City of Tucson / Tucson Water Solar Initiatives

Including background on
Solar Electric Generation
and focus on CAVSARP
1MW photovoltaic Project

Citizens Water Advisory Committee

Wednesday, May 6, 2009

Overview of Presentation

- Solar technology deployment
  - LARGE (utility-scale generation)
  - MEDIUM (large-scale distributed generation)
  - SMALL (small commercial and residential generation)
- Solar funding framework
  - COT “1% for solar” and Arizona Corporation Commission Mandates for Electric Utilities
  - Clean Renewable Energy Bonds (CREBs)
  - Solar America Cities Grant
  - CAVSARP photovoltaic
  - Public/Private partnerships

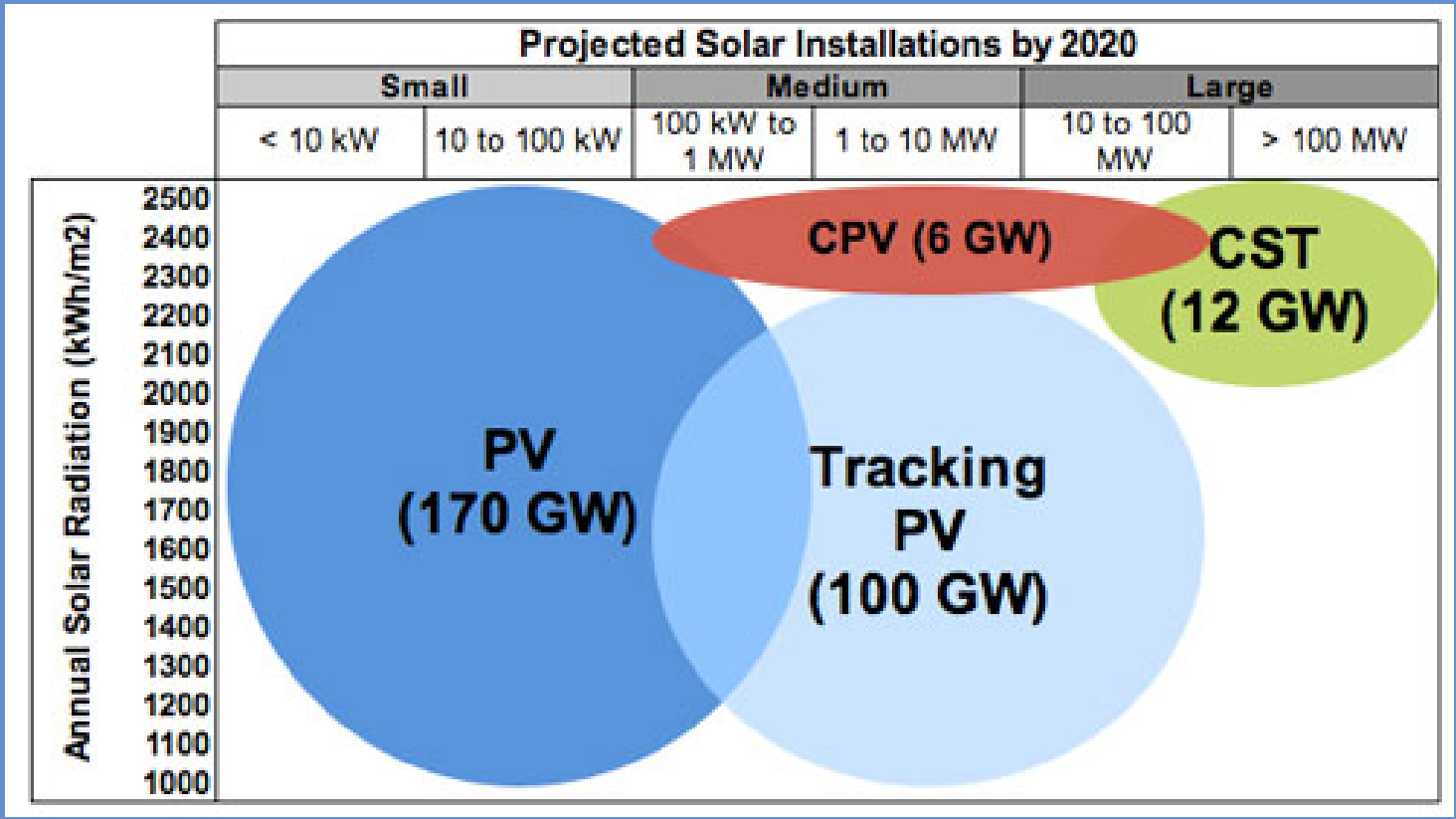
Solar Technology Deployment - 2020

PV
fixed angle photovoltaic

Tracking PV
photovoltaic with ability to track sun

CPV
concentrating photovoltaic

CST
concentrating solar thermal



Credit: greentech Media, The Prometheus Institute: Concentrating Solar Power - Technology, Cost, and Markets, 2008 Industry Report

Solar Technology Deployment - LARGE scale generation

Solar Thermal Electric - Power Tower

Concentrating Photovoltaic

Solar Thermal Electric - Trough

Solar Thermal Electric - Stirling Engine

Solar Technology Deployment - LARGE scale generation

Major U.S. Projects from solar Energy Industries Association
http://www.seia.org/

