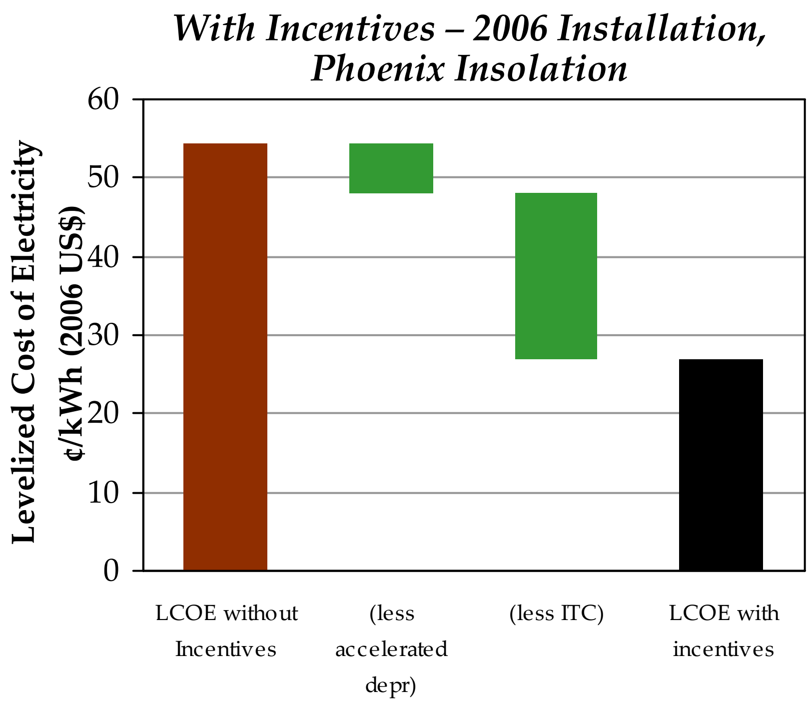
1. kW peak alternating current. An 82% DC to AC rating factor is assumed that takes into account system losses (dust, wiring, module mismatch), system equipment efficiencies (inverter) and impact of temperature on PV system output. Excludes land costs. Land required is approximately 5 acres per MWac (Land source: STAR Facility, Interview with Herb Hayden, 5/2006.
2. Excludes inverter replacement, which is assumed to occur every 10 years.

Source: NCI estimates based on industry interviews, January 2006. Capacity factor estimates based on discussions with Herb Hayden at APS and analysis using PV WATTS, May 2006.

Flat plate PV with tracking costs may be competitive after 2010 as well.

AZ Levelized Cost of Electricity for Flat Plate PV, Single Axis Tracking, Developer Financed





Key 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%. Loan period = 10 years. Project economic life = 25 years. Property tax rate of $11.70/$100 of assessed value. Depreciation under Modified Accelerated Cost Recovery System (MACRS): Depreciation period considered is 15 years. Key assumptions (with incentives): Accelerated depreciation under Modified Accelerated Cost Recovery System (MACRS) 5 year schedule. Federal investment tax credit = 10% of **total installed** cost in year 1 after 2007. Note currently the incentive level is 30%, but this is due to expire in 2007.

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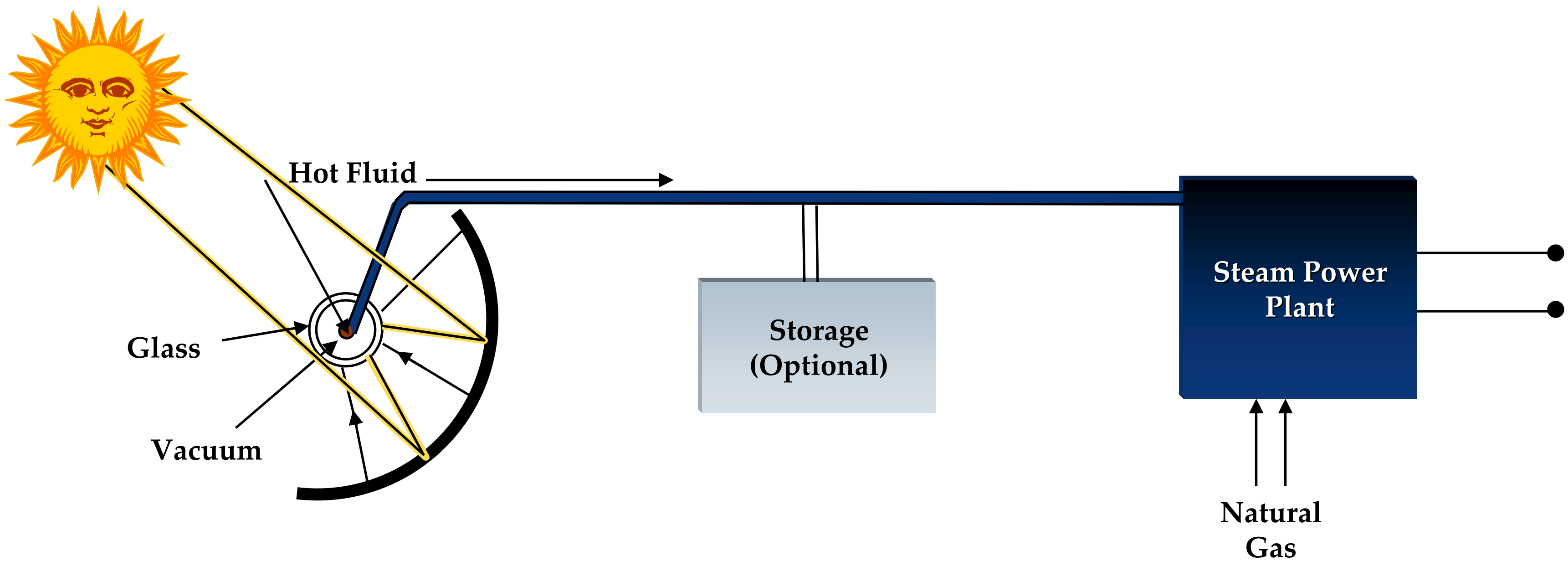
All solar thermal electric (STE) processes use concentrated solar energy to raise the temperature of a heat transfer fluid.

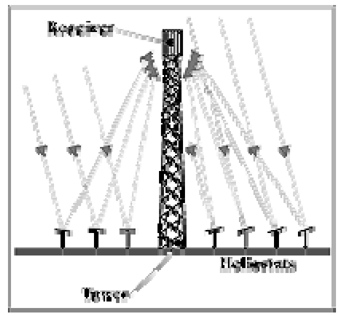


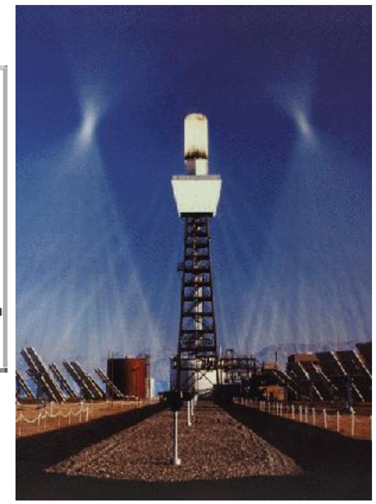
"Co-firing" with natural gas is commonly considered in order to stabilize operation and ensure a dispatch capability.

Solar thermal electric technologies convert solar energy into heat for use by a turbine generator or heat engine.

Three Basic Solar Thermal Electric Technologies

Parabolic Trough





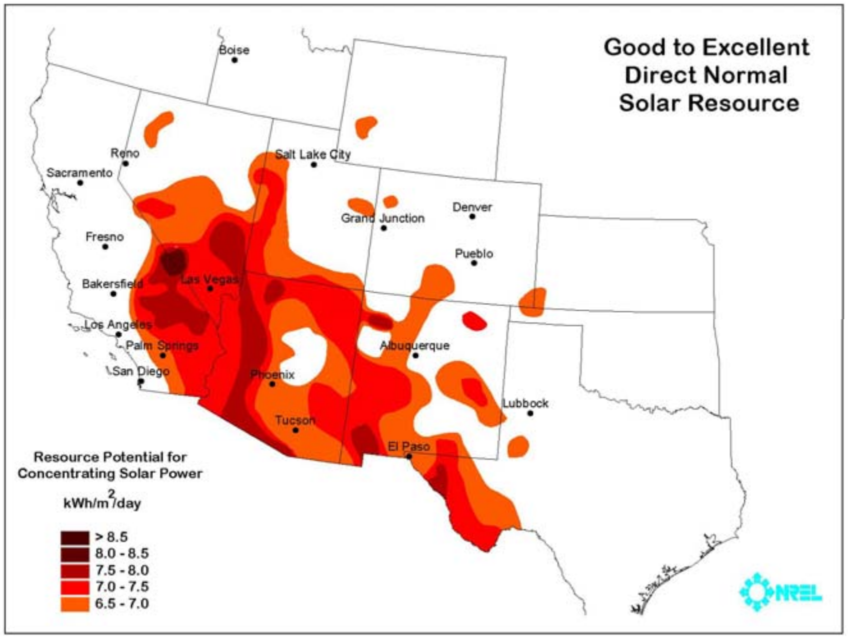
Power Tower

Solar Dish

Each technology employs some type of concentrator to focus energy on a receiver that contains an oil or another fluid that is heated.

AZ has excellent solar resources to both flat plate and concentrating solar power technologies.

Resource Potential for Concentrating Solar Power (kWh/m2/day)



Source: National Renewable Energy Laboratory.

NAVIGANT CONSULTING

The National Renewable Energy Laboratory estimates the technical potential for concentrating solar power at ~2.5 GW in Arizona.

State	Land Area (mi^2)	CSP Capacity[1] (MW)	CSP Generation Capacity (GWh)
AZ	19,300	2,467,700	5,836,500
CA	6,900	877,200	2,074,800
CO	2,100	271,900	643,100
NV	5,600	715,400	1,692,200
NM	15,200	1,940,000	4,588,400
TX	1,200	148,700	351,800
UT	3,600	456,100	1,078,900
Total	**178,400**	**6,877,000**	**16,265,700**

1. Includes parabolic trough, power tower, dish engine, and concentrating PV

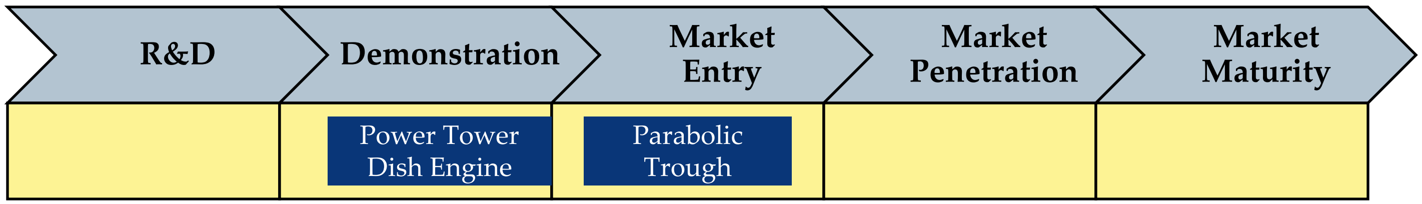
Source: WGA Solar Task Force – Central Solar Working Group, Draft Report, July 2005 and confirmed via interview with, Mark Mehos, NREL, February 2006.

Solar thermal electric technologies will eventually use thermal storage or natural gas hybrids that can result in capacity factors of > 40%.

Advantages	Disadvantages
• No emissions, except when combined with natural gas capability in hybrid configurations. • Potential high coincidence between peak output and peak demand. • Strong potential in Arizona due to abundance of direct sunlight. • Large scale relative to photovoltaics, with plant size ranging from 25 kW (dish Stirling) to 50 MW or more (dish and trough systems).[1] • Uses some of the same technologies as conventional central power plants (steam turbine generators), accelerating the learning curve. • The use of thermal storage or natural gas hybrids (using gas turbines) eventually will soon result in capacity factors >40%.	• High first costs relative to competing technologies such as simple and combined cycle gas turbines • Transmission/distribution systems need to be developed to transport power from good solar sites to load centers • Large land requirements (about 5 acres per MW for trough or dish Stirling) • Central station solar applications (such as trough, Power tower, and in some cases dish engines) compete with wholesale electricity costs. PV technologies by contrast generally compete with retail power at the end use.

1. Tower systems have the potential for up to 200MW in 10 years

Parabolic trough costs need to further decline, and solar dish engine costs need to decline from the present hand-built level of production.



Development Issue	Description
Performance	• Trough: Heat Collection Element: new coatings and better reliability. Improve collector/mirror designs. Advanced heat transfer fluids that do not degrade at 400^{o}C and that have a low freezing point and viscosity. Temperature increase to 500^{o}C for storage applications and tower technology to 650^{o}C. • Stirling engine reliability improvements and enhancements continue at Sandia
Land Use Implications	• Requires large land areas of 5 acres per MW for trough and dish Stirling • Emissions are zero unless combined with natural gas, minimizing impacts on local communities and climate
Noise and Visual Impacts	• Visual impacts can be great, with large land areas covered with reflective surfaces • Noise can be associated with steam turbines and generators, but these are centrally located which helps minimize noise at the plant perimeter
Storage	• Not expected to be economically viable for troughs until after 2010. Spain is installing a 50 MW trough unit with 6 hrs of storage that is closing financing in 2006. Should be operational in 2007. • Now use two storage tanks with HX/oil. Goal in future is one tank and to put molten salt in the field.

Source: NCI based on interview with National Renewable Energy Laboratory, February 2006 and input from Bob Liden, Executive VP and General Manager, Stirling Energy Systems, September 19, 2006.

Dish engine technologies, in small deployment volumes, are costly and their performance in large power plant applications is unproven.

Solar Dish Technology and Resource Availability	• Solar potential in AZ is high, but large-scale field experience is not yet proven • Several experimental dish/Stirling units operating, each ~10-25 kW in size with 38 foot diameter dish. Active development of multi 100 MW systems. • System efficiencies of nearly 30% have been achieved, higher than either trough or tower systems. Typical efficiencies are around 22 - 24%. Reliability issues. • Use very little water – less than 1% of the water required for steam-driven plants • Stirling Energy Systems (SES) in Phoenix AZ is the key remaining U.S. player, with six units operating in demonstration mode at Sandia. There is also one 25 kW system in Johannesburg purchased by ESKOM, and a 25 kW system at University of NV at Las Vegas. – Have PPA with Southern California Edison (Edison International) for 500 MW with 350 MW option. Plant will be in Mohave Desert and PPA with San Diego Gas & Electric (Sempra) for 300 MW with 600 MW option – Total potential is 1,750 MW (70,000 units) to aid with mass production that is needed to reduce cost
Economic Issues	• High efficiency is offset by small system size, which results in high capital costs. 2006 installed cost estimated at $8,000/kW without mass production.[1] • Economic data are not publicized for dishes, but SES has provided some ballpark figures based on their experience and work with equipment suppliers.

[1] Source: NCI based on interview with National Renewable Energy Laboratory, February 2006; the Wall Street Journal, *Solar's Day in the Sun*, November 17, 2005; input from Bob Liden, Executive VP and General Manager, Stirling Energy Systems, September 19, 2006.

Reliability improvements and significant cost reductions are needed for dish engine systems to be viable.

Advantages

- Smaller unit sizes can be used for distributed generation (<75kW) where it would compete with retail electricity improving its potential economic attractiveness.
- Uses small Stirling or Brayton cycle engine for power generation, both of which can be hybridized with natural gas to extend operation.
- Higher temperature (720^{o}C) than trough technology.
- Currently offers the highest solar to electric efficiency.
- Technology has the support of the Western Governors' Association

Challenges

- Stirling engines demonstrated, but not yet commercialized
- Reliability and performance improvements still needed:
  - Dish: increase mirror area
  - Engine: improve generators, seals, and Δt
- O&M costs are unknown for large deployment of systems and overall economics are not solidly established
- Small system size limits potential for decreased costs beyond economies of production
- Initial capital costs are estimated at $8,000/kW.

Sources: NCI based on Design News, *Sun Rises on Solar*, January 9, 2006 and input from Bob Liden, Executive VP and General Manager, Stirling Energy Systems, September 19, 2006.

Solar dish Stirling economics are still somewhat unproven. Below are some estimates of their economics.

	Solar Dish Stirling Economic Assumptions for Given Year of Installation			
	2006	**2010**	**2020**	**2025**
Plant Capacity (MW/year)	15	15	15	15
Total installed cost ($/kW)[1]	$6,000	$4,000	$2,000	$1,300
Non-Fuel Fixed O&M ($/kW-yr)[3]	$200	$80	$20	$15
Capacity Factor (%) – High Insolation[2]	23%	23%	23%	23%
Project Life (yrs)	25	25	25	25
CO_2 (lb/kWh)	No Air Emissions			
NOx (lb/kWh)				
SOx (lb/kWh)				

1. SES cost estimates assume close to 750 MW build rate to achieve the low cost pricing. The performance reliability of their product has not been verified, so NCI has not used SES claims.
2. 23% is for Phoenix
3. Includes items such as the receiver engine and gas working fluid costs

Source: Navigant Consulting, Inc. estimate based on interviews with NREL and Herb Hayden, APS February 2006.

Note: 25 kW dish installations (without 15 MW volume production) would result in installed costs of $8,000/kW today.

NAVIGANT CONSULTING

Stirling Energy Systems (SES) provided cost projections to NCI. Below are SES projections assuming scale up targets are met.

	Solar Dish Stirling Economic Assumptions for Given Year of Installation			
	2006	**2010**	**2020**	**2025**
Plant Capacity (MW/year)	15	250	250	250
Total installed cost ($/kW)	$6,000	$2,000	$1,500	$1,300
Non-Fuel Fixed O&M ($/kW-yr)[2]	$125	$8	$8	$8
Capacity Factor (%) – High Insolation[1]	25%	25%	25%	25%
Project Life (yrs)	35	35	35	35
CO_2 (lb/kWh)	No Air Emissions			
NOx (lb/kWh)				
SOx (lb/kWh)				

1. 25% is for Phoenix
2. Includes items such as the receiver engine and gas working fluid costs

Source: Bob Liden, Executive VP and General Manager, Stirling Energy Systems, September 19, 2006.

NAVIGANT CONSULTING

Parabolic trough is potentially an attractive renewable energy option for AZ applications.

Technology and Resource Availability

- Parabolic trough technology is the only solar thermal technology with years of operating commercial units. Expected operating life is 30 years. Existing plants are often natural gas hybrids, using gas fired boilers to supplement solar energy.
- 354 MW of trough technology has been operating in CA since mid-1980s; 64 MW Solargenix trough installations are planned in NV with ribbon cutting February 2006, and a 50MW trough plants with 6 hr storage in Spain by end of 2007. Spain unit is currently closing financing.
- Parabolic trough capacity factors are 25-29% without storage; 38-42% expected with 6 hours of storage by 2010 as molten salt storage technology is advanced.
- Efficiency is 14%, rising to 16% over the next 10 years. Optimum project size is 50 MW, but 30-80 MWe are commercialized.

Economic Issues

- The LCOE for parabolic trough is currently 10-15¢/kWh (with incentives), nearly 2-3x the cost of wholesale power.
- Many projects get stalled in planning due to the large capital outlay ($3,900/kW no storage). This cost is expected to drop to $3,200/kW by 2020 with 6 hours of storage.
- Advances in storage technology will improve economics by increasing the capacity factor; similarly, gas turbine hybrid systems can also extend operating hours.

Parabolic trough is technically viable, and field performance has been proven.

Advantages

- Most advanced and proven solar thermal technology
- North-South tracking system is less complex than the 2-axis movement required by power tower and dish engine
- Long operating life (30 years)
- Potential for hybrid with natural gas improves economics and dispatchability
- The LCOE will decline over time as storage capability extends operating hours
- Technology has the support of the Western Governors' Association

Challenges

- High initial capital cost today at $3,800/kW without storage
- Transmission cost of bringing power into load centers may be high.
  - Costs of extending transmission lines $500,000 - $1 million per mile for 230 – 500 kV lines
- Unresolved heat storage issues. System may need to reach higher temperatures (450-500˚C) to make storage practical
- Heat storage capability will increase system cost by ~$350-400/kW, but improvements in the structure, receiver, and reflector costs will help bring overall system price down.
- Historically have used wet cooling tower for cooling. Cooling tower make-up represents 90% of raw water consumption. Steam cycle make-up 8% and mirror washing 2%. Availability of water can be an issue.
  - 2.8m^3 per MWh[1]
- 5 acres of land for each MW (no storage)[1]

1. Arizona Utility Estimates, September 2006.

The capacity factor for solar parabolic trough could increase dramatically with the introduction of storage by 2010.

	Solar Parabolic Trough Economic Assumptions for Given Year of Installation (2006$)			
	2006	**2010**	**2020**	**2025**
Plant Capacity (MW/yr)	50	50	50	50
Total Installed Cost ($/kW)[1]	$3,900	$4,500	$3,200	$2,600
Non-Fuel Fixed O&M ($/kW-yr)	$60	$40	$35	$35
Capacity Factor (%) – Phoenix[2]	27%	38%[2]	38%[2]	38%[2]
Project Life (yrs)	30	30	30	30
CO2 (lb/kWh)	No air emissions			
NOx (lb/kWh)				
SOx (lb/kWh)				

1. A 50 MW system with 6 hrs of storage is being installed in Spain and should be operational by the end of 2007. Increasing the plant capacity to 100 MW would reduce costs 10%.
2. Assumes 6 hours of molten salt storage starting in 2010.

Source: Navigant Consulting, Inc. estimates based on Sargent and Lundy, “Assessment of Parabolic Trough and Power Tower Solar Technology Cost and Performance Forecasts,” 2003 and interview with Mark Mehos and Hank Price, NREL, February 2006.

The capability of Tower technology could be enhanced with storage.

Power Tower Technology and Resource Availability	• The biggest technical issue is the molten salt receiver. – The molten salt receiver for Solar Two was developed by Boeing's Rocketdyne division. – Rocketdyne was sold to Pratt and Whitney (part of United Technologies). – Rocketdyne is currently working with ESKOM on the development of a 100MW tower project in South Africa – Sener had developed a design for the Solar Tres plant • The PS 10 system (11 MW Tower system in Spain) has an estimated capacity factor of 20%. This could be increased to 75% with a molten salt storage system. • Molten salt systems require large amounts of energy for heating because sodium nitrate freezes at ~580^{0}F. Solar Two was not a net producer of electricity because of its heating power requirements. • Molten salt can be heated to 1000^{o}F, the utility standard steam temperature. • Land use for the PS10 plant is 11 acres per MW with no storage.
Economic Issues	• Lack of commercial history makes raising capital difficult. • Advances in molten salt receiver and storage will increase the capacity factor and decrease the LCOE • Large plant sizes (100 to 200 MW) can allow for economies of scale to reduce costs.

Switching to molten salt as a working fluid can increase the attractiveness of Power Tower systems.

Advantages	Disadvantages
• Higher temperature working fluid (~1000°F) than trough and Dish engines allows for higher efficiencies. • If steam used as working fluid, less heat exchange losses compared to trough • Higher efficiency storage than trough – Working fluid is at a higher temperature and is also a storage medium • Heliostats can be for astronomical observation at night. This is done with Solar Two. • Tower systems have potential for up to 12 hours of storage with molten salt, resulting in 65%+ capacity factors. • Large plant sizes can allow for economies of scale to reduce costs. This is not as feasible for Dish engine systems.	• Tower technology demonstrated, but not yet commercialized in comparison to trough • Focal efficiency is worse than trough because of central design. Significant losses in winter months. • O&M costs are unknown and overall economics are not solidly established. Trough systems have established costs. • Two axis tracking for heliostats requires more complex controls than trough's single axis system. • Water requirements for power block reduces amount of available land for siting • Central generation design requires longer construction times compared to Dish engine systems. • Tower systems require extremely flat land (less than 1% slope). Dish systems do not have this requirement.

Power Tower economics have potential, but there are significant near-term development risks, so more detailed analysis was not undertaken.