Major Solar Projects: Operational and Under Development
Updated 3/26/09

SEIA Solar Energy Industries Association®

Projects in Operation

Developer	Project Name	Electricity Purchaser	Location	Technology	Capacity (MW)
Concentrating Solar Power (including Concentrating Photovoltaic)					
Acciona	Nevada Solar One	NV Energy	Boulder City, NV	Trough	64
Solargenix	Saguaro Solar Power Plant	Arizona Public Service	Red Rock, AZ	Trough	1
Solel	Solar Energy Generating Systems (SEGS) I	Southern California Edison	Daggett, CA	Trough	14
Solel	Solar Energy Generating Systems (SEGS) II	Southern California Edison	Daggett, CA	Trough	30
Solel	Solar Energy Generating Systems (SEGS) III	Southern California Edison	Kramer Junction, CA	Trough	30
Solel	Solar Energy Generating Systems (SEGS) IV	Southern California Edison	Kramer Junction, CA	Trough	30
Solel	Solar Energy Generating Systems (SEGS) IX	Southern California Edison	Kramer Junction, CA	Trough	80
Solel	Solar Energy Generating Systems (SEGS) V	Southern California Edison	Kramer Junction, CA	Trough	30
Solel	Solar Energy Generating Systems (SEGS) VI	Southern California Edison	Kramer Junction, CA	Trough	30
Solel	Solar Energy Generating Systems (SEGS) VII	Southern California Edison	Kramer Junction, CA	Trough	30
Solel	Solar Energy Generating Systems (SEGS) VIII	Southern California Edison	Kramer Junction, CA	Trough	80
				Concentrating Solar Power Total	*419*
Photovoltaics (excluding Concentrating Photovoltaic)					
Conergy	Exelon-Conergy Solar Energy Center	Exelon Generation, LLC	Philadelphia, PA	PV	3
First Solar/Sempra Generation	El Dorado Energy Solar Project	Pacific Gas & Electric	Boulder City, NV	Thin-film PV[2]	10
SunEdison	Alamosa Photovoltaic Solar Plant	Xcel Energy	Alamosa, CO	PV	8
SunPower	Nellis Air Force Base	Nellis Air Force Base	Clark County, NV	PV	14
				Photovoltaics Total	*35*
Total Operational					**454**

Projects Under Development

Developer	Project Name	Electricity Purchaser	Location	Technology	Capacity (MW)
Concentrating Solar Power (including Concentrating Photovoltaic)					
Abengoa Solar	Solana plant	Arizona Public Service	Gila Bend, AZ	Trough	280
Ausra		Pacific Gas & Electric	Carrizo Plain, CA	Linear Fresnel	177
BrightSource Energy	Ivanpah	Pacific Gas & Electric	Barstow, CA	Tower	300
BrightSource Energy	Ivanpah	Southern California Edison	Barstow, CA	Tower	100
BrightSource Energy		Southern California Edison	California	Tower	1,200
Emcore/SunPeak Power			Southwest US	Lens CPV	200
eSolar	Gaskell Sun Tower (Phase I)	Southern California Edison	Kern County, CA	Tower	105
eSolar	Gaskell Sun Tower (Phase II)	Southern California Edison	Kern County, CA	Tower	140
Florida Power & Light Co.	Martin Next Generation Solar Energy Center	Florida Power & Light Co.	Martin County, FL	Trough[1]	75
GreenVolts, Inc.		Pacific Gas & Electric	Byron, CA	CPV	2
Harper Lake, LLC	Harper Lake Solar Plant		California	Trough	250
Inland Energy, Inc.	Palmdale Hybrid Gas-Solar plant		Palmdale, CA	Trough	50
Inland Energy, Inc.	Victorville Hybrid Gas-Solar plant		Victorville, CA	Trough	50
NextEra Energy Resources	Beacon Solar Energy Project		Kern County, CA	Trough	250
San Joaquin Solar, LLC	San Joaquin Solar 1	Pacific Gas & Electric	Coalinga, CA	Trough[1]	53
San Joaquin Solar, LLC	San Joaquin Solar 2	Pacific Gas & Electric	Coalinga, CA	Trough[1]	53
Solar Millennium	Nye County Project 1	NV Energy	Nye County, NV	Trough	250
Solar Millennium	Nye County Project 2	NV Energy	Nye County, NV	Trough	250
Solel	Mojave Solar Park	Pacific Gas & Electric	Mojave Desert, CA	Trough	553
Sopogy	Demonstration plant		Kailua-Kona, HI	MicroCSP	1
Stirling Energy Systems	SES Solar One	Southern California Edison	Victorville, CA	Dish-engine	500
Stirling Energy Systems	SES Solar One Expansion	Southern California Edison	Victorville, CA	Dish-engine	350
Stirling Energy Systems	SES Solar Two	San Diego Gas & Electric	Imperial County, CA	Dish-engine	300
Stirling Energy Systems	SES Solar Two Expansion	San Diego Gas & Electric	Imperial County, CA	Dish-engine	600
				Concentrating Solar Power Total	*6,090*
Photovoltaics (excluding Concentrating Photovoltaic)					
First Solar	Topaz Solar Farm	Pacific Gas & Electric	Carrisa Plains, CA	Thin-film PV	550
First Solar	Cimarron I Solar Project	Tri-State Generation and Transmission	Cimarron, NM	Thin-film PV[2]	30
First Solar	FSE Blythe	Southern California Edison	Blythe, CA	Thin-film PV	8
Florida Power & Light Co.	DeSoto Next Generation Solar Energy Center	Florida Power & Light Co.	DeSoto County, FL	PV	25
Florida Power & Light Co.	Space Coast Next Generation Solar Energy Center	Florida Power & Light Co.	Kennedy Space Center	PV	10
MMA Renewable Ventures and Suntech Power Holdings		Austin Energy	Austin, TX	PV	30
SunEdison		Lakeland Electric	Distributed in FL Service Area	PV	24
SunEdison		California State Universities	California	Thin-film PV	8
SunPower	California Valley Solar Ranch	Pacific Gas & Electric	San Luis Obispo County, CA	PV	250
	Commercial Rooftop Installations	Southern California Edison	Southern California	PV	250
		Public Service Electric & Gas Company	New Jersey	PV	120
				Photovoltaics Total	*1,305*
Total Under Developoment					**7,394**

Total Operational and Under Development

	Concentrating Solar Power Total	*6,509*
	Photovoltaics Total	*1,340*
Total Operational and Under Development		**7,848**

*Ausra also has a 5 MW Linear Fresnel test plant in operation in Bakersfield, CA that is not connected to the grid.

(1) Hybrid solar plants cofiring with other fuels (peak output reflects solar contribution only)

(2) Capacity reported in megawatts AC (alternating current)

Press inquiries should be directed to Monique Hanis at mhanis@seia.org

If you have comments on this list, please contact Justin Baca at jbaca@seia.org

Solar Technology Deployment – S AZ utilities generation

Solar Thermal – APS Saguaro Plant

Photovoltaic – TEP Springerville Generating Stn

Solar Technology Deployment - MEDIUM scale generation

West Basin Municipal Water District - El Segundo, CA

USPS - Sacramento, CA

Donaghy Distributor Warehouse - Fresno, CA

USPS - Oakland, CA

Solar Technology Deployment - SMALL scale generation

Thornydale Reclaimed Reservoir roof-mounted (above)

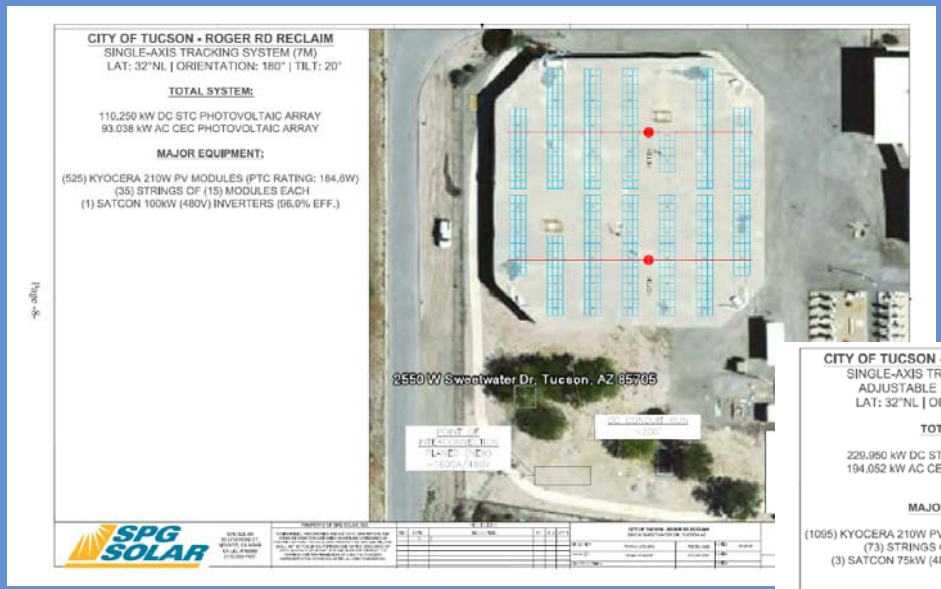
Hayden Udall Water Treatment Facility ground-mounted (below)