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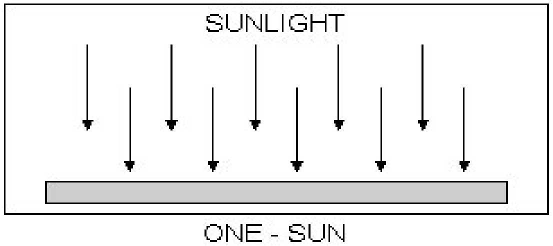
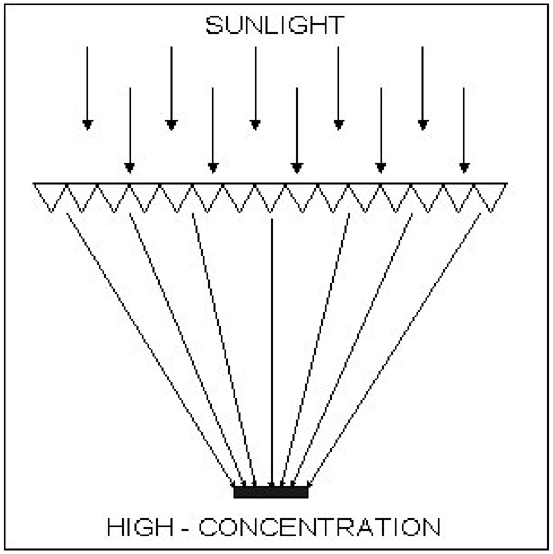
Concentrator photovoltaics (CPV) use lenses or reflective collectors to focus solar energy (typically > 100 suns) on a reduced area of solar cell material that is more efficient.





From www.amonix.com

Arizona Public Service photo: Prescott 35 kW, dual axis tracking system.

CPV is an early stage technology that holds the promise of higher efficiency PV in the 2 kW-5 MW size range.

Technology and Resource Availability

- CPV technology is in the prototype stage and under development at NREL, several universities, and private companies In 2004, 1 MW was installed, but Australia will be installing 150 MW in the next few years.
- Need to demonstrate performance reliability and 20 yr life to be competitive.
- Amonix, key U.S. player, claims to need minimum production of 10 MW to be competitive[1].
  – Arizona Public Service (APS) and Amonix have worked together since 1995 and have >600 kW operating in AZ with 26% efficient cells/250x solar concentration
  – Amonix/Guascor JV to build a 10 MW/year assembly plant in Spain
- Sharp and Daido (Japan); Isophoton (Spain); Concentrix Solar (Germany); Concentrating Technologies and Pyron (US) using III-V multi-junction solar cells. Amonix and Solar Systems are testing III-V cells which are best for higher levels of concentration.

Economic Issues

- At production volumes of 10 MW/yr, silicon CPV could drop below $3,000/kW.

Sources: Fraunhofer Institute, *Concentration PV for Highest Efficiencies and Cost Reduction,* June 2005; Boeing Spectrolab interview, Aug 2004 and Amonix interview Feb. 2006; Fraunhofer Institute for Solar Energy Systems, June 2004; "The Role of CSP in Filling APS' Future Solar Energy Needs", presentation by Herb Hayden, May 2005. [1] Interview with Amonix, February 2006.

CPV offers interesting advantages, but has technical challenges to overcome.

Advantages	Challenges
• There is good availability of direct solar resources in Arizona • CPV systems increase the power output while reducing cell area requirements • Solar cell efficiency increases under concentrated light • Because smaller PV areas are needed, smaller cells can be used which are less expensive to produce than large-area cells • MW sizes are possible using PV concentrators of up to 1,000 suns • Tracking the sun (with dual axis trackers) increases the energy produced (in kWhs) per kW compared with fixed flat plate	• Concentrating optical systems are more expensive than the simple glass or laminates used for flat plate PV • CPV systems have to track the sun daily throughout the year, which requires tracking mechanisms and more precise controls • Concentrators cannot focus diffuse light, which represents ~20% of available solar radiation. Flat plate PV utilizes both direct and diffuse light • Concentrated light can overheat PV cells, reducing their efficiency. As a result, CPV solar cells have to be kept cool, potentially adding to the cost. Highly conductive materials such as copper can be placed behind the cells, or air cooling can be used • 10 acres per MW for Amonix technology

Source: Navigant Consulting, Inc. based on Renewable Energy World, *Concentrating PV Prepares for Action*, Volume 8, September –October 2005 Issue and interview with NREL, February 2006.

Installed system costs for concentrating PV are high due to small production volumes.

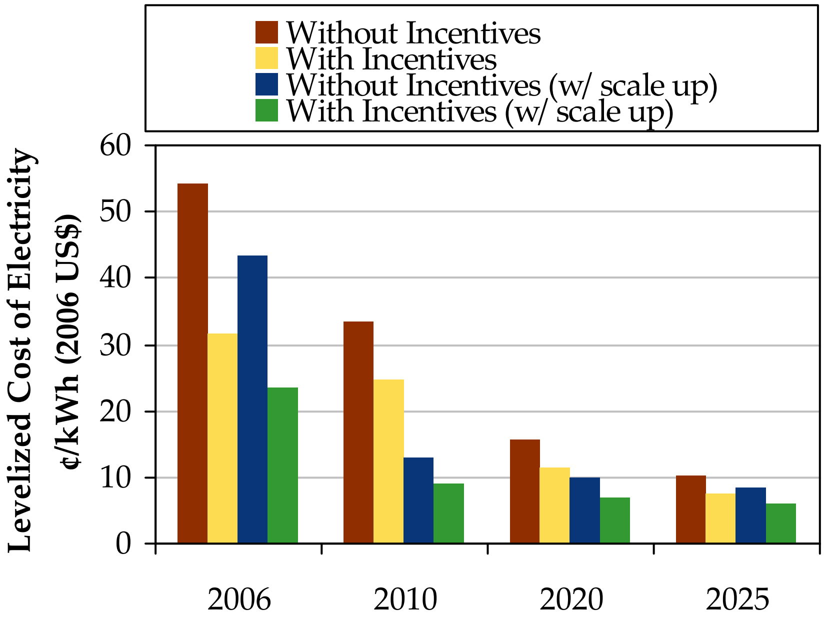
	Concentrator PV (Amonix) Economic Assumptions for Given Year of Installation (2006$)			
	2006	**2010**	**2020**	**2025**
Plant Capacity (MW/yr)	15	50	100	100
Total Installed Cost ($/kW)	$5,000	$4,000	$2,500	$2,100
Non-Fuel Fixed O&M ($/kW-yr)	$45	$35	$10	$8
Capacity Factor (%) – Phoenix	23%	23%	23%	23%
Project Life (yrs)	25	25	25	25
CO2 (lb/kWh)	No air emissions			
NOx (lb/kWh)				
SOx (lb/kWh)				

Source: Navigant Consulting, Inc. estimates based on interview with Amonix, February 2006 for installed costs, capacity factors and O&M. Capacity factors also based on interviews with NREL and APS February 2006.

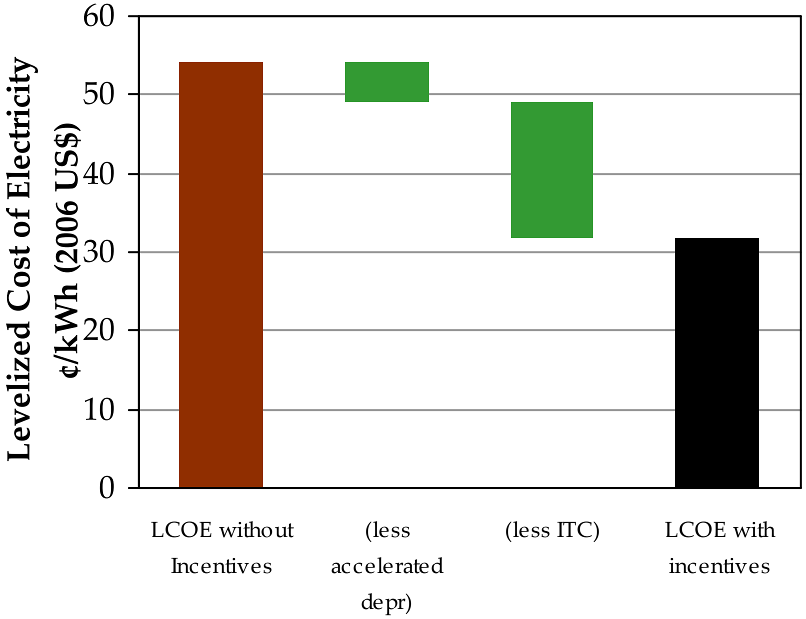
Dish Engine economics are currently expensive, but future expectations are that economics will improve with production volumes.

AZ Levelized Cost of Electricity for Dish Engine, Developer Financed

With and Without Federal Incentives for Given Year of Installation



With Incentives – 2006 Installation, Phoenix Insolation



Key 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 = 25 years. Property tax rate of $11.70/$100 of assessed value.

Key assumptions (with incentives): Accelerated depreciation under MACRS 5 year schedule. Federal investment tax credit = 10% of **total installed** cost in year 1 after 2007. Note currently the incentive level is 30%, but this is due to expire in 2007. Source: NCI analysis assuming data from NREL without incentives and from Bob Liden, Executive VP, Stirling Energy Systems, September 19, 2006.

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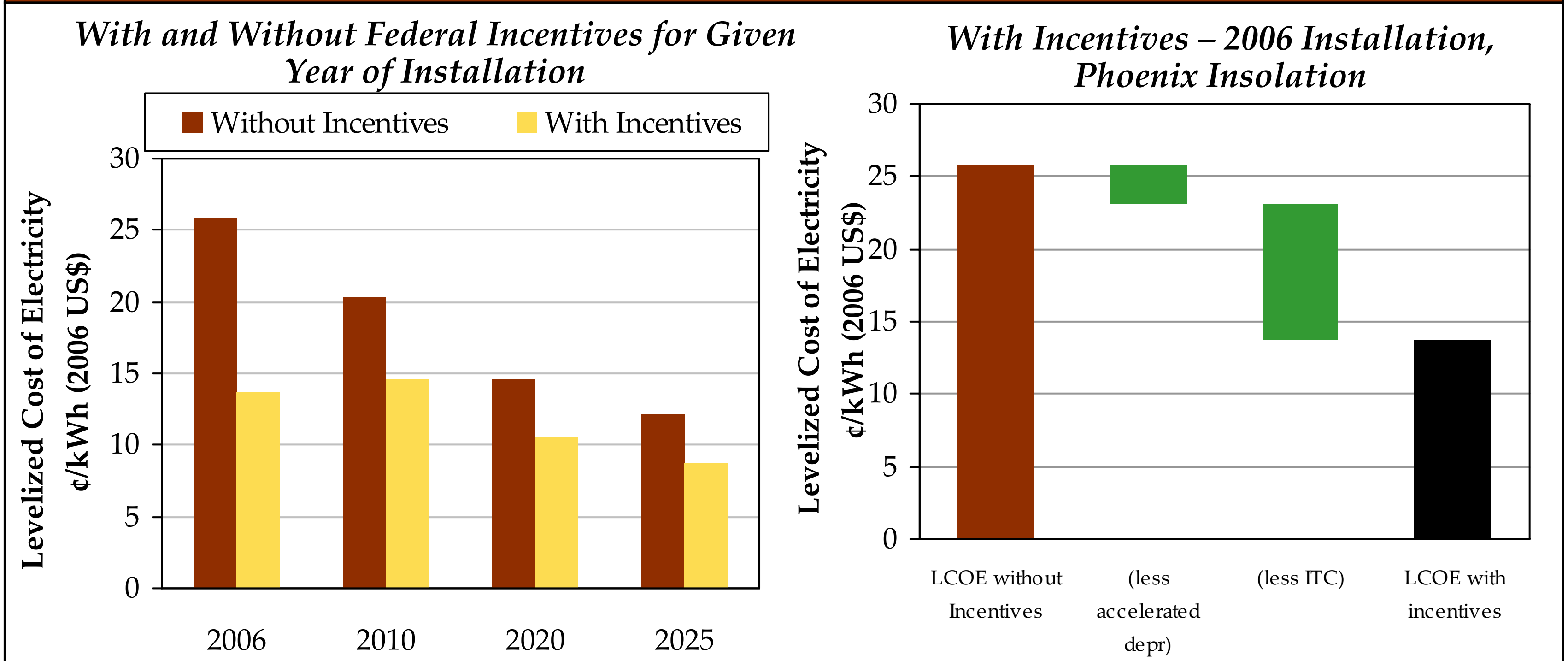
Assuming only conservative Federal incentives, trough technology may become attractive after 2010.

AZ Levelized Cost of Electricity for Solar Parabolic Trough, Developer Financed

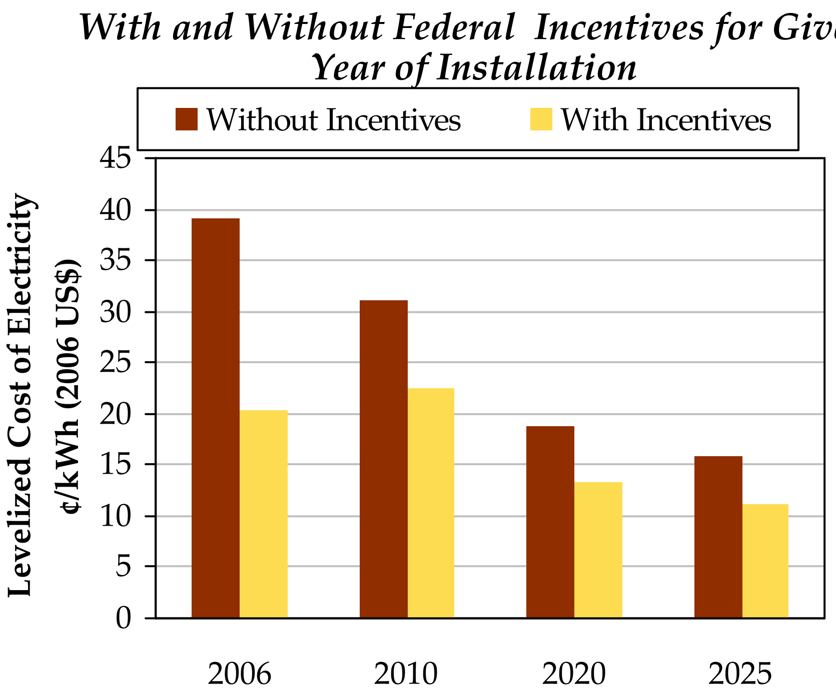


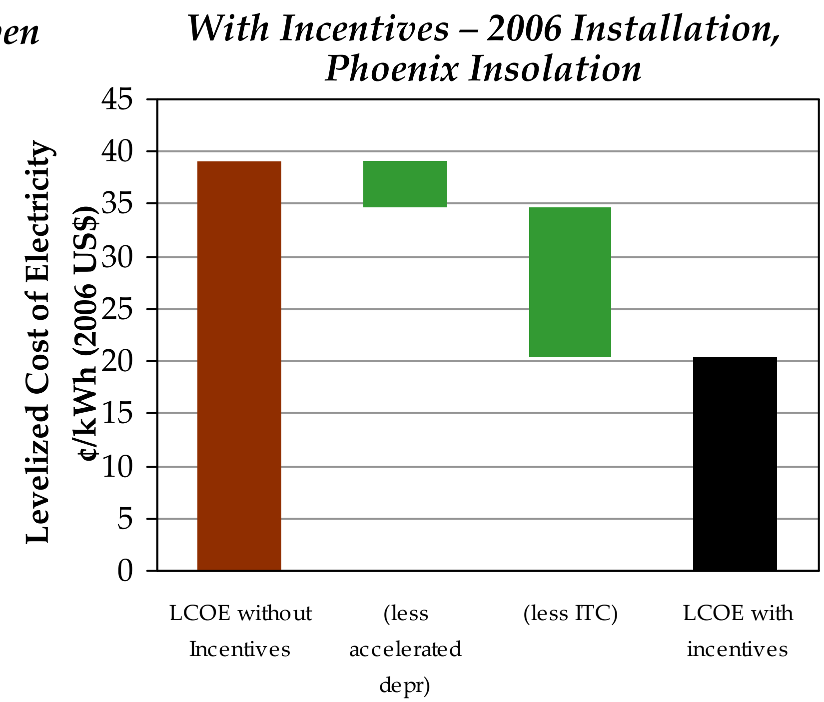
Key assumptions (without incentives): Debt equity ratio: 55%:45%, cost of equity = 15%, cost of debt = 8%, Marginal federal + state income tax = 41%. Insurance = 0.5%, Depreciation under Modified Accelerated Cost Recovery System (MACRS): Depreciation period considered is 15 years. Loan period = 10 years. Project economic life = 25 years. Property tax rate of $11.70/$100 of assessed value.

Key assumptions (with incentives): Accelerated depreciation under MACRS 5 year schedule. Federal investment tax credit = 10% of **total installed** cost in year 1 after 2007. Note currently the incentive level is 30%, but this is due to expire in 2007. Source: NCI analysis.

If one assumes the minimum amount of Federal incentives, the LCOE for concentrating PV may become attractive after 2010.

LCOE for Concentrating PV (Amonix), Developer Financed Conservative Incentive Assumptions





Key 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%, Loan period = 10 years. Project economic life = 25 years. Property tax rate of $11.70/$100 of assessed value. Depreciation under Modified Accelerated Cost Recovery System (MACRS): Depreciation period considered is 15 years. Key assumptions (with incentives): Accelerated depreciation under Modified Accelerated Cost Recovery System (MACRS) 5 year schedule. Federal investment tax credit = 10% of **total installed** cost in year 1. Note currently the incentive level is 30%, but this is due to expire in 2007. Source: NCI analysis.

The Solar Chimney is another concept being developed, but the technology is still in early stages of development.

Solar Chimney

- Produces a high capacity factor for a solar technology
- Simple principal of operation
- Remains unproven at large scale (200 MW)
- Limited experience building a tower this tall
- Would use "new" wind turbine technology (i.e., different from freestanding wind turbines) that are being custom designed and built for this application
  - While new, the turbines are based on well-proven, pressure-stage technology
- Land intensive relative to other renewable technologies
- Resistance to severe weather (high winds, tornados) and other natural disasters need to be tested
- Requires large scale-up for the technology to work and be economically attractive

The sun's radiation is used to heat a large body of air under an expansive collector zone, which is then forced by the laws of physics (hot air rises) to move as a hot wind through large turbines to generate electricity. A Solar Tower power station will create the conditions to cause hot wind to flow continuously through 32 x 6.25MW pressure staged turbines to generate electricity

Table of Contents

1	Project Scope and Approach
2	Policies Available for Solar
3	Solar Technology and Deployment Issues
4	**Opportunities**
5	Barriers and Risks
6	Solar Roadmap
	Appendix

Arizona's assets could support multiple opportunities for developing solar-related business in the state.

Arizona Has Significant Assets to Support Solar Deployment

- High levels of solar insolation
- Rapid growth
- Intellectual capability
- Central Southwest location
- State Trust Lands

Solar R&D

Micro-grids

Rooftop PV

Central Station Power

Manufacturing

To Provide Economic and Environmental Benefits

- Stable and economic energy
- Jobs
- Economic development
- Reduced emissions

The STAR facility is renown globally as a unique and excellent solar test and research center. AZ should capitalize on this unique position.

Solar Test & Research Center (STAR)

- In Tempe and serves needs of APS, manufacturers, scientists, engineers, & students
- Largest of its kind in the world and excellent reputation

Installations

PV – 5 MW

West Wetlands PV – 96 kW

Saguaro Trough – 1 MW

Prescott College – 10 kW

Cochise College Solar Heating & Cooling – 200 kW

APS Solar Energy

Solar Energy Customer Program

Project Sol: donated 5 2kW solar systems to education and performance monitored

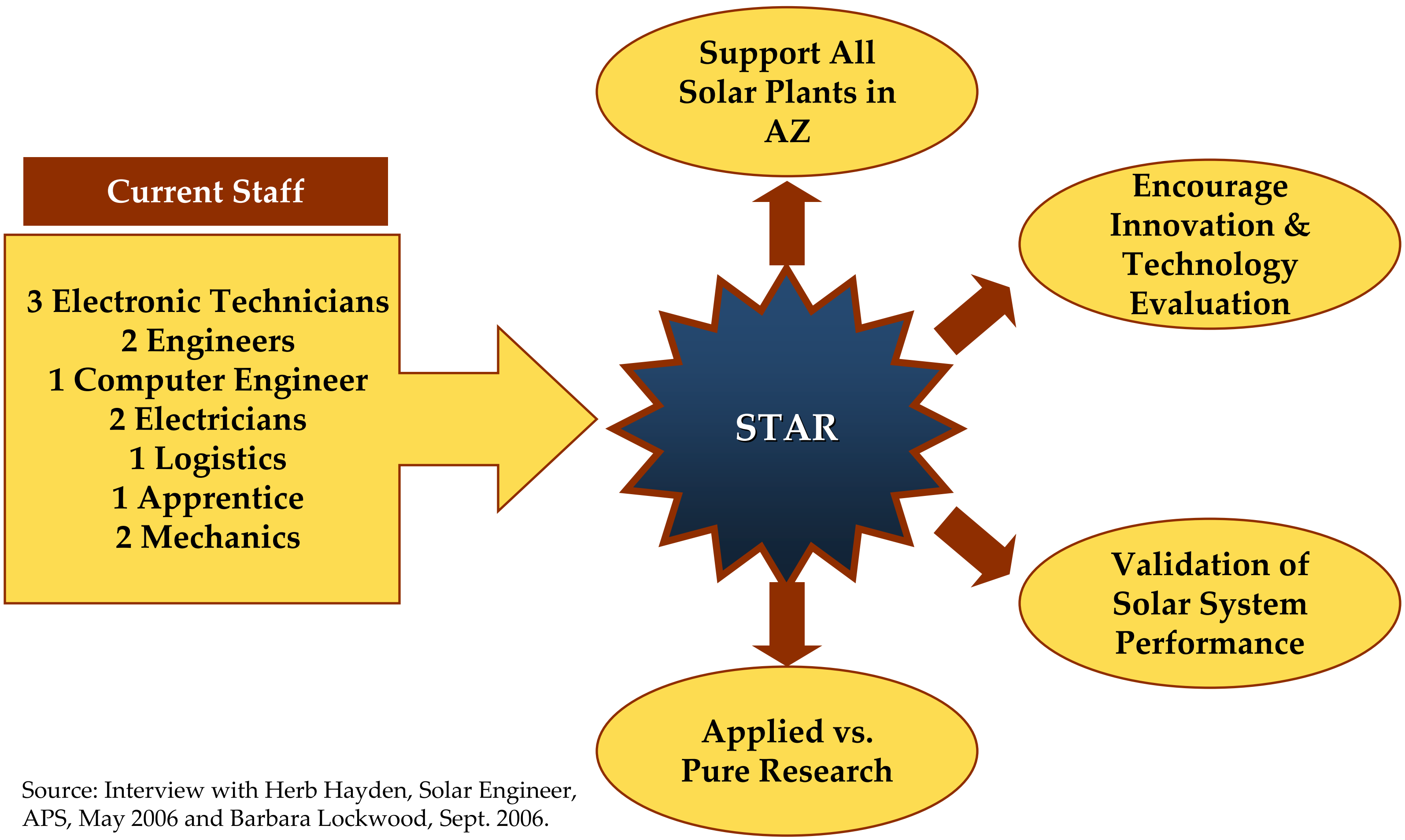
Solar Partners Incentive Program: $3/W for residential and $2.50/W for commercial. Cap of $500k per customer per year

Voluntary contributions where customers contribute $2.64 for 15 kWh blocks per month

Green: complete. Blue: under construction

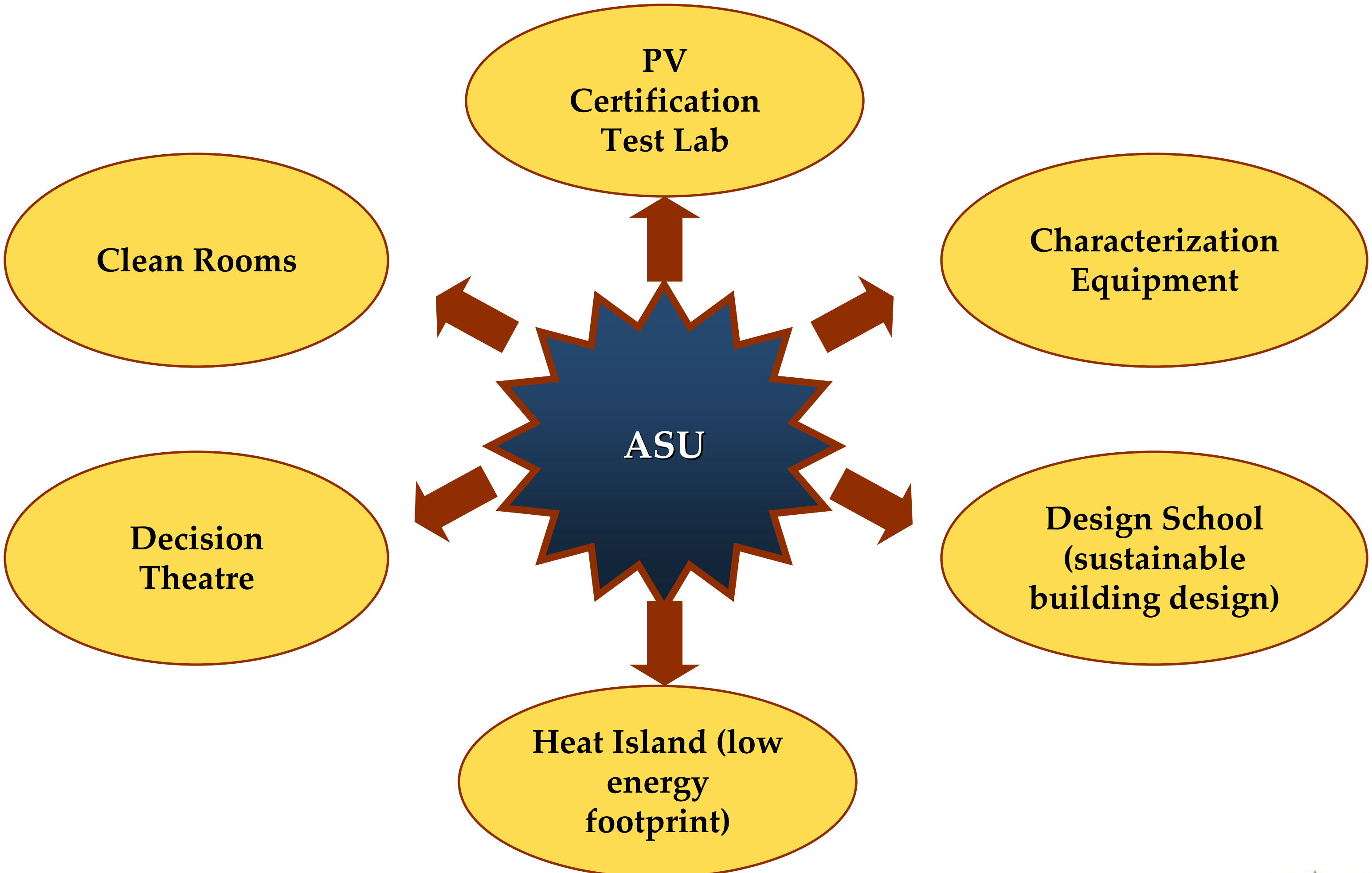
Source: Herb Hayden, Barbara Lockwood, Peter Johnston, APS, June and Sept. 2006.

STAR funding has decreased in recent years. New sources of funding should be explored.

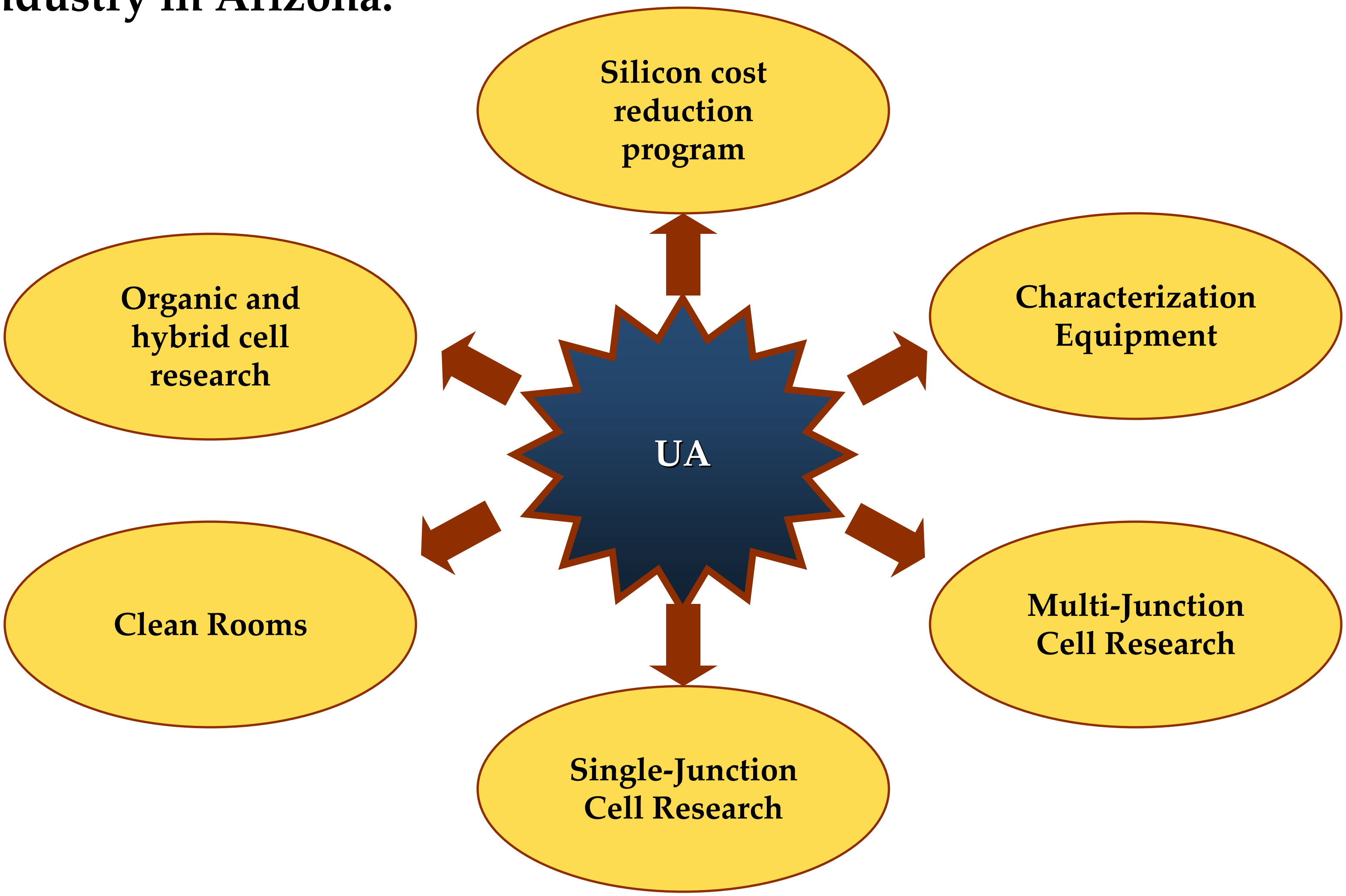


Source: Interview with Herb Hayden, Solar Engineer, APS, May 2006 and Barbara Lockwood, Sept. 2006.

ASU capabilities may need to be re-invigorated to support a large solar initiative in the state.



UA has several research programs and facilities to help grow the solar industry in Arizona.



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Opportunities » AZ University Coursework

Solar-Related Coursework Offered by Arizona's Higher Education Institutes		
University	**Course Name**	**Field**
Arizona State University	Environmental Rating Systems for Buildings	Architecture
	Applied Photovoltaics	Engineering
	Building Energy Analysis	Architecture/Engineering
	Energy Analysis and Techniques	Architecture/Engineering
	Environmental Control Systems	Architecture
	Energy Conversion and Applications	Engineering
Northern Arizona University	Energy, Ecology and You	Public Awareness
	Heat Transfer	Engineering
	Solar Engineering Analysis and Design	Engineering
	Energy Environment	Engineering
	Thermodynamics	Engineering
University of Arizona	Silicon Processing	Engineering
	Computer Energy Analysis	Architecture
	Advanced Computer Energy Analysis	Architecture
	Solar Utilization in the Built Environment	Architecture
Chandler-Gilbert Community College	Solar Energy	Public Awareness
Yavapai College	Solar Energy Systems	Construction
	Energy Efficient Buildings and Design	Construction
Coconino Community College	Solar Home Design	Construction
	Photovoltaics and Wind Power	Construction
Arizona State University	MS in Technology with a concentration in Environmental Technology Management	Engineering
Coconino Community College	Alternative Energy	Construction

Microgrids integrate loads and DERs in self-contained energy systems that can operate in parallel with the larger grid.

Microgrid Definition

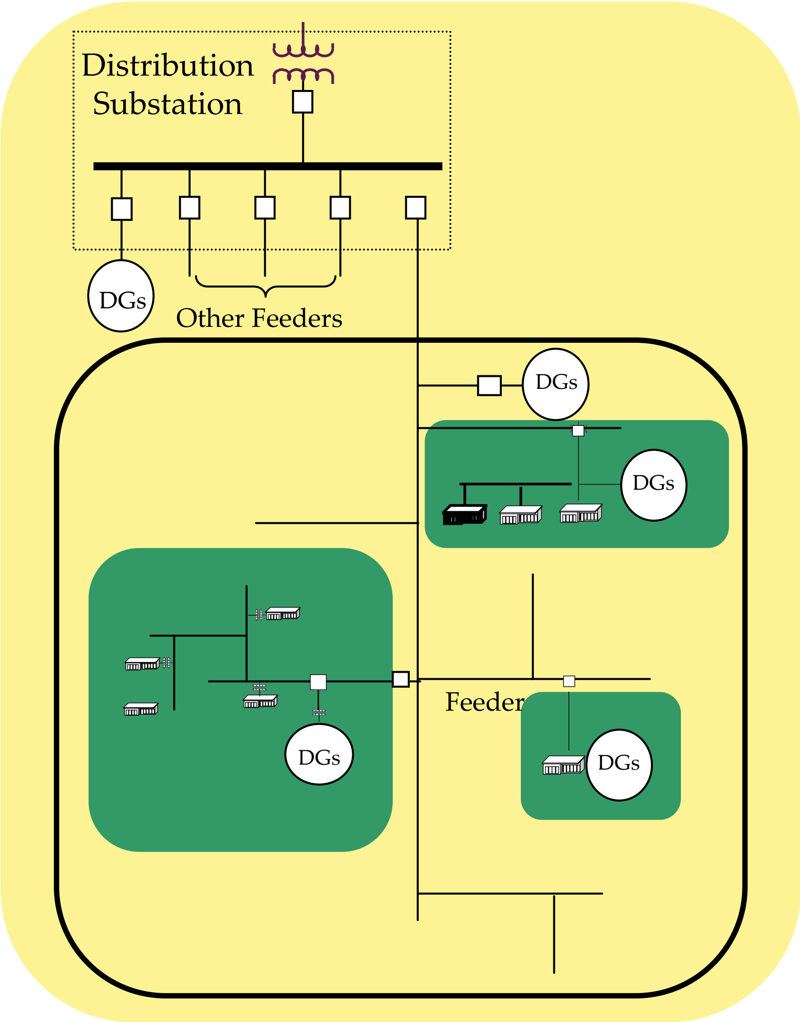
General Definition

A microgrid is an integrated energy system consisting of interconnected loads and distributed energy resources which as an integrated system can operate in parallel with the grid or in an intentional island mode.

Key Defining Characteristics

The integrated distributed energy resources are capable of providing sufficient and continuous energy to a significant portion of the internal demand. The microgrid possesses independent controls and can island and reconnect with minimal service disruption.

- **Flexibility** in how the power delivery system is configured and operated
- **Optimization** of a large network of load, local Distributed Energy Resources and the broader power system



The microgrid concept supports a compelling value proposition if technology and regulatory barriers can be overcome.

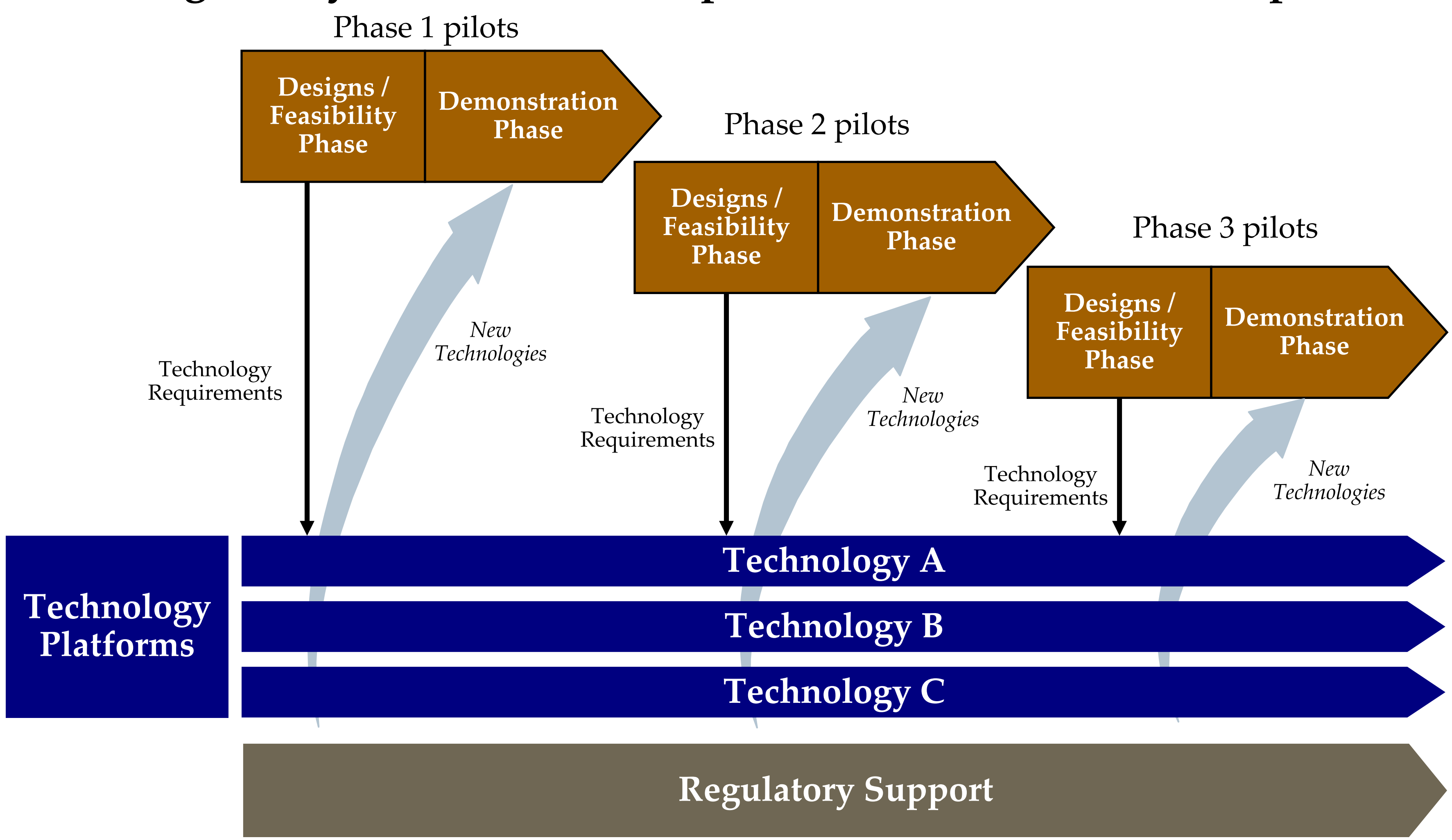
Microgrid Opportunities

- Microgrids can deliver several value propositions:
  - Reduced cost
  - Increased reliability & security
  - Green power
  - Service differentiation
  - Power system optimization.
- Market opportunities are driven primarily by reduction in energy cost and volatility
- Larger microgrids may offer the greatest opportunity for cost savings and other value propositions
- Market conditions and scenarios will dictate which vale propositions are most attractive to key stakeholders

Microgrid Challenges

- Current technology may meet many functional requirements, but overall cost and performance are insufficient for envisioned microgrids
- Complex value propositions beyond energy cost reduction, as well as larger microgrids, pose greater technology challenges
- Key technical challenges include:
  - System integration
  - Standards
  - Power electronics
  - Energy storage
  - Communications and control
- Overcoming regulatory barriers such as ownership and operating rights is critical.

A systematic program of pilots that design and demonstrate technology and regulatory models could be part of AZ R&D and roadmap.



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While Arizona has significant assets to support a solar R&D business, investment will be required to compete with established entities.

Strengths/Assets
- STAR
- PV certification center
- University facilities & professors
- Funds from RES?

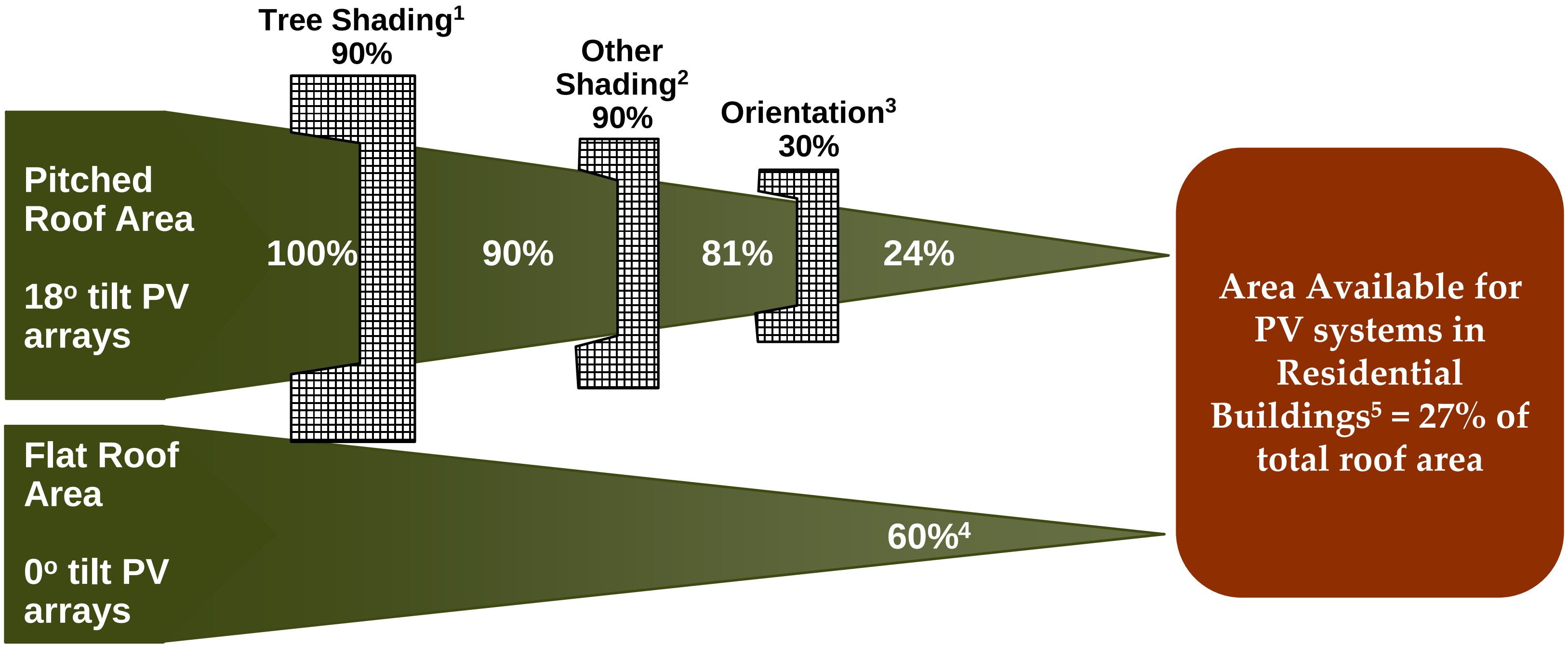
Opportunities
- DOE $170 million solar initiative, needs matching funds
- Significant R&D is required throughout entire value chain

Weaknesses
- Limited activity – primarily demonstration and testing as opposed to research
- Need to establish "Center(s) of Excellence"

Threats
- Established competition: NREL, University of California, Stanford, Ohio (Wright Center of Innovation)
- Need to make investments soon

DOE's $ 170 million solar initiative is a major opportunity to leverage Arizona investments to develop a capability and national leadership

The roof space available on *residential* buildings for PV installations is around 27% of total roof area.



1. Roof area available due to tree shading is around 90% for single homes and higher at 95% for townhouses Townhomes and other residential buildings are often higher and thus there would be less shading than for a detached house. Closely packed homes in high density neighborhoods allow little room for large trees to grow and shade roofs, compared to larger homes in low density neighborhoods.
2. Other shading may be due to chimneys, vent stacks and other roof obstructions.
3. Based on assumptions made for single homes, which account for 70% of the building stock. Assume that orientations from southeast clockwise around to west are appropriate for PV installations. For gable ended roofs with one long ridge line, assume that one of the pitched surfaces will face in the proper direction for 75% of the residences. If each surface is half the roof, 38% of the roof area can accommodate PV arrays. For hip roof buildings, one of four roof area will be facing in the right direction, or 25% of the roof area. The average of 38% and 25% is around 30%, which is what is assumed as the percentage of roof area with acceptable orientation.
4. See analysis of roof area availability for flat roof buildings on next page.
5. Assumes pitched roof accounts for 92% of total roof space, the balance 8% being flat roof space.
6. Note: The data are based on a study conducted by Navigant Consulting staff for a major U.S. utility company and adjusted for AZ specific based upon interview with Ed Kern of Irradiance, May 2006.

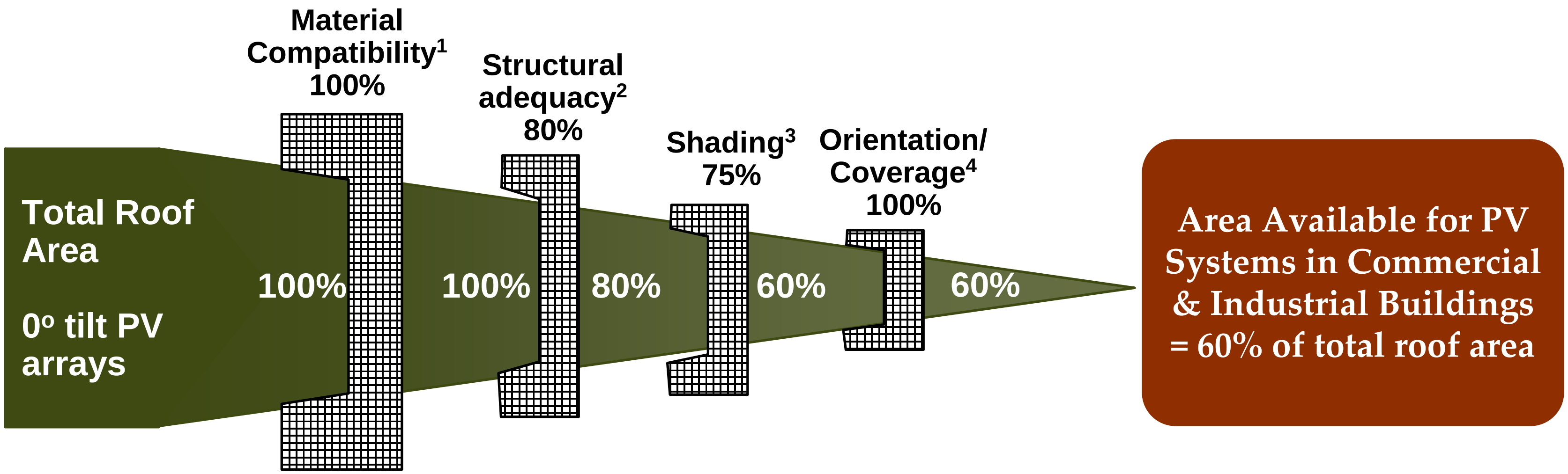
Not considering economics, the rooftop area available for *residential* PV could support ~7.5 GW of installations in 2025.

	Residential Roof Space and Solar PV Potential						
	Approx. Number of Homes[1,2]	Assumed Floor Space / Home (ft^2)[2]	Assumed Floors per Home[2]	Est. Total Roof Space (Million ft^2)[3]	Assumed % Available for PV[4]	Est. Roof Space for PV (Million ft^2)	Estimated Potential[5] (MWp)
2006	2,358,378[1]	1,433	1.65	2,048	27%	553	5,700
2010	2,540,643[1]	1,447	1.65	2,228	27%	602	6,210
2020	2,736,994[1]	1,484	1.65	2,461	27%	664	6,860
2025	2,948,520[1]	1,503	1.65	2,685	27%	725	7,480

Does not consider economics

1. Source: 2000 U.S. Census for number of homes and scaled with a 1.5% growth rate.
2. Source: U.S. Census Bureau, *American Housing Survey for the United States: 2003*, for homes in the Western United States
3. Calculated by multiplying column 1 times column 2 and dividing by column 3.
4. See assumptions on following pages.
5. Based on a 3kW system requiring approximately 300 ft^2 of space. This is based upon a module size of 5.25'X2.6' and a packing factor of 1.25 to account wiring, inverters, junction boxes, access to modules, etc.