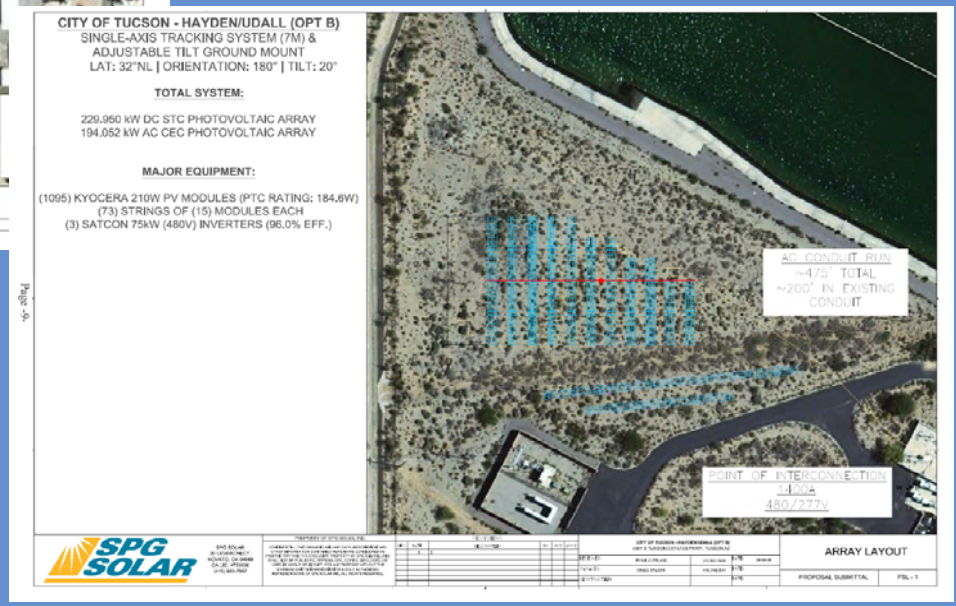
solar funding framework

- COT 1% for solar ("1%FS") and A.C.C. Renewable Energy Mandates
  - Environmental Portfolio Standard ("**EPS**")→ Renewable Energy Standard & Tariff ("**REST**")
- Clean Renewable Energy Bonds ("CREBs")
- Solar America Cities Grant
- CAVSARP photovoltaic
- Public/Private partnerships

1%FS and EPS

CREBs, 1%FS, and REST





Solar America Cities Grant

City Solar Objectives

- Mitigate electrical cost & rate increases.
- Increase % of renewable energy generation.
- Demonstrate viable applications for solar photovoltaic, hot water & day-lighting systems.
- Provide community leadership on reducing greenhouse gas emissions.