The roof space available in *commercial* buildings for PV installations is around 60% of total roof area.



1. Roofing material is predominantly built up asphalt or EPDM, both of which are suitable for PV, and therefore there are no compatibility issues for flat roof buildings.
2. Structural adequacy is a function of roof structure (type of roof, decking and bar joists used, etc.) and building code requirements (wind loading, snow loading which increases the live load requirements). Since snow is not a design factor in most areas of Arizona, it is assumed at 20% of the roofs do not have the structural integrity for a PV installation.
3. An estimated 5% of commercial building roofing space is occupied by HVAC and other structures. Small obstructions create problems with mechanical array placement while large obstructions shade areas up to 5x that of the footprint. Hence, around 25% of roof area is considered to be unavailable due to shading. In some commercial buildings such as shopping center, rooftops tend to be geometrically more complex than in other buildings and the percentage of unavailable space may be slightly higher.
4. Flat arrays are assumed. If tilted arrays were assumed, then more space would be required per PV panel due to panel shading issues, which would reduce the roof space available.
5. Note: The data is based on a study conducted by Navigant Consulting for a major U.S. utility company adjusted for AZ specific based upon interview with Ed Kern of Irradiance, May 2006.

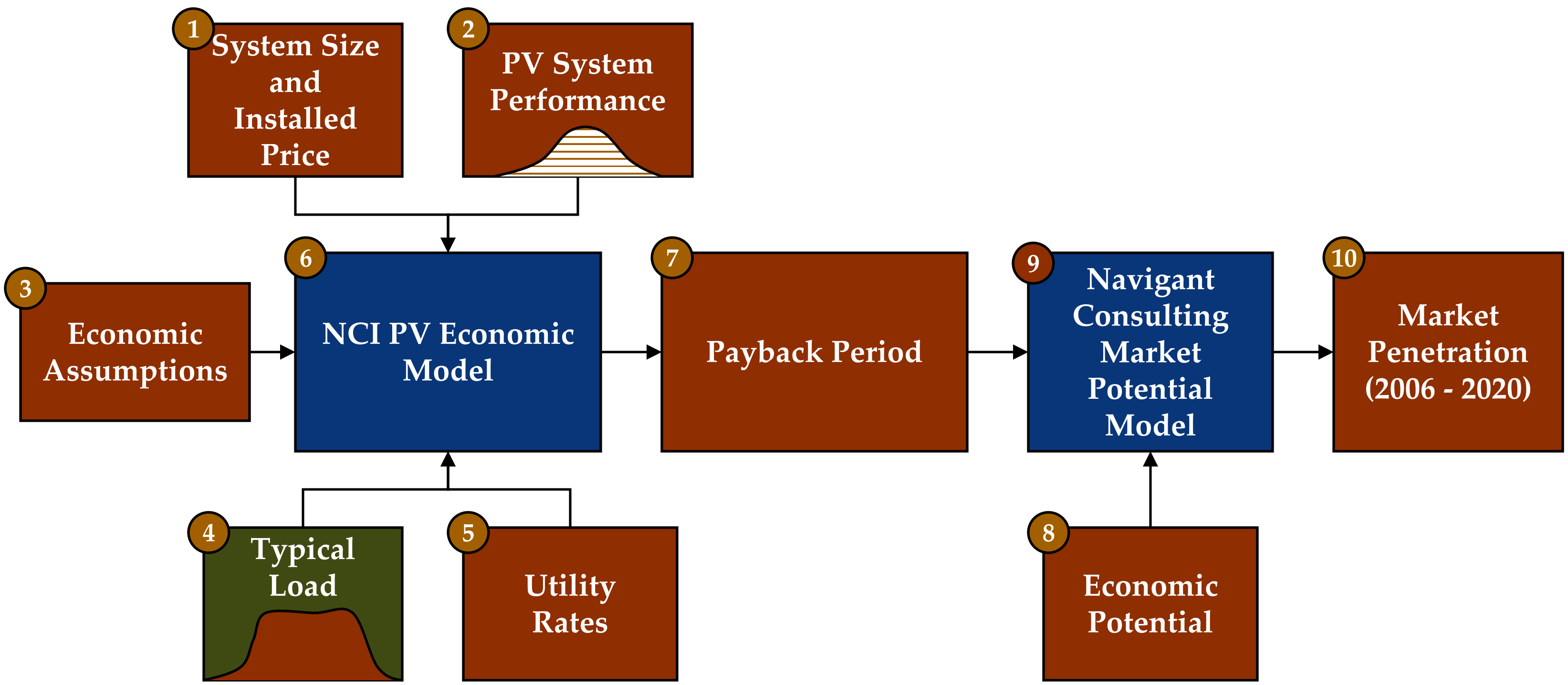
Not considering economics, the rooftop area available for commercial building PV could support ~7 GW of installations in 2025.

Commercial Roof Space and Solar PV Potential						
	Approx. Floor Space (Million ft^2)	Assumed Average # of Floors	Estimated Total Roof Space (Million ft^2)[3]	Assumed % Available for PV[4]	Est. Roof Space for PV (Million ft^2)	Estimated Potential[5] (MWp)
2006	1,284[1]	1.5[1]	856	60%	514	5,303
2010[2]	1,363[2]	1.5	908	60%	545	5,629
2020[2]	1,582[2]	1.5	1054	60%	633	6,532
2025[2]	1,704[2]	1.5	1136	60%	682	7,037

Does not consider economics

1. Source: State of Arizona, Department of Commerce, Energy Office, May 2006 and scaled with a 1.5% growth rate.
2. Calculated by dividing column 1 by column 2
3. See assumptions on following pages.
4. Based on 250 kW system requiring 25,000 ft2 or ~100 sq. ft. per kW. This is based upon a module size of 5.25'X2.6' and a packing factor of 1.25 to account wiring, inverters, junction boxes, access to modules, etc.

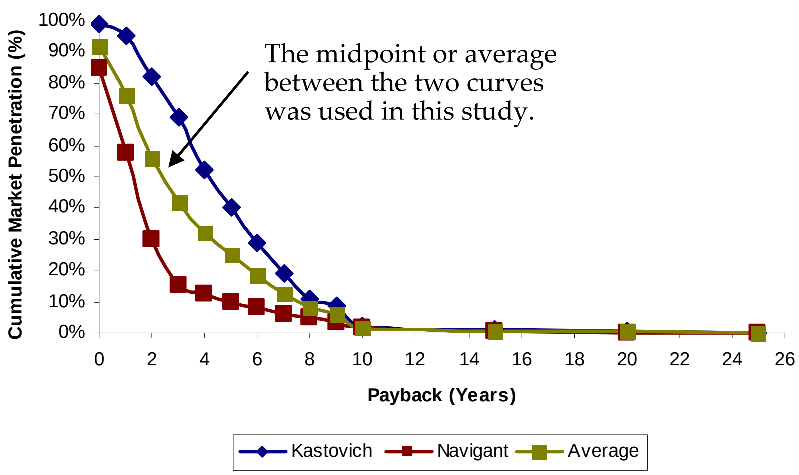
The approach used to assess the market penetration for customer-sited residential and commercial PV is illustrated below.



Note: For customer-sited PV, the analytical approach in step 9 in the flowsheet was used to estimate the market penetration, as described in the following pages.

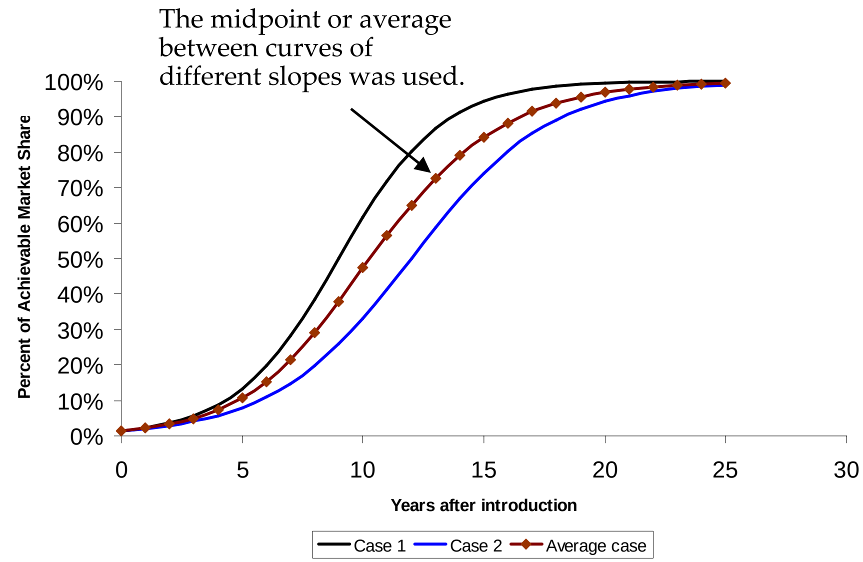
The market penetration potential is based on the payback period to the customer, and the rate of penetration is based on an S-Curve.

Payback vs. Cumulative Market Penetration Curves



- The curves provide the cumulative market penetration 10-20 years after product introduction, as a function of payback.
- The Kastovich curve is more aggressive than the Navigant curve: a midpoint between the two was thus considered in the analysis.

Typical S-Curve



- The S-Curve provides the rate of adoption of technologies, which is a function of the technologies characteristics and market conditions.
- An average of two curves was used, given the many factors that will impact penetration of PV.

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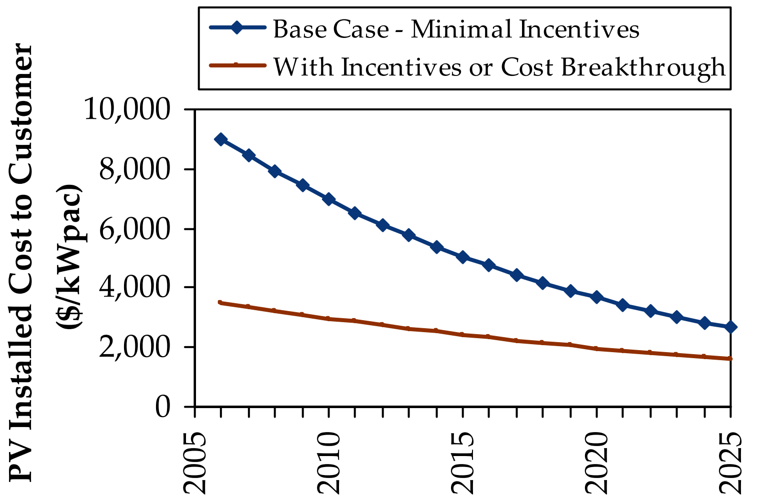
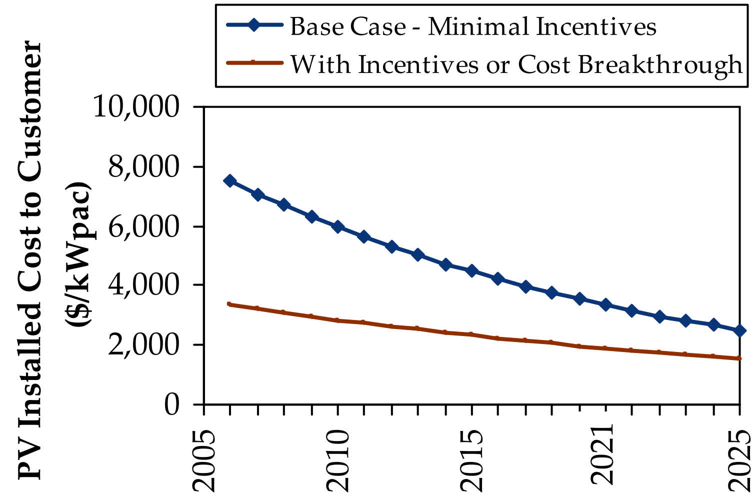
To estimate the market penetration of rooftop PV, NCI analyzed two scenarios for both residential and commercial applications.

PV Installed Costs - Residential



- Base Case assumes an average 6.2% decline in prices from 2006 at $9,000/kW to $2,650/kW in 2025. No incentives, except a $15/MWh REC which appreciates at 3% per year.
- With Incentive or Cost Breakthrough Case assumes the cost to customer declines an average 4% from $3,500/kW in 2006 to $1,600/kW in 2025. Prices could reflect a combination of incentives and/or cost breakthroughs.

PV Installed Costs - Commercial



- Base Case assumes an average 5.6% decline in prices from 2006 at $7,500/kW to $2,500/kW in 2025. No incentives, except a $15/MWh REC which appreciates at 3% per year.
- With Incentive or Cost Breakthrough Case assumes the cost to customer declines an average 4% from $3,350/kW in 2006 to $1,550/kW in 2025. Prices could reflect a combination of incentives and/or cost breakthroughs.

Note: Installed Costs in the Base Case have been simplified for modeling purposes to reflect a constant annual percentage decline.

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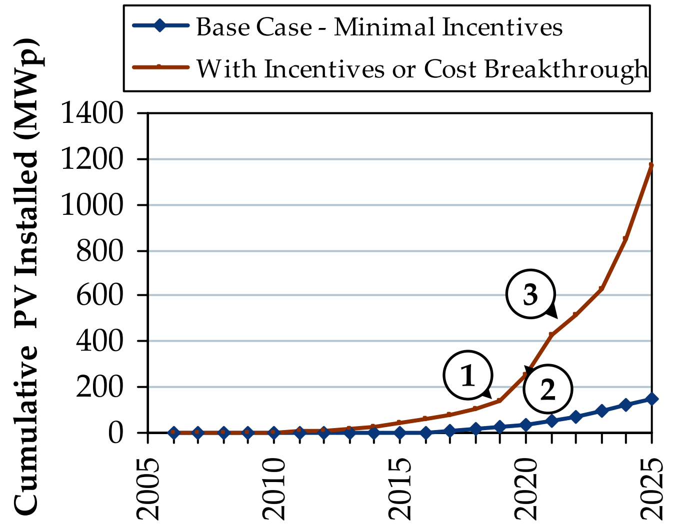
Cumulative installations of rooftop PV by 2025 is likely to be minimal unless significant subsidies or cost breakthroughs occur.

AZ Rooftop PV Market Penetration (Residential + Commercial)



- Significant market penetration does not begin until payback rates drop below 10 years. This occurs in 2020 in the incentive/breakthrough case
- Installed PV could increase more rapidly after 2025 if prices relative to the grid continue to drop

Source: Navigant Consulting, Inc. analysis, September 2006.

Key Market Dynamics

1. Installations cross a tipping point as the payback period drops below 10 years. However, not all customers adopt immediately. Current payback levels are 35 years for commercial and 32 years for residential, with incentives.
2. Installations accelerate as 1) the payback period decreases – causing more customers to want to buy PV systems, and 2) time passes and adoption increases (the slow adopters actually adopt).
3. Installations decelerate slightly as the slow adopters have already adopted, and new installations are driven primarily by those who have waited for the price to continue to come down.

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Without incentives, market penetration in Arizona for rooftop PV in the near term is likely to be minimal.

	AZ PV Market Penetration – Residential Buildings – Base Case			
	2006	2010	2020	2025
PV Installed Cost ($/kW)[1]	$9,000	$7,000	$3,700	$2,650
Net Annual Savings ($/kW)	$166	$180	$218	$220
Payback	54	39	17	12
Cumulative Installed (MWp)[2]	0	0	29	96

	AZ PV Market Penetration – Commercial Buildings – Base Case			
	2006	2010	2020	2025
PV Installed Cost ($/kW)[1]	$7,500	$6,200	$3,300	$2,500
Net Annual Savings ($/kW)	$109	$124	$143	$166
Payback	69	50	23	15
Cumulative Installed (MWp)[2]	0	0	10	49

1. Installed Costs in the Base Case have been simplified for modeling purposes to reflect a constant annual percentage decline.
2. Economic analysis does not reflect the impact of early adopters.

With incentives or further cost breakthroughs, payback periods in Arizona decline and start leading to greater purchases of rooftop PV.

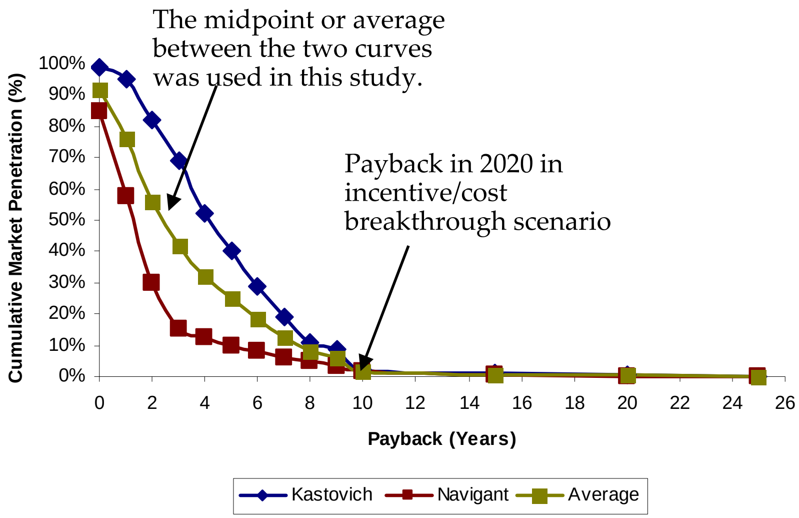
	PV Market Penetration – Residential Buildings – Incentive/Cost Breakthrough			
	2006	**2010**	**2020**	**2025**
PV Installed Cost ($/kW)[1]	$3,500	$2,970	$1,970	$1,600
Net Annual Savings ($/kW)	$166	$175	$205	$229
Payback	21	17	9.6	7
Cumulative Installed (MWp)[2]	0.3	3	187	829

	PV Market Penetration – Commercial Buildings – Incentive/Cost Breakthrough			
	2006	**2010**	**2020**	**2025**
PV Installed Cost ($/kW)[1]	$3,350	$2,845	$1,890	$1,550
Net Annual Savings ($/kW)	$108	$118	$1145	$165
Payback	31	24	13	9.4
Cumulative Installed (MWp)[2]	0	0.4	63	346

1. Installed Costs in the Base Case have been simplified for modeling purposes to reflect a constant annual percentage decline.
2. Economic analysis does not reflect the impact of early adopters.

Improvement to PV economics beyond the assumptions in the breakthrough scenario could significantly increase PV penetration.

Payback vs. Cumulative Market Penetration Curves



- The incentive/cost breakthrough assumes the payback to residential and commercial customers is near 10 years. Based on historical market penetration as described by the Kastovich and Navigant curves, any further improvement in PV economics would start having significant effects on market penetration.

Total Achievable Market Penetration in AZ

Payback (years)	Potential Cumulative Market Penetration (%)	AZ Technical Market Potential in 2025 (MW)	Total Achievable Market Penetration in AZ (MW)
15	~1%	14,520 MW (7,485 res, 7,035 comm)	145
12	~1.5%		215
10	~2%		290
9	6%		870
7.5	10%		1450
5	25%		3630

- The total achievable market penetration would be attained over several years as customers react to improved pricing – NCI uses an S-Curve to estimate this penetration.
- Analysis assumes the same payback and market penetration for residential and commercial markets.

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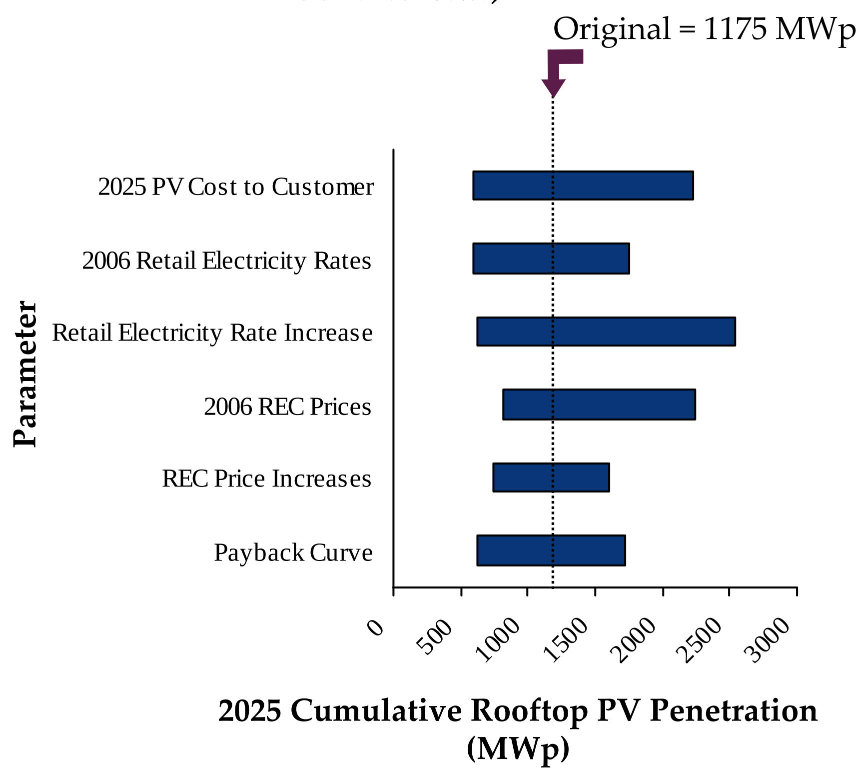
Electricity rate increases above the baseline assumption of 1% per year results in a significant increase in the market penetration of PV.

NCI PV Market Potential Model Settings and Sensitivity Range (With Incentives or Cost Breakthrough Scenario)

	Parameter	Baseline Setting	Range Tested
PV System Price / Performance	2025 Cost to Customer	\$1,600/Wp – Residential; \$1,550/Wp Commercial	+/- 20%
Electricity Prices and RECs	2006 Retail Electricity Rates	9.5 ¢/kWh Res, 7 ¢/kWh Comm	+/- 20%
	Electricity Rate Increase	1% per year	0% to 3%
	2006 REC Prices	\$15/MWh	\$10 - \$30/ MWh
	REC Price Increases	3% / year	0% - 5% / year
Payback Curve	Payback Curve	Average of Kastovich and NCI	Kastovich and NCI

Market Penetration Sensitivity – With Incentives or Cost Breakthrough Scenario (Cumulative MWp in 2025, Residential and Commercial)



Note: Only those parameters subject to sensitivity analysis are shown.

For the next 15 years, the principle opportunities for AZ central station solar include:

>> Meeting Arizona's peak load requirements
>> Fabricating hardware for stations to be built in the WECC

- Until about 2015, assuming forecasted gas prices, the demand for central solar will be driven by RPS and solar set asides.
- Under expected solar system cost reductions and gas price scenarios, central solar becomes economically competitive with gas-fired generation (especially, peaking) in the post 2015 timeframe.
- Arizona (especially when combined with Southern Nevada) is the fastest growing and a very large market for new capacity in the WECC
- Several other factors could increase the inherent value of solar relative to gas fired peaking capacity:
  - Gas prices are extremely volatile – this volatility should translate into an added benefit for solar.
    - Consumers buy insurance to protect against "worst case" scenarios
  - Solar is highly coincident with AZ utilities peak demand
  - If solar meets more of the peak demand, gas price volatility could be moderated
  - Greenhouse gas cost adders for fossil fuel may increase the cost of gas-fired generation by $5 to $10/MWh

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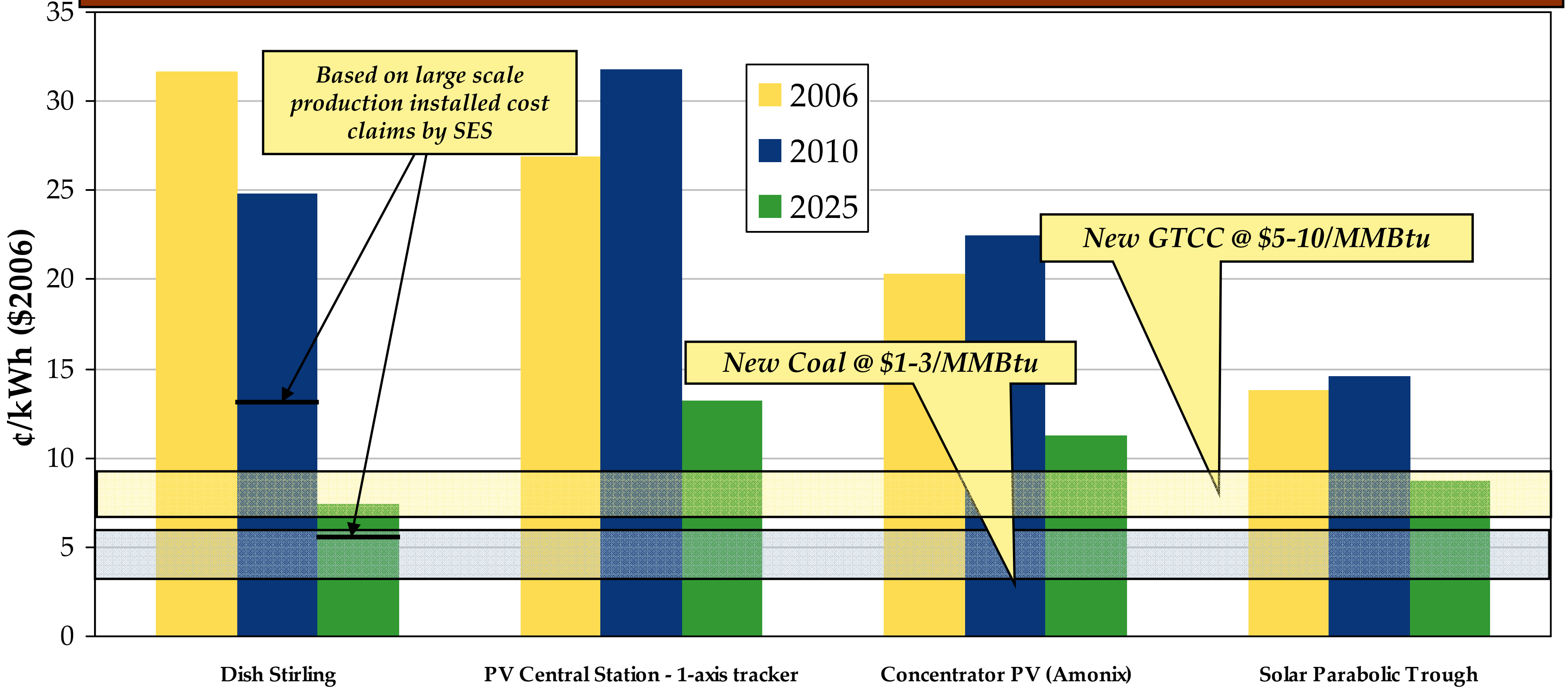
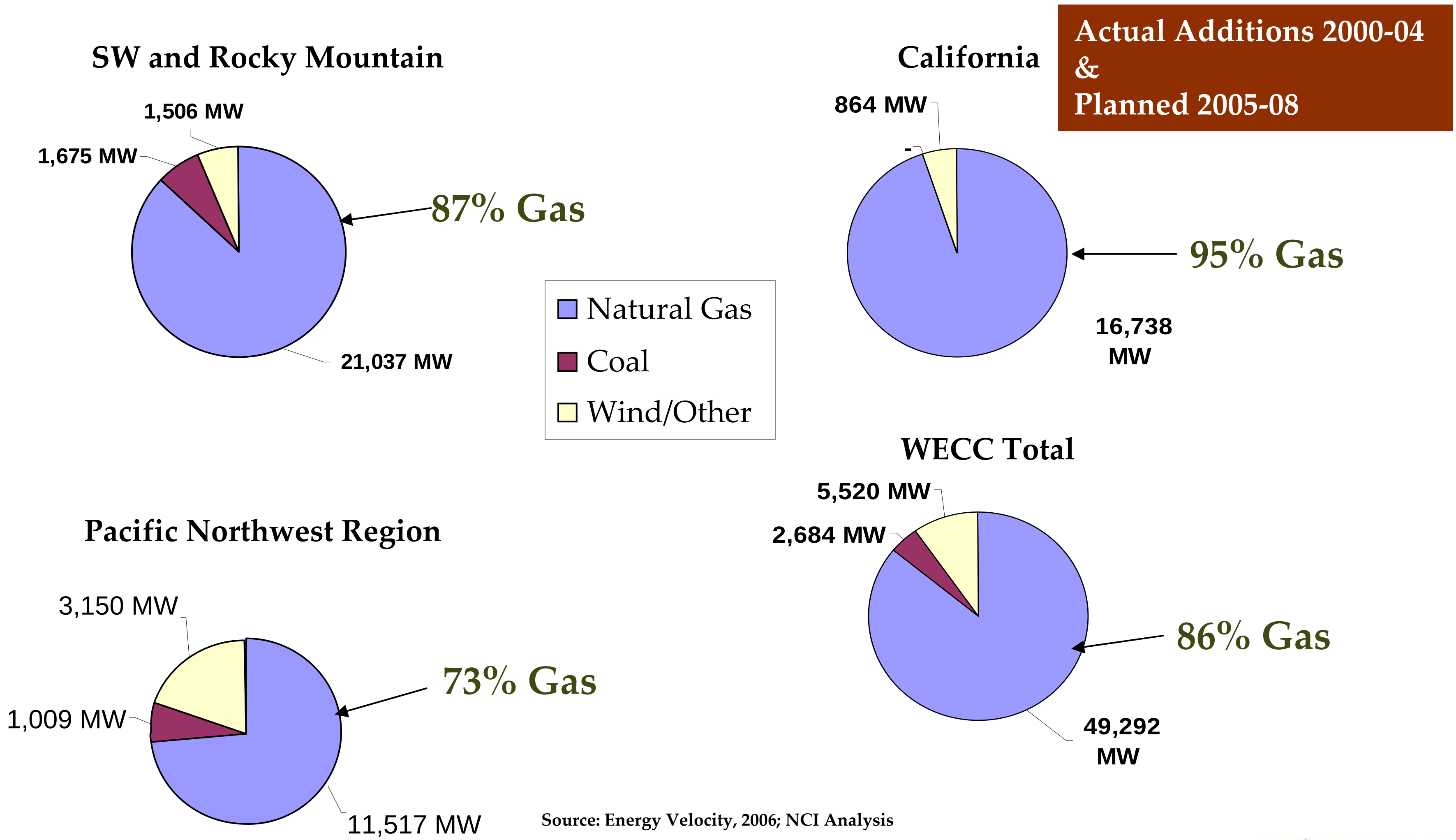
Technology improvements/cost reductions will allow central solar to compete with conventional baseload and intermediate generation.

AZ Levelized Cost of Electricity for Selected Wholesale Options (Developer Financed)*



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.

Over 80% of new capacity in the WECC is gas-fired, with higher percentages in the desert Southwest and California.



Source: Energy Velocity, 2006; NCI Analysis

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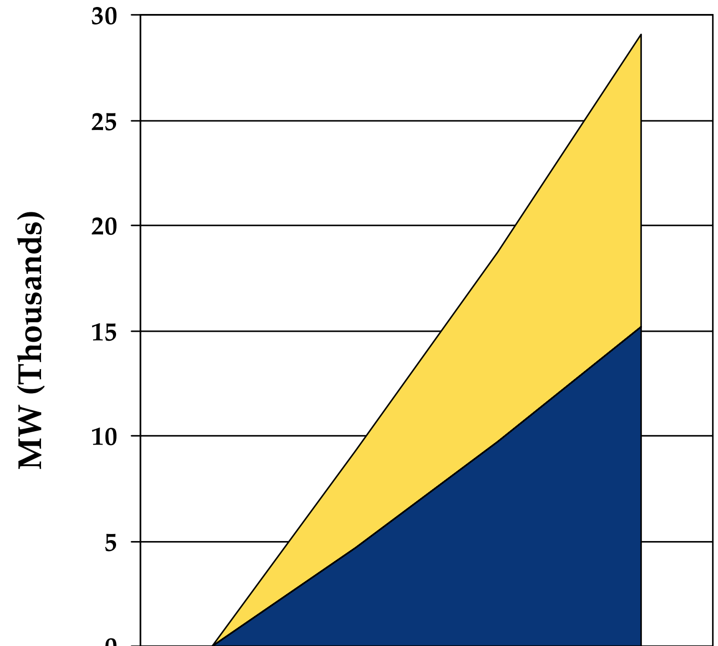
Peak loads in the Desert SW states and California are forecasted to grow by nearly 2,000 MW per year for the next 15 years.

	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 California.

Peak Load Growth (MW)

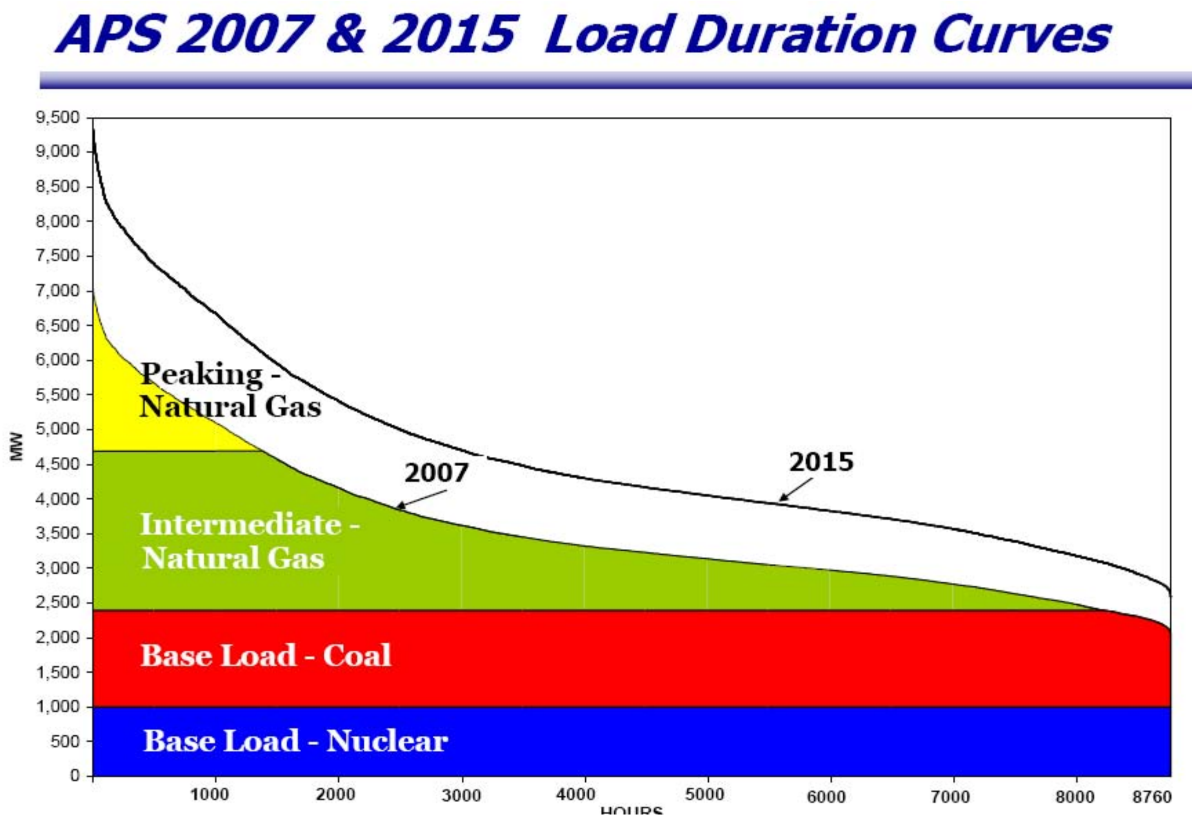


	2005	2010	2015	2020
AZ, NM, & So NV	0	4,652	9,000	13,925
California	0	4,661	9,707	15,169

Source: WECC, CA Energy Commission, NCI Analysis

For APS, gas is the marginal fuel in almost all hours, with peakers being on the margin for as many as 1,200 hours.

- A critical issue is the coincidence of loads and solar output
- Electric load tends to peak later than the output from a solar plant
- A few hours of storage would allow one to match profiles
- Demand Response could be coupled with the solar programs to compensate for intermittency



Source:: APS 2006 Base Load RFP Bidder's Conference

While APS has more gas than the rest of the state, gas is still on the margin for almost all daylight hours.

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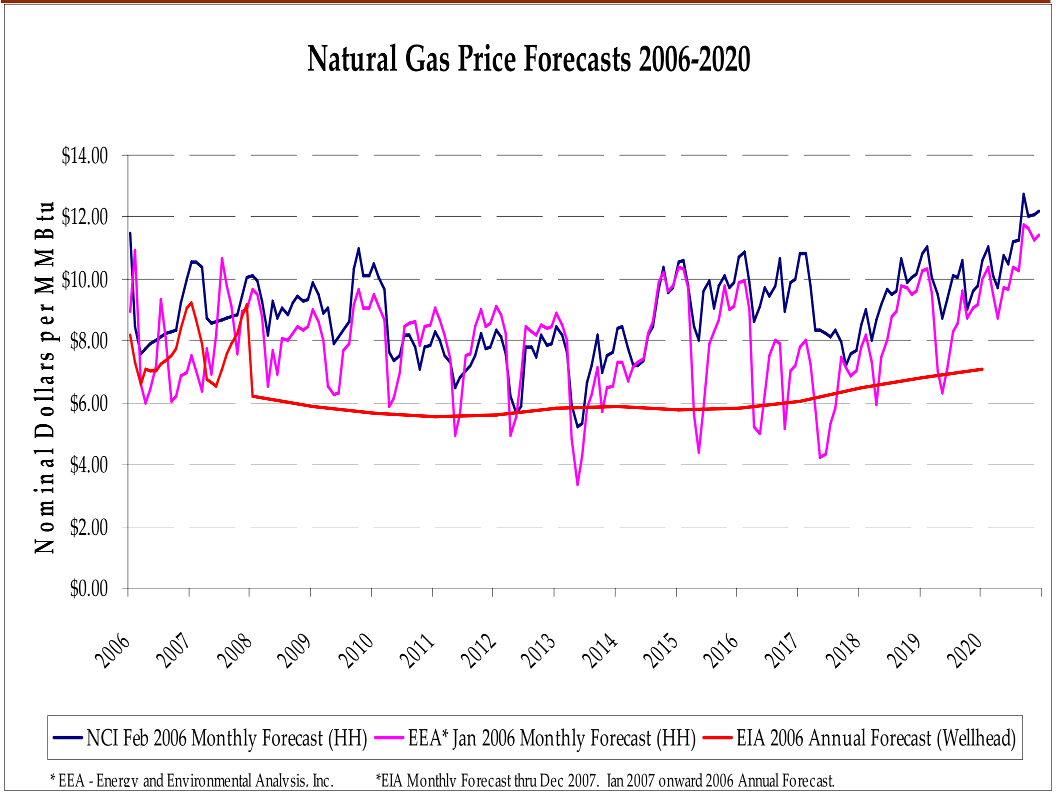
Gas prices may decline in the near future, but the long-term trend shows a return to higher prices.

- Many expect average gas prices to be higher than the EIA forecasts
- Seasonable and market conditions result in periods of sustained higher prices
- For this analysis, we recommend using an average price of $8.00/MMBTu for a reference forecast

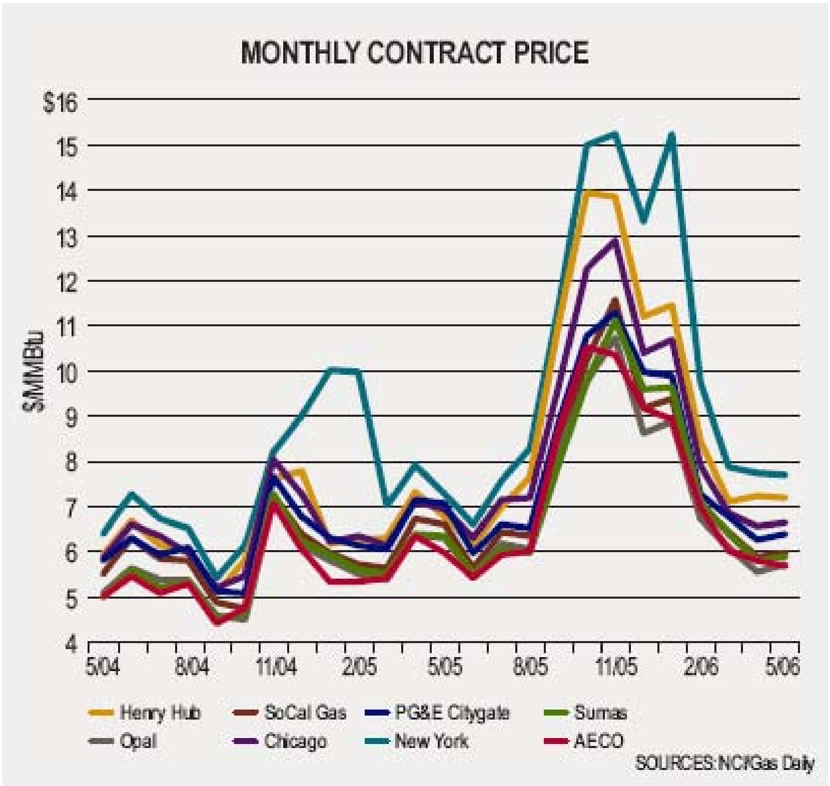
Sustained High Natural Gas Prices



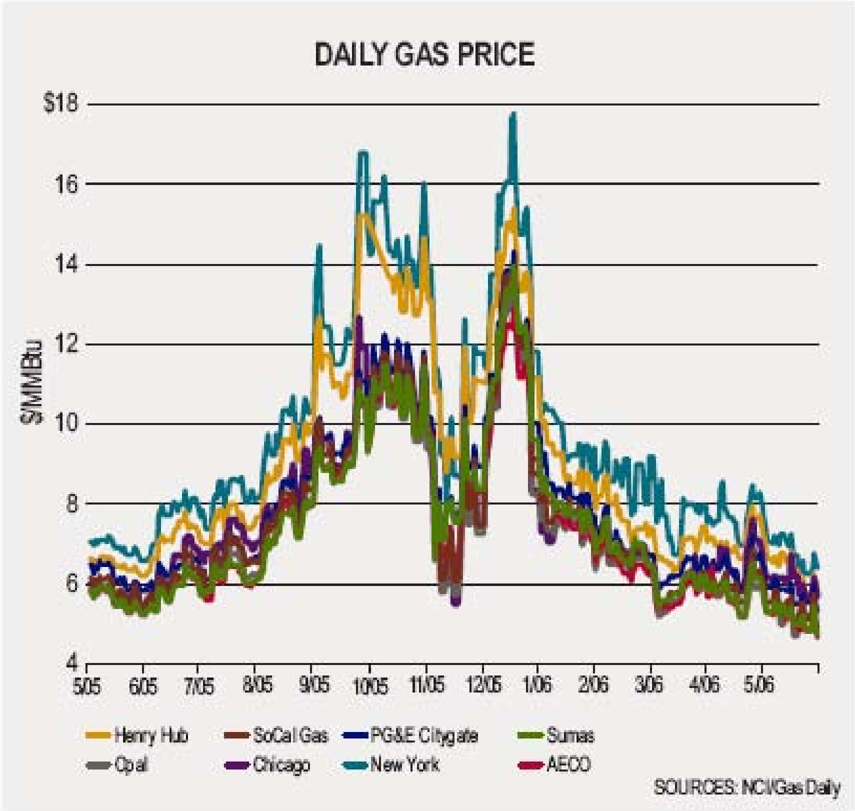
Source: EIA,2006; EEA, 2006, NCI Analysis

Gas prices are extremely volatile with prices being 50% to 100% above the annual average price for days or months at a time.

May monthly Index Price Was Off $0.15 per MMBtu to $5.67 per MMBtu, Continuing 8th Consequetive Month the Index Declined



April spot daily prices decline below $6.00 per MMBtu at Henry Hub; below $5.00 per MMBtu in Rockies, Canada and SoCal Border



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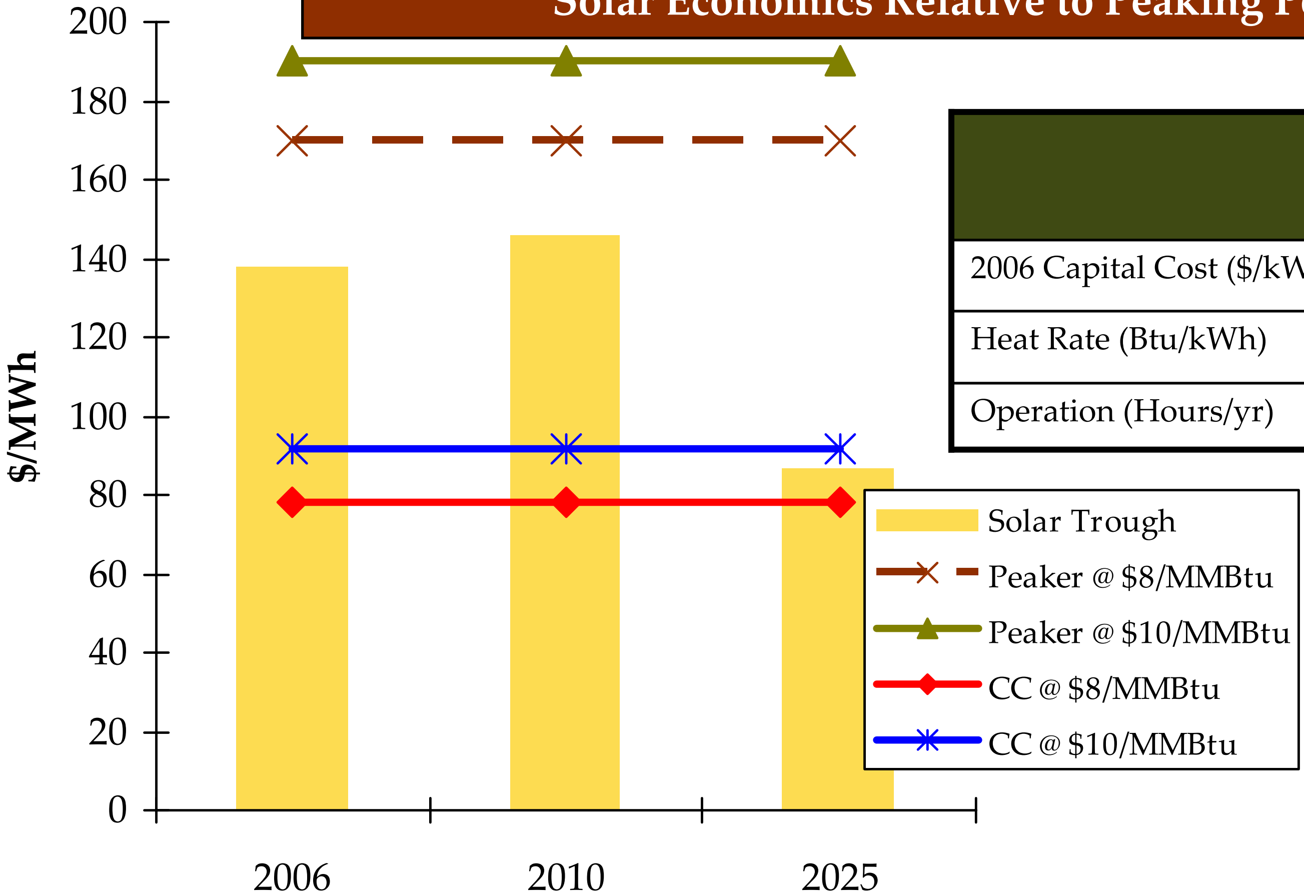
The cost of electricity from parabolic trough is near the cost of peaking power today, and is expected to decline by more than 50% by 2025.

Solar Economics Relative to Peaking Power



	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.

The LCOE for electricity from solar is not directly comparable to the LCOE from peakers or combined cycle plants for a number of reasons.