General Services

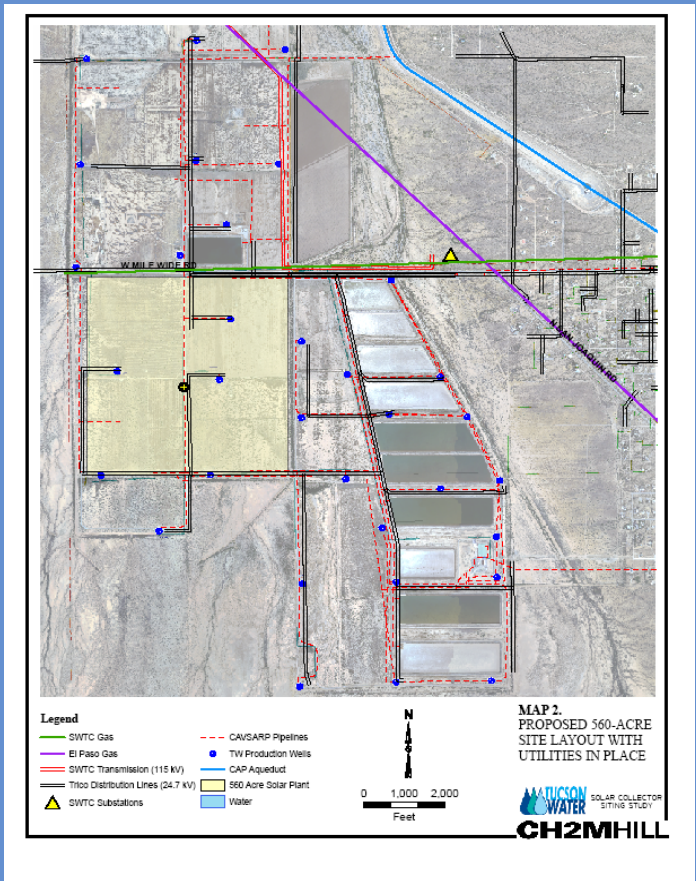
July 8, 2008

CAVSARP Photovoltaic System History / Timeline

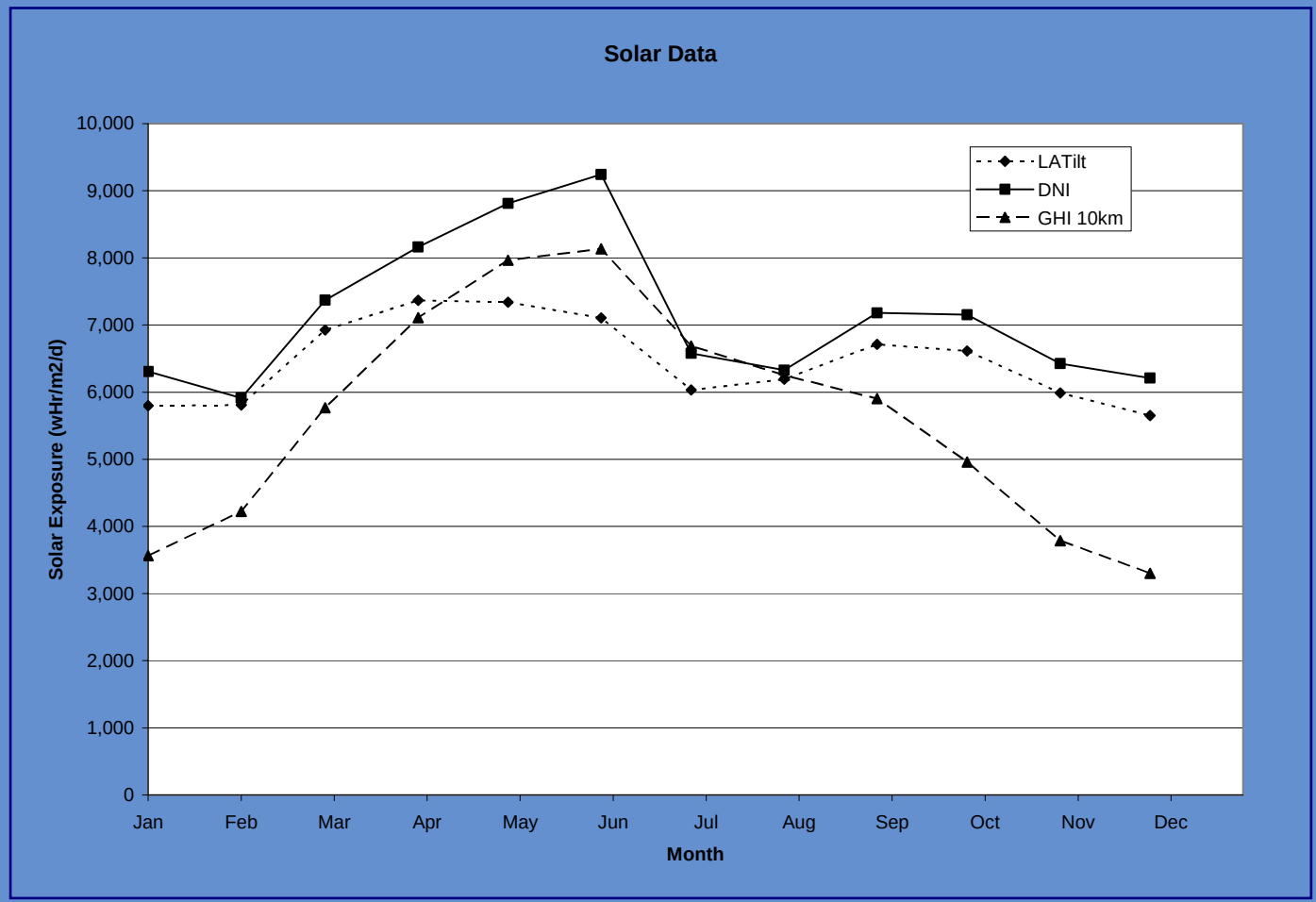
- **September 2006**
  - M&C directed study for feasibility of a solar farm on COT Avra Valley to feed COT electric load
- **January 2007**
  - analysis presented to M&C- distributed project recommended
- **September 2007 - January 2008**
  - CAVSARP solar feasibility study
- **June 2008 - July 2008**
  - RFP
- **March 2009 - April 2009**
  - Executed energy services agreement and lease
- **Fall 2009**
  - Scheduled groundbreaking

CAVSARP Solar Feasibility Study Site Assessment

http://www.tucsonaz.gov/water/docs/report_tucson_solar_final.pdf



CAVSARP Solar Feasibility Study
Solar Exposure



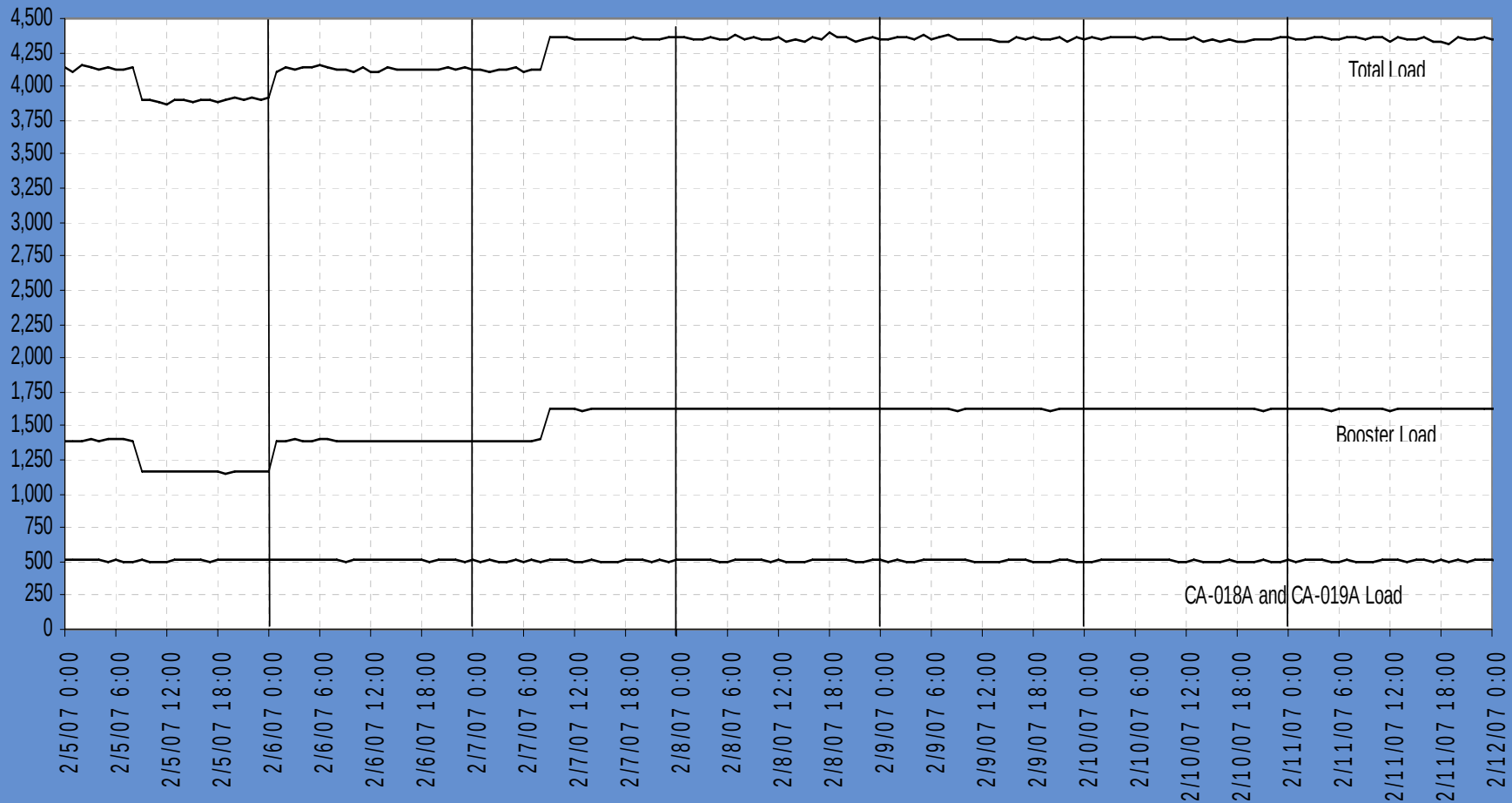
Definitions for insolation measures:

LATilt facing due south with tilt = latitude = 32 degrees

DNI direct normal insolation, follows sun

GHI 10km **h**orizontal surface

CAVSARP Solar Feasibility Study Site Electric Demand (kW)



CAVSARP Solar Feasibility Study Technology Assessment

	Photovoltaic Single Axis Tracking	CSP Troughs, Solar Only
Commercial Viability	Commercial	Commercial
Date for Commercial	2007	2007
Water Usage	Minimal—washing	High—900 G/MWH/yr
Capital Cost ($/kW)	5,750 to 6,250	3,800 to 4,300
O&M Cost (cents/kWh)	0.85 to 1.1	1.0 to 2.5
LCE (cents/kWh)	16 to 18	13 to 15
Permitting	Lowest	Moderate
Modularity	Modular	Large-scale
DG or Central Power	DG	Central

CAVSARP Solar Feasibility Study Financials and Potential Partners

- Solar developers with Income Tax appetite can offer Power Purchase Agreement (PPA) arrangement.
- REST requires utilities to meet annual targets for renewable energy.
- The yearly requirements began in 2006 and increase annually to reach a total of 15 percent of annual kWh by 2025.
- 30 percent of the renewable energy generation must come from distributed generators that are on the customer side of the meter.

CAVSARP Solar Feasibility Study Financials and Potential Partners

Year	Percent of Total MWh from Renewables	TEP		AEPCO*	
		Total Renewables Required	Distributed Renewables Required	Total Renewables Required	Distributed Renewables Required
		MWh	MWh	MWh	MWh
2006	1.25%	158,025	47,408	25,313	7,594
2007	1.50%	189,630	56,889	30,375	9,113
2008	1.75%	221,235	66,371	35,438	10,631
2009	2.00%	252,840	75,852	40,438	12,150
2010	2.50%	316,050	94,815	50,500	15,188
2011	3.00%	379,260	113,778	60,625	18,225
2012	3.50%	442,470	132,741	70,750	21,263
2013	4.00%	505,680	151,704	81,000	24,300
2014	4.50%	568,890	170,667	91,125	27,338
2015	5.00%	632,100	189,630	101,250	30,375
2016	6.00%	758,520	227,556	121,500	36,450
2017	7.00%	884,940	265,482	141,750	42,525
2018	8.00%	1,011,360	303,408	162,000	48,600
2019	9.00%	1,137,780	341,334	182,250	54,675
2020	10.00%	1,264,200	379,260	202,500	60,750
2021	11.00%	1,390,620	417,186	222,750	66,825
2022	12.00%	1,517,040	455,112	243,000	72,900
2023	13.00%	1,643,460	493,038	263,250	78,975
2024	14.00%	1,769,880	530,964	283,500	85,050
2025	15.00%	1,896,300	568,890	303,750	91,125

E.g. under the REST, 32 MW of solar (25% capacity factor) would be needed by AEPCO by 2012 to generate the 70,750 MWh req'd.

Less capacity would be needed if using other sources (LF gas).

CAVSARP Solar Feasibility Study Conclusions

- Ideal site for solar electric plant
  - Significant on-site demand
  - 140 acres: up to 7 MW PV, 25 MW CSP
  - 560 acres: 25 MW PV, 100 MW CSP
- Solar developer response
  - Ideally 4 to 5 MW, threshold ~ 1 MW
  - $0.13 to $0.20 /kWh
- 30 % investment tax credit risk after 2008

RFP # 084003: Photovoltaic System At CAVSARP

- Issued: May 30, 2008
  - 1 to 5 MW PV (PPA or similar)
- Pre-Bid: June 18, 2008
  - High attendance /interest
- Bid closed: July 8, 2008
  - 7 proposals