Discount Factors for Gas

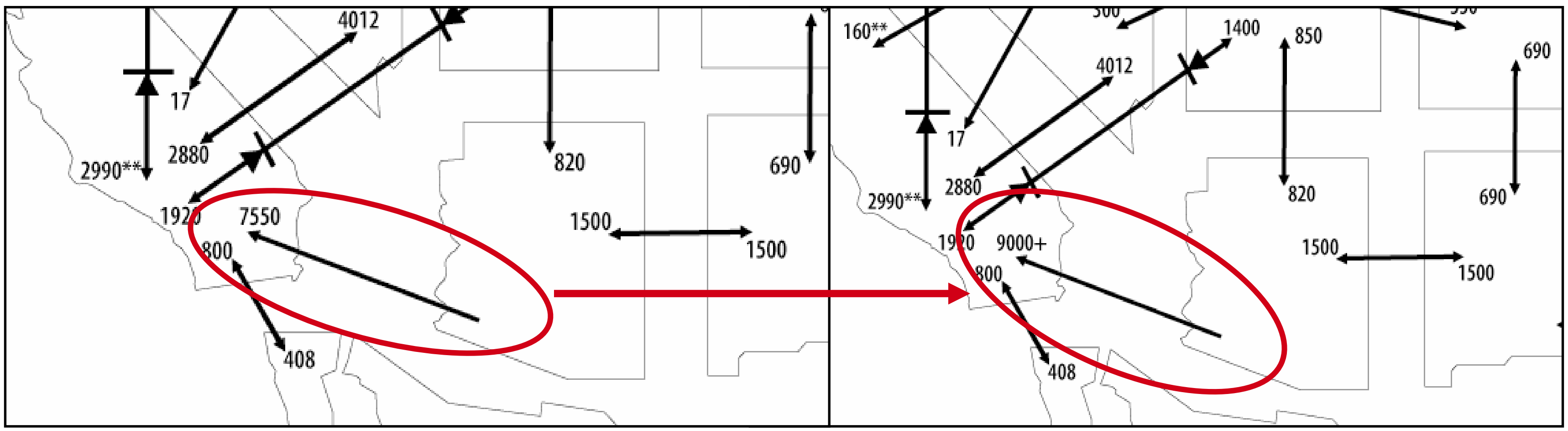
- Peaker capacity may still be required to address:
  - Non-coincidence of system and solar peak
  - Intermittency
- Solar output is comparable to a mix of peaker and combined cycle
- Peaker capacity has added flexibility to generate when needed

Discount Factors for Solar

- Hedge value against gas price volatility
- Impact of lower gas usage upon average gas prices
- Value/compliance costs for emissions reduction
- Six hour storage capability built into post 2010 costs mitigate intermittency and non-coincidence issues

Electric transmission is a critical link. Under current infrastructure, potential exports to other markets are limited.

WECC NON-SIMULTANEOUS TRANSFER CAPABILITIES 7/05 (MEGAWATTS)	WECC NON-SIMULTANEOUS TRANSFER CAPABILITIES 2010 (MEGAWATTS)



Source:: WECC, 2005

Planned upgrades may provide limited capability for additional exports.

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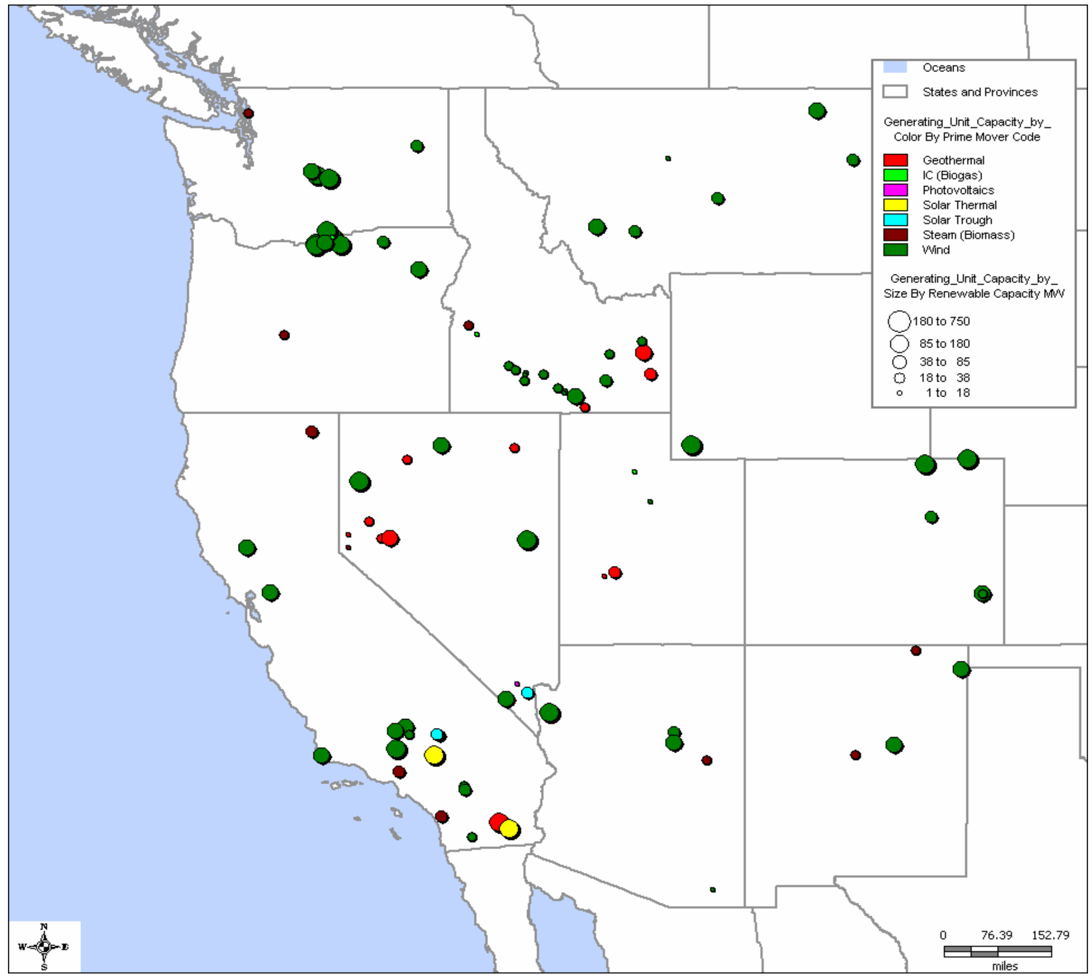
There are currently an estimated 140 renewable energy projects being planned in the WECC.

Renewable Energy Capacity (MW) under development in the WECC:	
NW Power Pool:	**6,567**
Rocky Mountain:	**1,635**
AZ-NM- So. NV:	**1,001**
California:	**3,532**
Total:	**12,735**

- Wind accounts for most of the capacity additions
- There are a few major solar projects under development in Southern CA
- Some portion of these projects will not get developed
- AZ, NM, NV RPS needs are approximately 3,700 MW by 2020. CA adds another 14,100 MW.



Source: Energy Velocity, 2006; Navigant Consulting, Inc. analysis, 2006.

Two scenarios were developed for deployment of central station solar power through 2020.

	Base Case	Accelerated
Key Assumptions	• Business as usual • Central solar costs decline, but no breakthrough • Average gas prices remain in the $7.00 to $8.00/MMBtu range • Siting and transmission issues result in minimal export capability • Solar trough has 6 hour storage after 2010	• Early central station solar technology projects perform as planned, and costs decline as forecast • Average gas prices in the $9.00 to $10.00/MMBtu range • Greenhouse gas and other emissions add $5/MWh to combined cycle costs • Transmission capability developed by 2020 to support an additional 200 MW of exports

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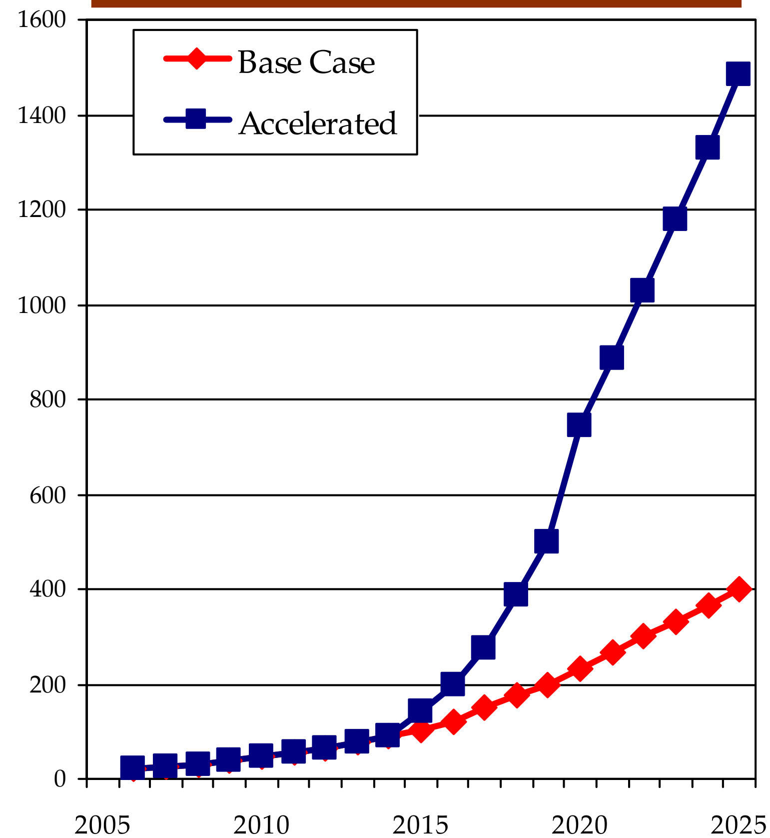
In the breakthrough scenario, central station solar deployment expands dramatically after 2015.

- Through 2015, central solar captures about 10% of the RES requirements in both scenarios
- For the Base Case, central solar continues to capture about 10% of the RES applied on a state-wide basis (~ 400 MW by 2025)
- In the Accelerated scenario about 10% of 2015 capacity are central solar, ramping up to 20% of capacity additions by 2020. In addition, slightly more than 20 MW is developed for export annually

Central Station Solar Deployment by Scenario (MW)

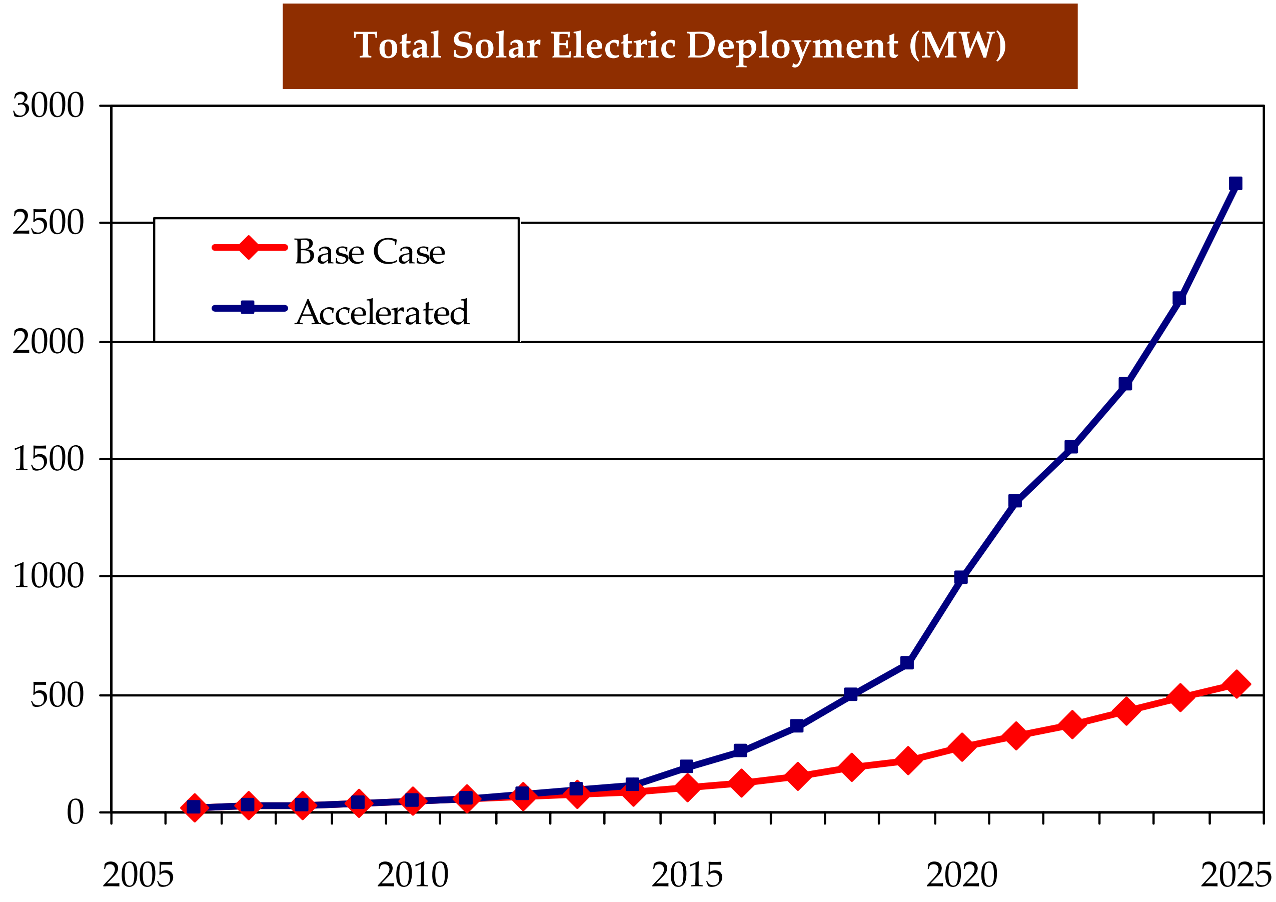


Source: Navigant Consulting, Inc. estimates, 2006.

The central station opportunities include both power production as well as manufacturing of components for plants to be built elsewhere.

Major Markets for Central Station Solar Development		
	2020 Market Size	**Considerations**
Power Production – AZ, NM, & So NV	120 to 130 MW/yr	Based on breakthrough scenario
Power Production for Export to CA	20-25 MW/yr	Limited potential due to CA favoring in-state renewables, and transmission
Manufacturing for Plants to be Built within Region and CA	100 MW/yr	Production costs lower in AZ than CA
Manufacturing for Export Out of Western U.S.		Production and shipping costs may limit exports

Total solar deployment could exceed 2,600 MW in the accelerated scenario with rooftop PV accounting for ~ 45% of the capacity.



Job and direct earning PV impacts were estimated using NCI's proprietary models and industry interviews.

Primary Data Sources and Data Elements[1]	• NCI's PV module manufacturing cost model and LCOE (levelized cost-of-energy) model, provides detailed labor and non-labor cost estimates for all aspects of PV system manufacturing and installation • Interviews with PV industry sources – manufacturers, equipment suppliers, and installers • *The Work That Goes Into Renewable Energy*, Renewable Energy Policy Project (REPP), November 2001, Research Report No. 13
Method	• Use NCI models and interview results to confirm and update REPP labor estimates. Account for changes in technology, automation and material prices, and apply the updates to the range of available PV technologies • Weight the hours estimates by technology market shares to derive a weighted average hours for each labor task category • Convert weighted estimates to job-years (1 job-year = 1960 hours) • Using labor-hours and materials estimates per installation task from NCI's LCOE model, and labor rate data from interviews with industry professionals and R. S. Means, calculate labor costs for residential 3.5-kW, commercial 1,500-kW and utility central station 2-MW system installations. • Convert all results to per-MW costs

[1]In the manufacturing model, a process flow details each step and its costs, with technology improvements tracked as they occur. For each step, a detailed activity-based accounting is made of material, labor, capital and overhead costs, based on material quotes, machine capability spec sheets, machine cost quotations, U.S. labor rates, and industry financial parameters. The LCOE model accounts for module prices, inverter costs, installation labor, system integration, installer margins, etc. to build total system price, based on interviews with a wide array of industry sources.

Job and direct earnings impacts of central solar development were estimated for plant construction and O&M.

Primary Data Sources and Data Elements[1]	• April 2006 study of CSP development in California, including: — NREL Excelergy model data on components of capital and O&M costs for 100-MW parabolic trough plants constructed in 2007, 2009, 2011, and 2015 — NREL data on allocation of component costs to labor and non-labor — Authors' methodology for assigning certain labor costs to out-of-state resources • Interviews with NREL staff and authors of California CSP study
Method	• Review recent CSP economic development studies and determine most robust source[1]. • Estimate construction cost components for 2008, to match job estimate presented for a plant constructed in that year. • Estimate construction cost components for 2010 from 2009 and 2011 data. • Apply the NREL/CA study's percentage estimates (of cost component as a percentage of total cost, labor as percentage of each cost component, and in-state labor as percentage of each component's labor estimate) to the calculated 2010 component costs, to estimate in-state labor costs per component in 2010 and 2015. • Adjust component labor cost items, based on total capital cost estimates for 2010 and 2020 from interviews with NREL staff, using 2015 ratios of cost items for 2020. • Apply the same approach to develop O&M job and direct earnings estimates, using the NREL Excelergy model labor cost estimates. • Convert all results to per-MW values.

[1]*Economic Energy and Environmental Benefits of Concentrating Solar Power in California*, Black & Veatch, NREL/SR-550-39291, April 2006.

Direct jobs[1] per MW of installed PV are projected to average 28 job-yrs for residential and 23 job-yrs for commercial/central station in 2010.

Year	Application	Direct Jobs Per MW of PV Capacity[1]			
		Wafer & Cell (Job -Yrs[2])	Module (Job-Yrs)	Installation (Job-Years)	Annual O&M
2010	Residential	8	3	17	0.2
	Commercial	8	3	12	0.4
	Utility	8	3	12	0.4
2020	Residential	2	1	11	0.2
	Commercial	2	1	9	0.4
	Utility	2	1	9	0.4

[1]"Direct jobs" does not include economic multiplier effects of spending in the local economy.
[2]One job-year is equal to 1960 hours (40 hours per week, 49 weeks per year)
Source: Navigant Consulting, Inc. estimates, June 2006.

Each MW of central solar plant capacity should generate 4.3 job-years in 2010. The direct job impacts are expected to decline 30% by 2020.

Year of Construction	Direct Jobs[1] Per MW of Central Solar Capacity	
	Construction (Job-Years[2])	Annual O&M
2010	4.30	0.4
2020	2.99	0.3

[1] "Direct jobs" does not include economic multiplier effects of spending in the local economy.
[2] One job-year is equal to 1960 hours (40 hours per week, 49 weeks per year)

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

PV manufacturing/assembly labor expenditures are expected to decline severely (70-80%) from 2010 to 2020…

Year	Application	Direct Labor Expenditures Per MW of PV Capacity			
		Wafer & Cell	Module	Installation	Annual O&M
2010	Residential	$600,000	$90,000	$2,500,000	$11,000
	Commercial	$510,000	$74,000	$1,500,000	$22,000
	Utility	$540,000	$79,000	$1,300,000	$22,000
2020	Residential	$130,000	$19,000	$1,700,000	$9,000
	Commercial	$150,000	$22,000	$1,000,000	$19,000
	Utility	$150,000	$22,000	$950,000	$19,000

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

… while installation labor should decline only by 25-35% -- better prices, fewer jobs.

Central station power labor expenditures are much lower, on a per-MW basis, than those of PV, but annual O&M labor expenditures are higher.

Year of Construction	Direct Labor Expenditures Per Central Solar MW Capacity	
	Construction	Annual O&M
2010	$550,000	$40,000
2020	$380,000	$35,000

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

Declines in CSP construction labor 2010-2020 should be like those of PV installation, with smaller declines in O&M labor.

The accelerated scenario for solar could add over 3,000 jobs in 2020.

Accelerated Scenario	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.

Total 2020 employment = 3,047 jobs for solar in an accelerated scenario

Emission reduction is estimated at 400,000 tons per year in an accelerated scenario in 2020.

Emission Reduction Potential in AZ (Accelerated Scenario in 2020)				
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.

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6 Solar Roadmap

Appendix

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Manufacturers indicated that new collaborative business models that provide a win-win for all involved could help to attract companies.

Manufacturer Interviews

Conditions for relocating/initiating manufacturing in AZ	• Different collaborative business models with community activities vs. just single one-off rooftop installations. May not lead to more manufacturing jobs, but will create more jobs. • Incentives that are aligned with manufacturing production volumes of 500 MW – 1 GW plants (what will be built in the next 3 – 4 years (a $250 million to $1 billion investment
Main barriers to developing a vibrant AZ solar industry	• Limited supply of modules • Stronger market opportunities elsewhere and often consider expanding close to good markets
Ways of overcoming barriers	• Sustainable market growth will justify manufacturing
Two most important things that AZ could do to promote solar	• Increase the potential for scale with new collaborative business models • Require that a certain percentage of new homes in a development must be solar
Activities of other states or countries	• Income tax holiday (corporate and personal); Free real estate; Power at reduced rates; Access to water • Germany: up to 35% benefit up front vs. tax credit. Capped at $500,000 per year
Export potential	• Japan, Germany, Spain, Italy, Czech Republic, South Korea, India, China, NJ, CA

Source: Interviews with BP, Sharp, and a large semi-conductor company, May and June 2006

The ACC expressed a desire to invest RES dollars in R&D, but was concerned about solar intermittency, cost, and siting issues.

ACC Interviews

Main barriers to developing a vibrant AZ solar industry	• Cost. AZ's strongest renewable resource is solar and it is four times more expensive than alternatives. Utilities need to look at lowest cost resources. RPS helps as long as AZ-sourced/delivered power is required. • Intermittency of solar, therefore need spinning reserves supplied by natural gas technology • Siting: It will be difficult to site 5 acres per MW. They have issues siting a 10 acre substation. — large % of available land is Trust Land that yields high prices (maximizing revenues for education). Perhaps the state could work to make certain land (e.g., land around prisons) available at lower cost. Siting problems likely to stem from local opposition, not opposition from the state. High prices of auctioned land trusts. • Lack of infrastructure to install and service solar • Technology is too immature to justify making large scale investments at this time • High price of gas may limit hybrid solar/combined cycle projects. • Lack of infrastructure – need to build up installation/servicing capabilities. Educational efforts and long-term commitment needed. • For CSP – lack of long-term contracts so that developers can obtain financing. New RPS provides more of an incentive for utilities and developers to enter into long-term contracts. • Transmission capacity – limited availability, public (NIMBY) & armed forces (training obstacle) opposition, competition from other states for capacity that is built. • Negative historical experience with solar water heaters and freezing. Educational efforts and training will be needed.

Source: Interviews with Chairman Hatch-Miller, Kris Mayes, and Ray Williamson, June 2006.

The state might consider discounting state land for solar development.

ACC Interviews (continued)

Role of Utilities in Developing Solar Power	• Due to utility regulation, utilities are prime movers for energy policy. • New 30% distributed resource requirement will require utilities to aggressively involve customers, which will require significant educational and promotional efforts.
Ways of overcoming barriers	• Need to provide low cost and reliable power • Convert heat into cooling • Governor to have state agencies discount land of state facilities (e.g. land around prisons)
Ideas for RES funds	• Provide funds to universities for solar research. This would be an investment. • Provide grants to the private sector
Export potential	• Transmission capacity is an issue for export of solar power to other states — Frontier and TransWest transmission projects are far off — Transmission lines and towers interfere with training for the armed forces in AZ — No desire to turn Arizona into an “energy farm” for other states
Renewables Surcharge	• RPS % ramp-up designed to match ramp-up in load growth. Higher ramp rate not likely to be an easy sell.

Source: Interviews with Chairman Hatch-Miller, Kris Mayes, and Ray Williamson, June 2006.

Tribes could offer land for CSP generation/PV manufacturing plants, but seek local jobs and revenue-sharing in return.

Tribe Interviews

Conditions for locating solar manufacturing or power generation on Tribal Lands	• Everything varies by tribe, but generally a favorable disposition to renewables. • Land is probably available for siting manufacturing or solar generation, but tribes will want a partnership rather than leasing of land.
Main barriers to developing solar electric facilities on tribal lands	• Manufacturing plants/solar generation: — Generally, low skill level of locals, and objections to bringing in workers from outside tribal lands to take jobs — Resistance to straight leasing deals; prefer partnerships — Concerns about utility cooperation with transmission/distribution pricing • PV installation: — Lack of home mortgage financing and housing shortage leads Housing Authorities to choose more, less expensive houses over fewer, higher-quality houses (small pay-off seen from enormous PV cost increment) — Lack of net metering; concerns about lack of utility cooperation
Ways of overcoming barriers	• Significant training, and commitment to long-term training and retention of tribal workers might address significant employment issues and provide local labor • Opportunities for revenue-sharing, empowerment zoning, tax credits, other partnerships
Three most important things that AZ could do to promote solar	• Make it easier to IPPs to enter market. Ensure general cooperation by utilities • Tax rules and access to portion of tax revenues • Help educate tribes on business and politics of energy

Source: Interview with Inter-Tribal Council representative – Dave Castillo.

A leading builder in the state suggested providing a lower electric rate for customers who use solar and providing more solar education.

Builder Interview

Main barriers to developing a vibrant AZ solar industry	• Solar is the highest cost renewable • Lack of customer demand and awareness – There is virtually no demand for solar among prospective homeowners. Salespeople report that customers view solar as new, "techy", and experimental. • Other states have more diverse set of renewable resources (wind and biomass) • Past experience and association with solar hot water will need to be overcome • Market forces – Currently, the home-building market is in a slow-down, with the market flooded with used homes. Sales of new homes have dropped by 50%. • Pulte builds 6,000 homes per year and there is limited demand for solar — Customers view solar as new, high-tech, cutting-edge, experimental
Possible solutions	• Provide a lower electric rate or similar incentive for customers who use solar • Present solar as a hedge against rising electric rates • Educate customers on current status of solar technology and on solar benefits (including non-economic ones) • Once there is initial demand, educate developers, who can then conduct research with customers regarding adding solar to homes.

Source: Interviews with Pulte Homes, June 2006.

The Executive Director of the Solar Energy Research and Education Foundation identified several areas for overcoming PV barriers.

Barriers

- Solar has no leverage with home builders
- Home owner association governance can prevent solar development
- The first cost of solar is often too high

Possible Solutions to Overcome Barriers

- Facilitate expedited permitting for new homes with solar
- Build public awareness to help home owners realize the value of solar and for consumers to understand that they are reliable and proven systems
- Provide zero interest financing or bonds to utilities that offer solar to customers
- Create a market for solar and the jobs will come
- Develop a long term (5 – 10 year) strategy that is reliable and consistent

The interviews identified several ideas for overcoming solar barriers and to increase employment in the state.

"Make incentives simple and stable, and link incentives to performance. Our state has focused on installation as well as manufacturing. All systems over the past three years have been inspected for quality and performance…and we get back to contractors about what worked and what did not. Two years ago we started a 35% Business Energy Tax Credit for energy efficiency and renewable energy that is applied to the total capital cost. It is spread over 5 years and applies to up to $10 million per project."	Chris Dymond, Senior Energy Analyst, Oregon Department of Energy
"Have state agencies work together to support solar growth by providing or discounting the land of state facilities, e.g. land around state prisons, so that developers face lower land acquisition costs."	Ray Williamson, ACC
"Ways to overcome barriers include: facilitate expedited permitting for new solar homes, build public awareness about the reliable performance, provide zero interest financing or bonds to utilities offering solar. Be certain to develop a long term strategy that is reliable and consistent. Create a market and the jobs will come.".	Peter Lowenthal, Executive Dir. Solar Energy Research & Educ. Foundation
"Other countries are offering an income tax holiday (corporate or personal, free real estate, power at reduced rates, and access to water…we are however, interested in identifying different collaborative business models."	Lee Edwards, CEO, BP Solar
"Perhaps the greatest lesson learned from the past few years is to place a high premium on patience (sustainable results do not appear overnight) and flexibility (programs need to evolve with the market)."	Jeff Peterson, Program Mgr for Renewables, NYSERDA

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NCI's road-mapping process identified actions/recommendations based on analyses of the market opportunities, competition, and barriers.

Market Opportunity → **Potential Benefits To Arizona** → **Arizona Competitive Position** → **Barriers** → **Roadmap & Action Plan**

Market Opportunity
- Research & Development
- Manufacturing
- Distributed systems deployment
- Central station development & operation

Potential Benefits To Arizona
- Jobs
- Supply security
- Electricity prices and stability
- Reduced emissions
- Image

Arizona Competitive Position
- Strengths
- Weaknesses
- Threats
- Areas of competitive advantages

Barriers
- Financial
- Institutional
- Infrastructure
- Availability
- Wholesale markets
- Transmission
- Siting
- Other

Roadmap & Action Plan

Policy and program recommendations and action items for:
- Near–term
- Mid-term
- Long-term

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There are many unique attributes in AZ that were identified in the interviews that were incorporated into the roadmap.

AZ Uniqueness & Strengths

- AZ Corporation Commission proactive leadership on its Renewable Energy Portfolio Standard
- AZ population and economic growth
- The excellent solar resource (high direct and diffuse solar radiation which is excellent for concentrating and flat plate PV)
- AZ high dependence on gas and its volatile price
- The ideal and central location of AZ to key nearby solar markets (TX, CA, NV, CO, NM)
- State Trust Lands and tribal lands could be used for large scale solar developments
- Competitive labor costs and tax rates
- ASU Poly PV certification capability is only one of three in the world (other 2 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
- Availability of funds close to $1.2 billion from RES through 2025 ($60 million per year)
- ASU assets (e.g. clean room, monitoring and evaluation equipment)
- UA assets (R&D on 3rd generation solar cells, clean rooms and characterization equipment)
- STAR facility for evaluating emerging technologies (only 2 others in world: Weizmann Institute in Israel and Australian National University)

Many threats were also identified through the interviews.

- A natural gas price collapse would reduce the competitiveness of solar
- Public concerns about NIMBY, aesthetics etc., may influence and limit the siting and large-scale deployment of central plants
- The planned use of central station or next generation PV systems that have not been fully proven may weaken the initiative
- Sustained economic recession results in concerns about investments in initially more expensive solar options
- Module shortage persists so systems can not be obtained to be installed

Key Threats

Several barriers were identified for large scale development of customer sited and central station solar.

- Capital cost
- Technology immaturity
- Significant solar incentives in other countries
  - 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 market (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
- Homeowner associations and restrictions on solar installations

Key Barriers

NCI identified initiatives to help eliminate rooftop PV solar barriers.

Rooftop PV			
Barriers	**AZ Solar Marketing and Outreach**	**Solar Zone**	**AZ Sustainable Partners**
High Capital Costs	○	●	○
Availability of Modules	○	○	○
Solar Incentives in Other States	●	●	⊙
Lack of Infrastructure	○	⊙	○
Public Perception	●	●	●
Low Utility Rates	○	○	○
Lack of Strong Local Market	⊙	●	●
Local Building Codes	○	●	○
Homeowner Association Restrictions	⊙	●	○

Key to Effectiveness: High ● Medium ⊙ Low ○

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NCI identified initiatives that could help to overcome key central solar initiatives.

Central Solar		
Barriers	AZ Solar Marketing and Trade Mission	Central Station Solicitation
High Capital Costs	○	●
Availability of Modules	⊙	○
Solar Incentives in Other States	●	●
Technology Immaturity/Risk	⊙	⊙
Siting/Land Use	○	○
Utility Ownership Issues	○	●
Intermittency/ Coincidence	○	⊙

Key to Effectiveness: High ● Medium ⊙ Low ○

NCI identified initiatives to overcome possible R&D barriers.

R&D	
Barriers	**Center of Excellence**
High Capital Costs	⊙
Competition in Other States and Countries	●
Public Perception	●
Insufficient Intellectual Capital	●

Key to Effectiveness: High ● Medium ⊙ Low ○

If some of the barriers can be overcome, there is potential for annual installations > 250 MW/yr in 2020, resulting in close to 3,000 new jobs.

Opportunities

- MWs in 2020 (Accelerated Scenario):
  - Central Solar: 145 per year
  - Rooftop: 115 per year
- Jobs in 2020 (Accelerated Scenario):
  - Direct Manufacturing: 510 per year
  - Installation/Construction + O&M: ~2,535
- Emissions Reductions in 2020 (Accelerated Scenario):
  - Central Solar: ~338,200 Tons of CO_2/Year
  - Rooftop: ~60,000 Tons of CO_2/Year
- Spin-off value of R&D development
- Additional economic development e.g. tourism to visit solar "centers of excellence" and deployment centers
- Enhanced sustainable AZ: maintaining AZ's quality of life

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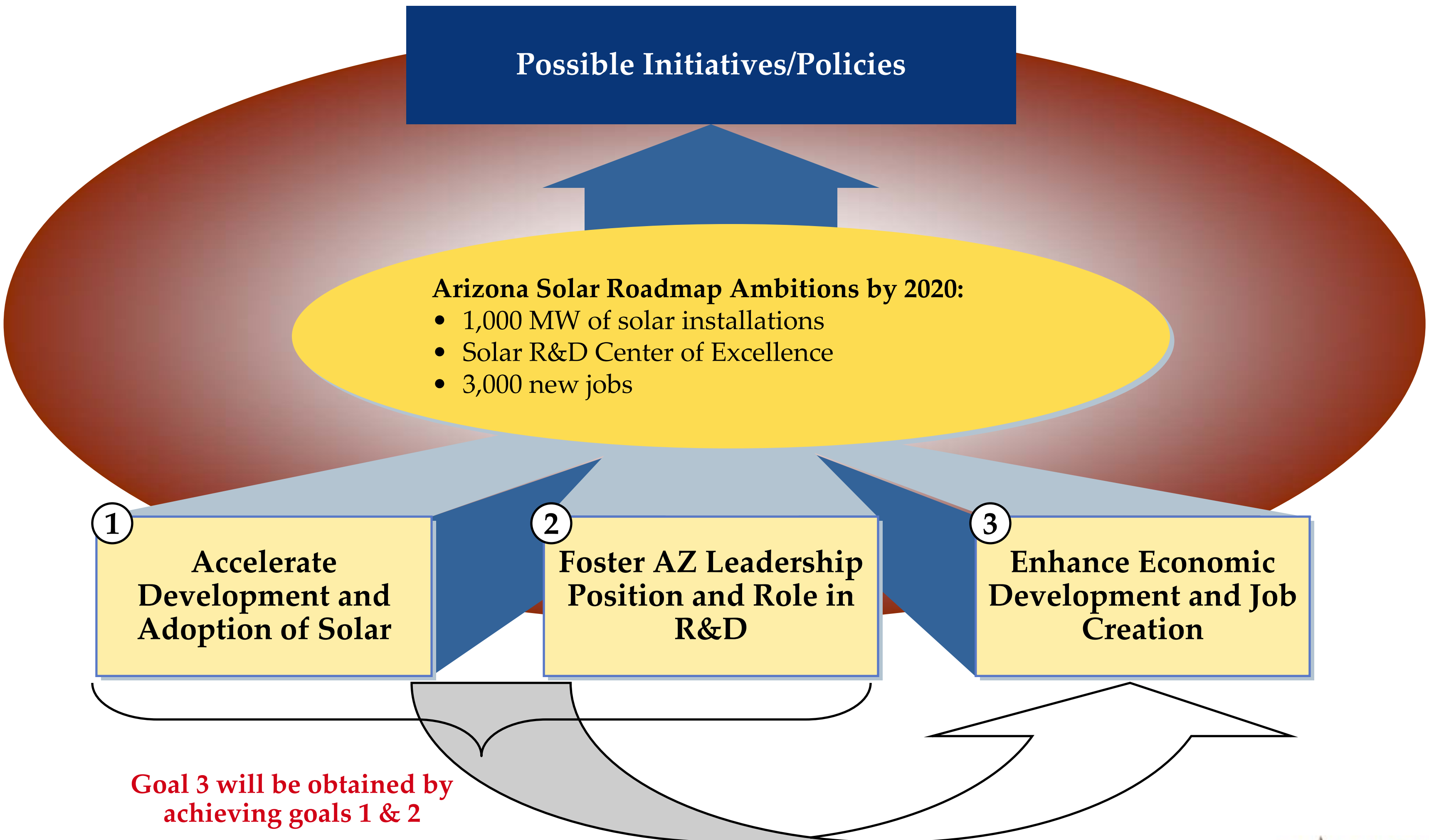
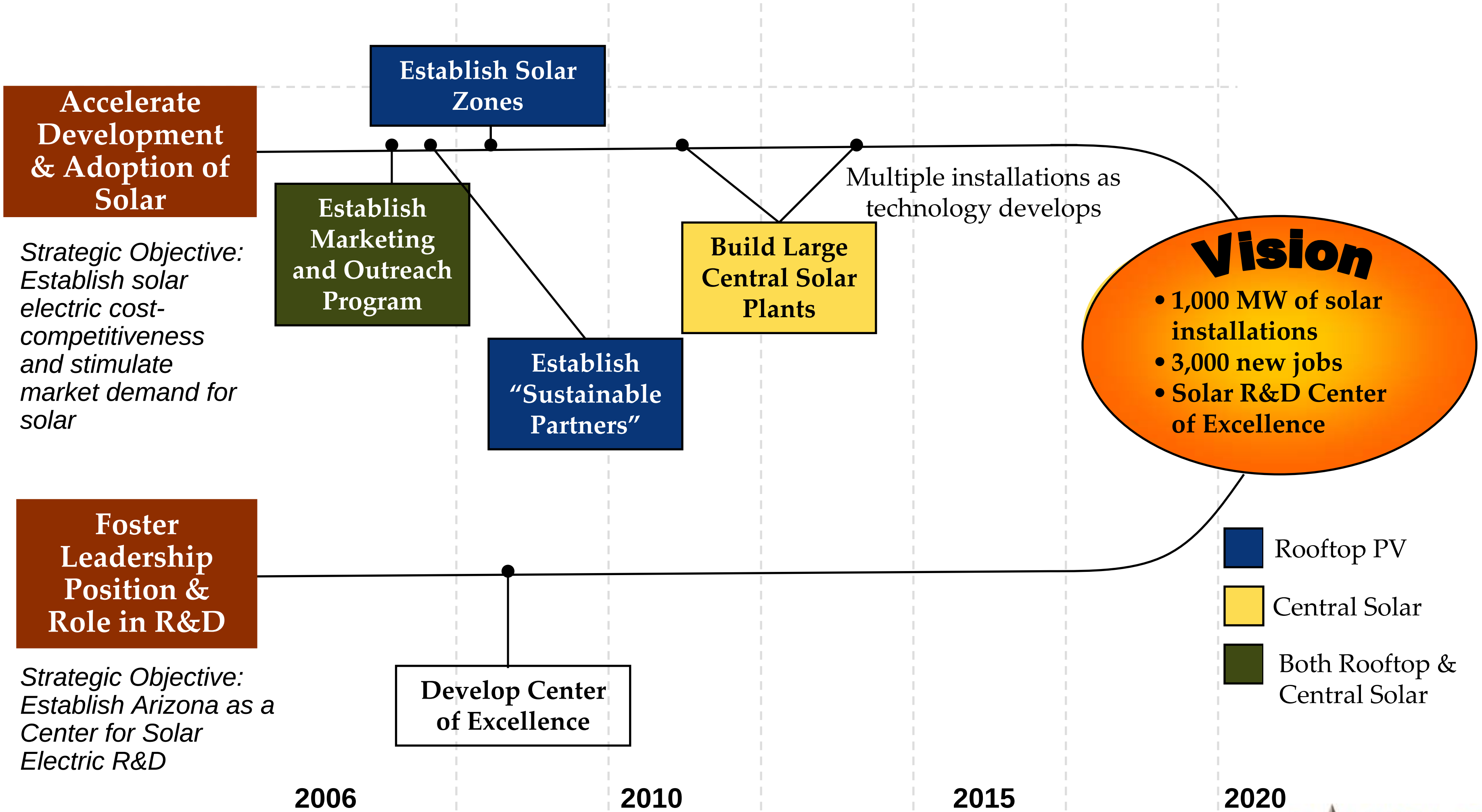
NCI along with the Steering Committee identified initiatives and policies that would address three goals and ambitions.



The vision and ambitions are achieved through integrated initiatives that build upon established policies and incentives.



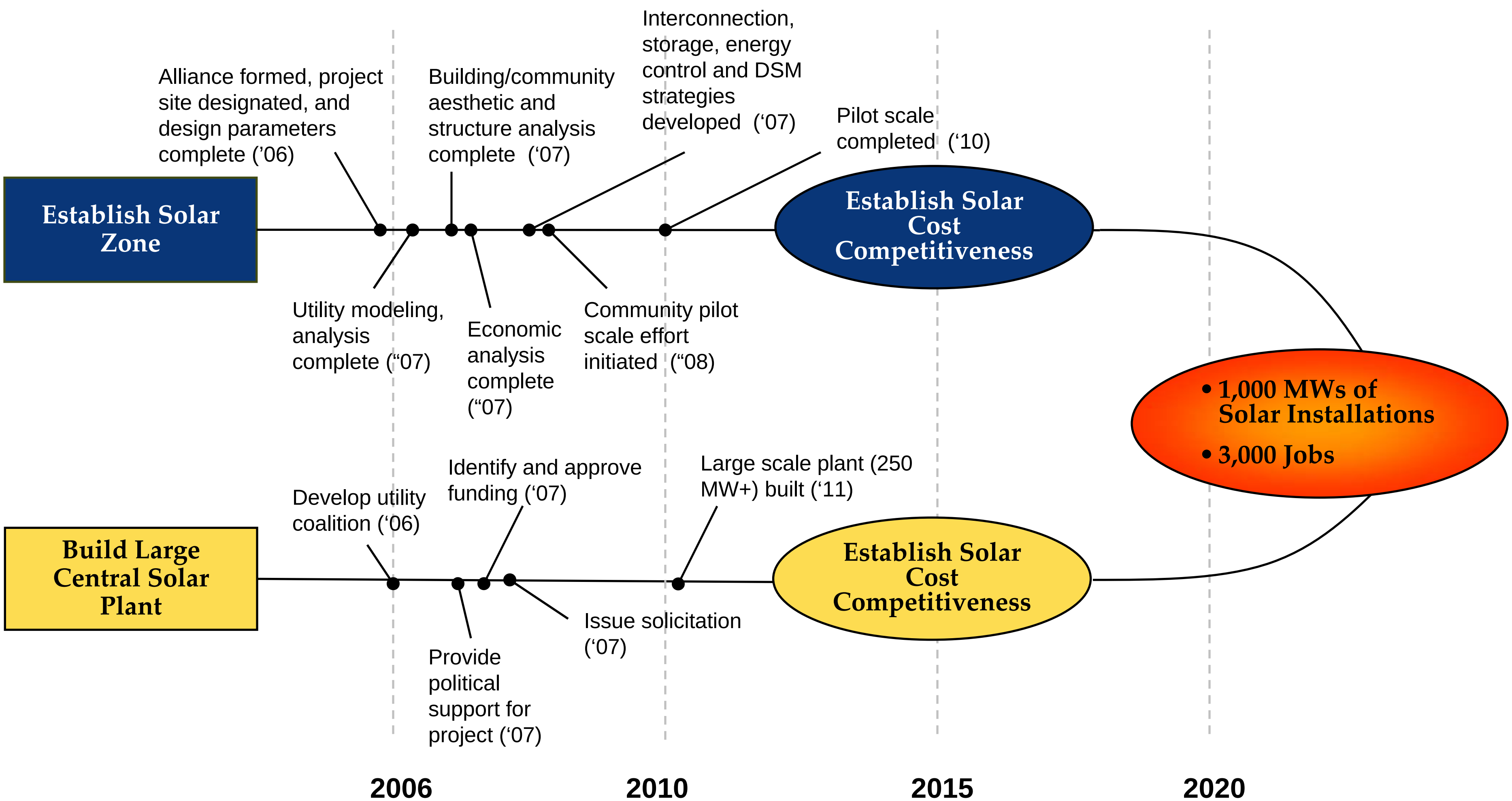
Establish Master Planned Community Alliance that provides scalability, reduces costs, and raises the value of distributed solar energy systems.

Solar Zones for Large Solar Development Action Plan	
Action/ Rationale	Deliver a fully integrated 30-50 MW distributed solar project that targets the scale, cost, performance, reliability and aesthetic requirements of large master planned communities. Establishes AZ as a market leader-- first with solar distributed energy applications large enough to impact grid infrastructure. support. Uses market forces and R&D dollars to stimulate innovation. High profile exposure.
Barriers Addressed	Developers, builders, homeowners require technical and financial risk reduction strategies and viable roofing to community designs and system siting options. Utilities need to allay power quality, reliability and safety concerns, understand interconnection architectures needed to support 30 MWs or greater of concentrated distributed generation. Municipal planners need greater understanding of benefits of distributed solar energy systems. Industry needs large single market to achieve learning cost reductions. Buying public needs a real demonstration community.
Potential Risks	Community wide system proves technically unworkable or financially not viable Unable to attract resources needed to carry out project.
Timeline	2006 to 2010
Who	Master planned community developers and builders. Impacted electric utility, Power Systems Engineering Center, building and community design experts, municipal planners
Potential Key Milestones	• Alliance formed, project site designated and design parameters complete (2006) • Utility modeling, analysis complete (2007) • Building/community aesthetic and structure analysis complete. Economic analysis completed (2007) • Interconnection, storage, energy control and demand side management strategies developed (2008) • Community pilot scale effort initiated (2008). Completed (2010)

Forming a coalition of utilities to develop a large scale central solar project can provide certainty to stimulate investment.

Central Station Solicitation Action Plan	
Action/Rationale	Form coalition with western utilities to develop large scale central solar projects in Arizona. Focus on a single significant scale project, e.g. 250 MW, to be solicited in 2007 and completed within four years. Develop cross state utility partnership model mimicking large nuclear and coal plants. Leverage Arizona's solar resource to benefit surrounding state RPS and solar obligations.
Barriers Addressed	High current costs; lack of local market; need to develop labor skills; competition with Germany, California, etc. for attention of solar investors; difficulty of financing solar stations; current resource RFPs are not well suited for emerging technologies because of their costs, risks and development time-fame
Potential Risks	Do not get good quality bids. Planned acquisitions do not take place. Getting locked into long-term, high-priced contracts. Lack of adequate transmission capacity.
Timeline	2007-2011
Who	Utilities, ACC, Governor, Legislature
Potential Key Milestones	• Develop utility coalition (utilities, 2006 – 2007) • Provide political support for project (Governor, Legislature, 2007) • Identify and approve funding (ACC, 2007) • Large scale (250 MW +) plants built (2011)

Below are key milestones to help accelerate the development and adoption of solar.



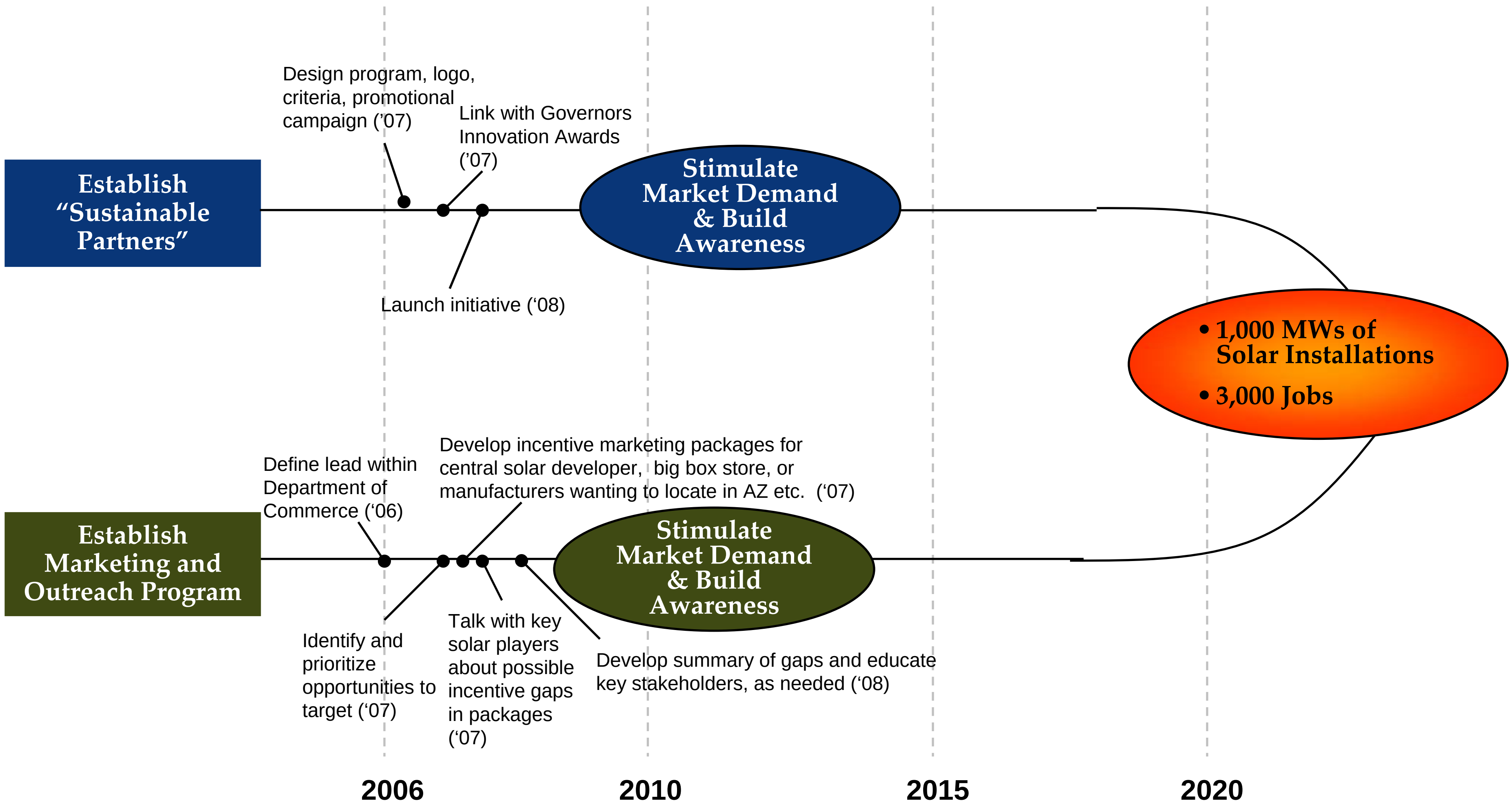
Providing high profile visibility for solar utilization, development, and/or investment may also stimulate demand for solar.