RFP panel selects SunPower September 2008

Pre-Bid Participants:
Parsons
Sun Edison
SunPower Corp.
Sol Equity
Gloria Spire Solar
APS Energy Services
Brown & Caldwell
Sundial Energy
Spectrum Energy
EDA Eng. Inc.
Honeywell
Solon America
Recurrent Energy
GeoInnovation
Suntech

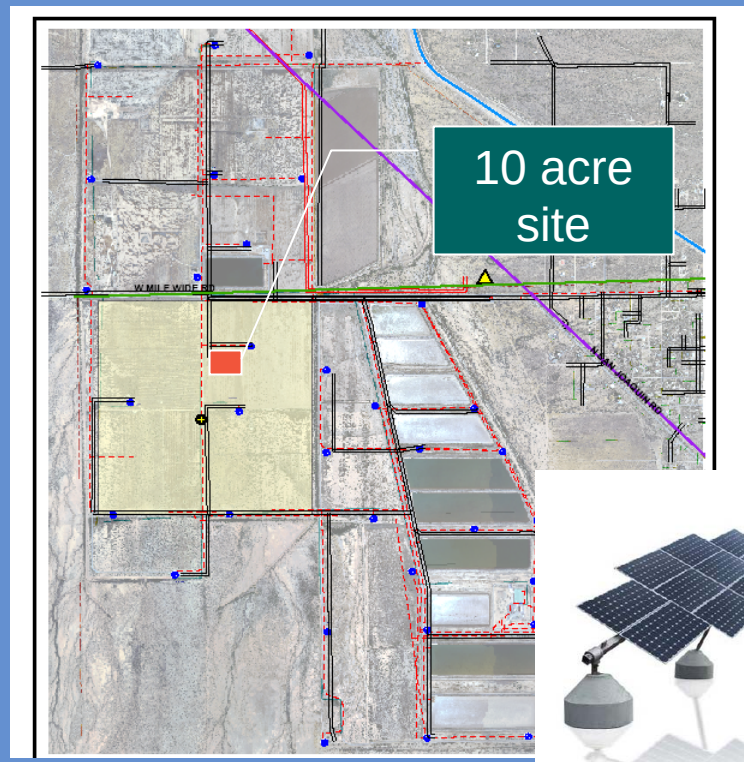
CAVSARP Photovoltaic System Power Purchase Agreement

Estimated Energy:

- 2.3 million kWh/yr
- 5% of CAVSARP electric use
- Sending to Tucson ~647 million gallons or 1,985 acre-feet per year

Cost:

- 0.159 $/kWh, 3%/yr escalator
- 20 year term
- Pricing includes ‘brown’ energy, renewable energy attributes and other energy services



System: 1 MWdc
2500 modules
275 T-20 trackers

CAVSARP Photovoltaic System Operational Benefits

- Financial
  - Savings in the cost of grid energy due to lowered demand during peak with ability to continue controls operations and some pumps
- Reliability/Security
  - Potential to use during long-term outage (considered a very low probability)
  - PV is grid tied, will shut down if grid goes out, would require manual switching

CAVSARP Photovoltaic System Environmental Advantages

- Renewable fuel source (sunlight)
- Reduced carbon footprint
- Lower water use for photovoltaic than other (fossil fuel/solar thermal) generation
- On-site distributed generation
  - locally produced energy
  - reduced transmission losses

CAVSARP Photovoltaic System Environmental Advantages

	kWh	Tons CO2	vehicles	Million miles	acres of trees	Million gallons of water
20 year avg	2,221,622	2,417	422	6.04	681	.644
20 year total	44,432,438	48,349	8,445	120	13,620	12.9

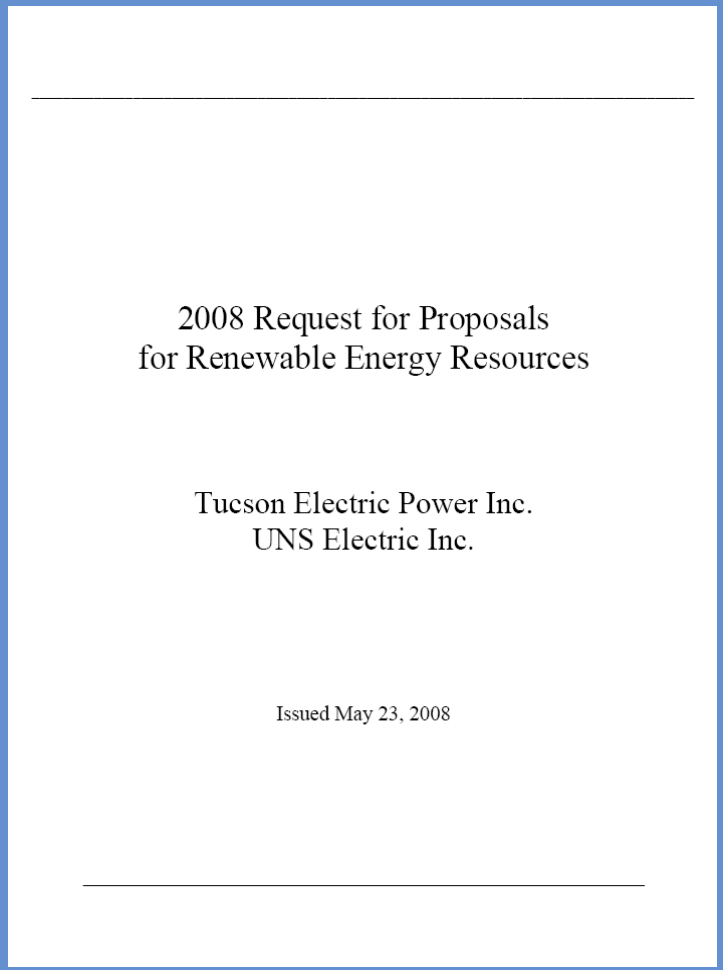
CAVSARP Photovoltaic System Outreach Opportunities