Sustainable Partners Action Plan	
Action/Rationale	Prestigious recognition and awards that businesses display for solar utilization, development, or investments. Incorporate with Governors Innovation Awards and other high profile events. Awards provided at annual high profile banquet with the Governor. Awardees can use Sustainable Partner logo in their place of business and in advertisements. This program stimulates the demand for solar, making it a matter of being a good corporate citizen or showing environmental leadership. This stimulates commitment from corporate senior leadership.
Barriers Addressed	Lack of local markets, competition from other regions.
Potential Risks	No one elects to join. Insufficient political support.
Timeline	2007-2010
Who	Governors office, ADOC Energy Office
Potential Key Milestones	• Design program, logo, criteria, promotional campaign (1st half of 2007) • Launch initiative (2nd half of 2008)

Incentive packages need to be developed for a marketing and outreach to lure key solar players to the state.

AZ Solar Marketing and Outreach Action Plan	
Action/ Rationale	Campaign to market AZ to solar manufacturers and national retail chains. Provide state incentive package that is comparable to other states/countries e.g. tax holidays for state investment or seed money to locate company in state.
Barriers Addressed	Many AZ programs and incentives have recently been expanded and the industry needs to be aware of these. Need to distinguish AZ apart from CA, NM or even Germany where incentives lure players.
Potential Risks	AZ tax payers perception of the program being a waste of money.
Timeline	2006 – on-going
Who	Arizona Department of Commerce
Potential Key Milestones	• Define lead within Department. of Commerce (2006) • Identify and prioritize opportunities to target (2007) • Develop incentive package for central solar developers, big box stores, and manufacturers or developers/installers wanting to locate in AZ (2007) • Talk with key solar players interested in locating in AZ (2007) • Develop summary of gaps and educate key stakeholders, as needed (2008)

Below are additional key milestones for development and adoption of solar through stimulating market demand and building awareness.



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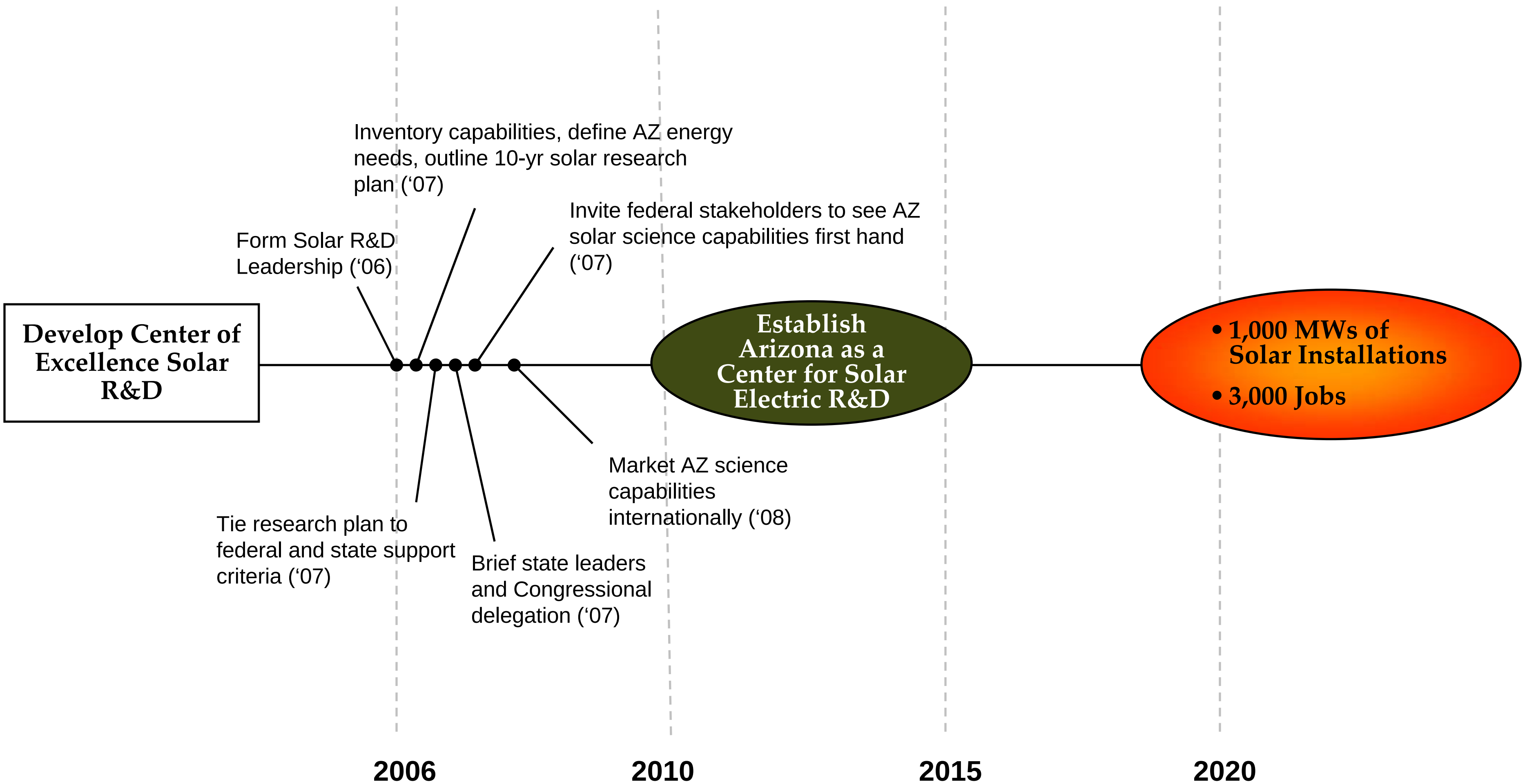
AZ might consider the development of a Solar Center of Excellence to help establish itself as a leader in solar intellectual capital.

Establish Arizona as Leader in Solar Intellectual Capital Action Plan	
Action/ Rationale	Build solar Center of Excellence using existing expertise at STAR, ASU's Photovoltaic Testing Laboratory, together with science/technology strengths at ASU and UA. Define both near-term research strengths in solid state sciences, flexible display, power engineering and sustainable design; as well as longer-term strengths in light based bioscience and very high efficiency materials. Leverage federal funding using state resources from Science Foundation Arizona, approved utility R&D funding and new funding from the legislature. Using solar resource with scientific capabilities, AZ can lead the world in sustainable solutions for hot desert climates.
Barriers Addressed	Solar cost barriers in the short term, and limitations on carbon for energy production in the longer term.
Risks	Failure to attract state and private funds to build, package, and market AZ scientific capabilities.
Timeline	2007 - 2015
Who	State universities, state utilities, Science Foundation Arizona, ACC, AZ Legislature and congressional delegation
Potential Key Milestones	• Form Solar R&D Leadership Group (2006) • Inventory capabilities, define AZ energy needs, outline 10-year solar research plan (2007) • Tie research plan to federal and state support criteria (2007) • Brief state leaders and congressional delegation (2007) • Invite federal stakeholders to see AZ solar science capabilities first hand (2007) • Market AZ science capabilities internationally (2008)

Below are the key milestones for building knowledge to support the development of a Center of Excellence for Solar R&D.



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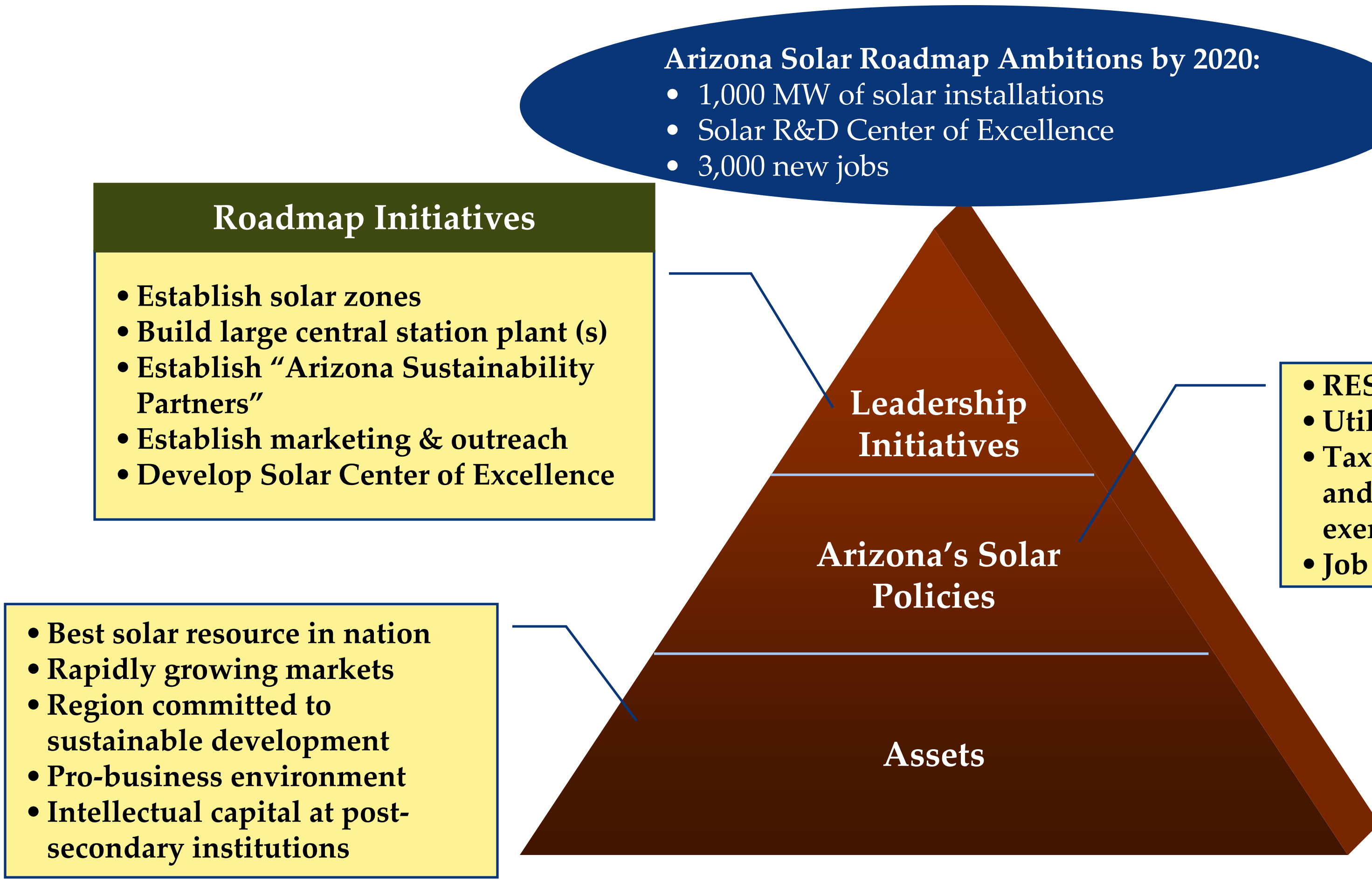
Implementing the roadmap initiatives will allow AZ to build upon its assets and policies to establish a leadership position in fostering solar.



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Appendix A – LCOE Model

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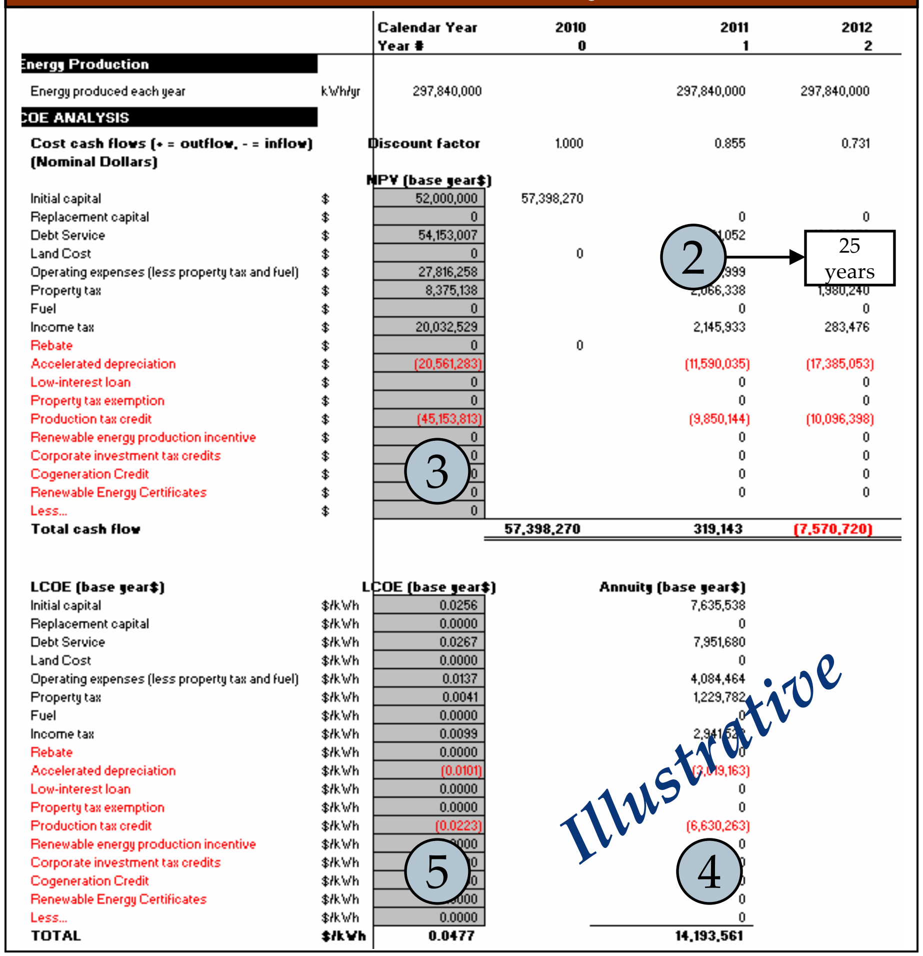
NCI's Levelized Cost of Electricity (LCOE) model computes electricity costs at the busbar level.

NCI's Levelized Cost of Electricity (LCOE) Model
• 25-year cash flow model • Estimates all costs associated with a project, (e.g. capital, O&M, fuel and taxes), and discounts all costs to the present at the cost of equity and then computes a levelized cost in constant dollars • 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). Focuses on costs, not market prices. • LCOE is for busbar cost – does not include transmission and distribution. • Includes the effects of Federal and state incentives (e.g., Federal Investment Tax Credit, accelerated depreciation, production tax credit, property tax exemptions)

The NCI LCOE model has six primary calculation steps that drive the cost of electricity results.

NCI LCOE Model - Primary Calculations



		Calendar Year	2010	2011	2012
		Year #	0	1	2
Energy Production					
Energy produced each year	kWh/yr	297,840,000		297,840,000	297,840,000
COE ANALYSIS					
Cost cash flows (+ = outflow, - = inflow) (Nominal Dollars)		**Discount factor**	1.000	0.855	0.731
		NPV (base year$)			
Initial capital	$	52,000,000	57,398,270		
Replacement capital	$	0		0	0
Debt Service	$	54,153,007		[illegible]	[illegible]
Land Cost	$	0	0	[illegible]	[illegible]
Operating expenses (less property tax and fuel)	$	27,816,258		[illegible]	[illegible]
Property tax	$	8,375,138		2,066,338	1,980,240
Fuel	$	0		0	0
Income tax	$	20,032,529		2,145,933	283,476
Rebate	$	0	0		
Accelerated depreciation	$	(20,561,283)		(11,590,035)	(17,385,053)
Low-interest loan	$	0		0	0
Property tax exemption	$	0		0	0
Production tax credit	$	(45,153,813)		(9,850,144)	(10,096,398)
Renewable energy production incentive	$	0		0	0
Corporate investment tax credits	$	0		0	0
Cogeneration Credit	$	0		0	0
Renewable Energy Certificates	$	0		0	0
Less...	$	0			
Total cash flow			**57,398,270**	**319,143**	**(7,570,720)**

LCOE (base year$)		**LCOE (base year$)**	**Annuity (base year$)**
Initial capital	$/kWh	0.0256	7,635,538
Replacement capital	$/kWh	0.0000	0
Debt Service	$/kWh	0.0267	7,951,680
Land Cost	$/kWh	0.0000	0
Operating expenses (less property tax and fuel)	$/kWh	0.0137	4,084,464
Property tax	$/kWh	0.0041	1,229,782
Fuel	$/kWh	0.0000	0
Income tax	$/kWh	0.0099	[illegible]
Rebate	$/kWh	0.0000	0
Accelerated depreciation	$/kWh	(0.0101)	[illegible]
Low-interest loan	$/kWh	0.0000	0
Property tax exemption	$/kWh	0.0000	0
Production tax credit	$/kWh	(0.0223)	(6,630,263)
Renewable energy production incentive	$/kWh	[illegible]	0
Corporate investment tax credits	$/kWh	[illegible]	[illegible]
Cogeneration Credit	$/kWh	[illegible]	[illegible]
Renewable Energy Certificates	$/kWh	[illegible]	0
Less...	$/kWh	0.0000	0
TOTAL	**$/kWh**	**0.0477**	**14,193,561**

Primary Calculations - Descriptions

1. Assumes an annual revenue stream (not shown in figure on the left) in ¢/kWh to allow the model to calculate an initial tax estimate.
2. Forecasts 25 years of cost cash flows for several cost categories (e.g., capital, debt, fuel, taxes).[1]
3. Calculates the Net Present Value of each cost item by discounting annual flows by the discount rate of the owner.
4. Calculates the equivalent annuity (levelized cost) for each category based on the owner's discount rate.
5. Divides the levelized costs (annuity) by the annual energy output in kWh to calculate the first estimate of the LCOE in ¢/kWh.
6. Iterates until the LCOE calculated in step 5 equals the assumed revenue required in step 1. This is the revenue required to cover the costs and return on capital required by the owner.

1. Separate sections of the model calculate the annual flows for each category based on inputs regarding incentives, technology costs, cost of capital.

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Appendix B – References

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Appendix C – Glossary of Terms

The various acronyms used throughout this document are defined below.

Acronyms	Definitions
ACC	Arizona Corporation Commission
ADG	Anaerobic Digester Gas
APS	Arizona Public Service
ASU	Arizona State University
BIGCC	Biomass Integrated Gasification Combined Cycle
CERB	Commercial and Existing Residential Buildings
CPV	Concentrating Photovoltaics
CSP	Concentrating Solar Power
DSM	Demand Side Management
GHG	Greenhouse Gas
IRP	Integrated Resource Plan
kW	KiloWatts
kWh	KiloWatt-hours
LCOE	Levelized Cost of Electricity[1]
LFG	Landfill Gas
MACRS	Modified Accelerated Cost Recovery System
MSW	Municipal Solid Waste
MW	MegaWatt
MWh	MegaWatt-hours
NCI	Navigant Consulting, Inc.
NREL	National Renewable Energy Laboratory

Acronyms	Definitions
PPA	Power Purchase Agreement
PTC	Production Tax Credit
PV	Photovoltaic(s)
REC	Renewable Energy Certificate
RES	Renewable Energy Standard
REPI	Renewable Energy Production Incentive
RNCC	Residential New Construction Component
RPS	Renewable Portfolio Standard
SAI	Solar America Initiative
SBC	System Benefit Charges
SRP	Salt River Project
TEP	Tucson Electric Power
UA	University of Arizona

1. The LCOE is the total lifecycle cost, expressed in real (constant) dollars, of producing electricity from a given project. It includes all the capital charges, fuel, and non-fuel O&M costs over the economic life of the project. Annual capital charges are computed based on the discount rate, cost of equity, debt/equity ratio, tax rate, depreciation schedule, property tax and insurance requirements. Thus the annual capital charges will vary significantly for different entities such as municipal utilities vs. private developers.

Definitions of selected terms are presented below.

Base Load	The minimum load experienced by an electric utility system over a given period of time.
Capacity Factor	The ratio of the average load on a machine or equipment for a period of time to the capacity rating of the machine or equipment.
Coincidental Peak Load	Two or more peak loads that occur at the same time.
Demand (electric)	The rate at which electric energy is delivered to or by a system, part of a system, or a piece of equipment. Demand is expressed in kW, kVA, or other suitable units at a given instant or over any designated period of time. The primary source of "demand" is the power-consuming equipment of the customers.
Distributed Generation	A distributed generation system involves small amounts of generation located on a utility's distribution system for the purpose of meeting local (substation level) peak loads and/or displacing the need to build additional (or upgrade) local distribution lines.
Fuel Escalation	The annual rate of increase of the cost of fuel, including inflation and real escalation, resulting from resource depletion, increased demand, etc.
Gigawatt	This is a unit of electric power equal to one billion Watts, or one thousand megawatts – enough power to supply the needs of a medium-sized city.
Grid	Matrix of an electrical distribution system.
Independent Power Producers (IPPs)	These are private entrepreneurs who develop, own or operate electric power plants fueled by alternative energy sources, such as biomass, cogeneration, small hydro, waste-energy and wind facilities.
Intermittent Resources	Resources whose output depends on some other factory that cannot be controlled by the utility (e.g., wind or sun), thus the capacity varies by day and by hour.
Investor-Owned Utility (IOU)	An IOU is a form of electric utility owned by a group of investors. Shares of IOUs are traded on public stock markets.
Kilowatt-Hour (kWh)	The basic unit of electric energy equal to one kilowatt of power supplied to or taken from an electric circuit for one hour.
Levelized	A lump sum that has been divided into equal amounts over a period of time.

Definitions of selected terms are presented below (continued).

Load Forecast	Estimate of electrical demand or energy consumption at some future time.
Load Profile	Information on a customer's usage over a period of time, sometimes shown as a graph.
Megawatt	One million Watts.
Megawatt-hour (MWh)	One thousand kilowatt-hours or one million-watt hours.
Off-peak	Periods of relatively low system demands.
Payback	The length of time it takes for the savings received to cover the cost of implementing the technology.
Peak Demand	Maximum power used in a given period of time.
Peaking Unit (Peakers)	A power generator used by a utility to produce extra electricity during peak load times.
Power Purchase Agreement	This refers to a contract entered into by an independent power producer and an electric utility. The power purchase agreement specifies the terms and conditions under which electric power will be generated and purchased. Power purchase agreements require the independent power producer to supply power at a specified price for the life of the agreement. While power purchase agreements vary, their common elements include: specification of the size and operating parameters of the generation facility; milestones in-service dates, and contract terms; price mechanisms; service and performance obligations; dispatchability options; and conditions of termination or default.
REC	Renewable Energy Certificates are used to track the "cleaness" of a power generator vs. the kWhs or power generated. They convey the right to claim the attributes associated with electricity generated from a specific renewable facility and are used to demonstrate compliance with renewable portfolio standard rules and substantiate green power marketing claims. RECs can also be used for labeling/ disclosure purposes.

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Appendix D – Steering Committee

NAVIGANT CONSULTING

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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

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

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Appendix E – Department of Commerce Team

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Content of Report

This report was prepared by Navigant Consulting Inc.[1] This report was prepared for the exclusive use of the Arizona Department of Commerce - that has supported this effort. The report summarizes our findings from an evaluation of solar opportunities in the state of Arizona. The work presented in this report represents our best efforts and judgments based on the best information available at the time that we prepared this report. Navigant Consulting, Inc. is not responsible for the reader's use of, or reliance upon, the report, nor any decisions based on the report. NAVIGANT CONSULTING, INC. DOES NOT MAKE ANY REPRESENTATIONS, OR WARRANTIES, EXPRESSED OR IMPLIED. Readers of the report are advised that they assume all liabilities incurred by them, or third parties, as a result of their reliance on the report, or the data, information, findings and opinions contained in the report.

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