CAVSARP Photovoltaic System Financials

- Current CAVSARP $/kWh ……. 0.075
- Negotiated PPA $/kWh …….. 0.159
- Negotiated REC sale* $/kWh…. 0.080
- Bottom line to COT/TW $/kWh… 0.079

Public/Private partnerships for utility-scale projects

TEP's Renewable Energy RFP



2008 Request for Proposals
for Renewable Energy Resources

Tucson Electric Power Inc.
UNS Electric Inc.

Issued May 23, 2008

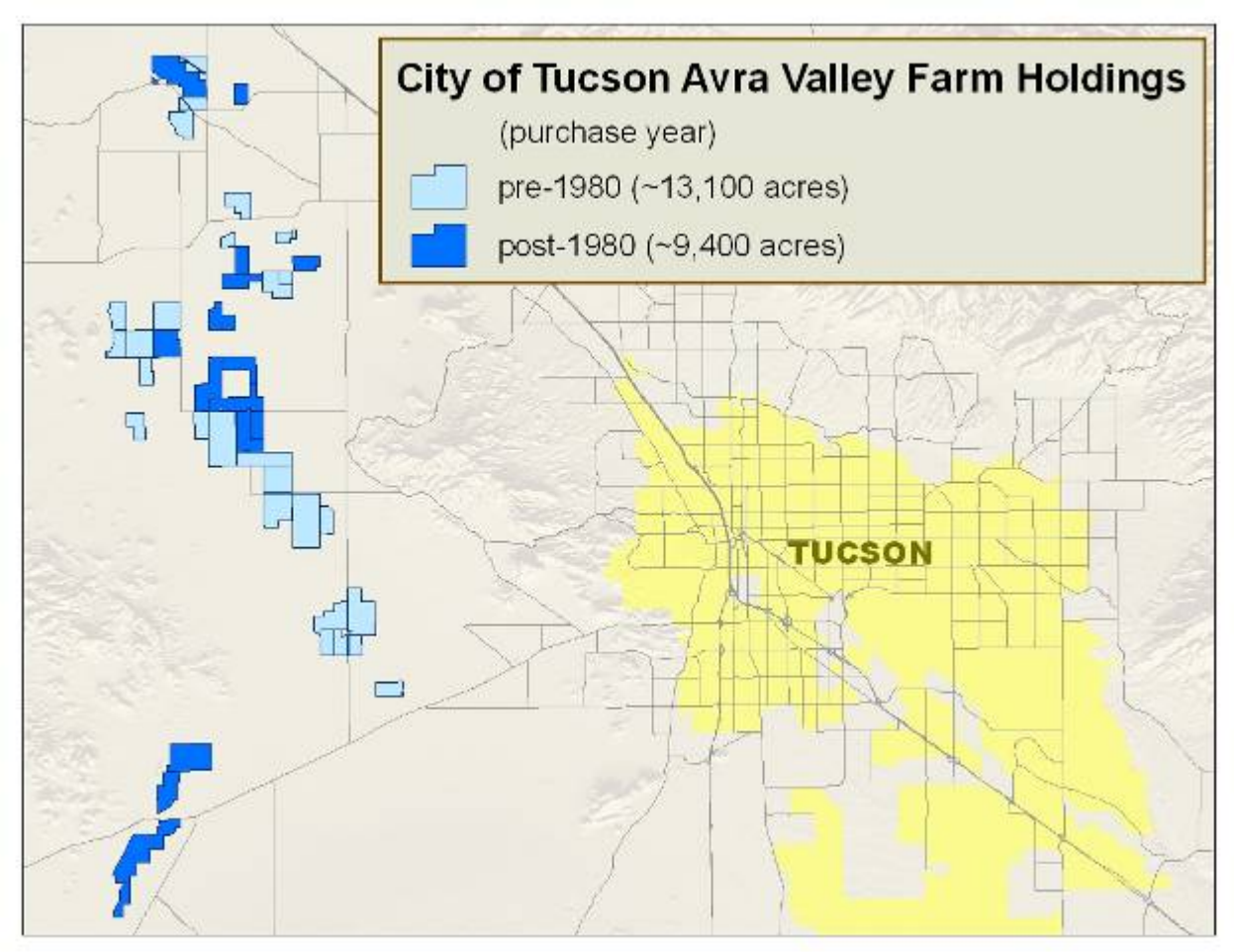
- TEP's REST levies ~0.8 cent per kWh on electric bills, capped at
  - Residential: $4.50 /month
  - Small General Service: $75.00 /month
  - Large General Service: $350.00 /month
  - Large Light and Power & Mining: $1,600 /month
- TEP issued RFPs in 2007 and 2008 to generate project proposals to utilize R.E.S.T. funding

Proposals from Solar Developers

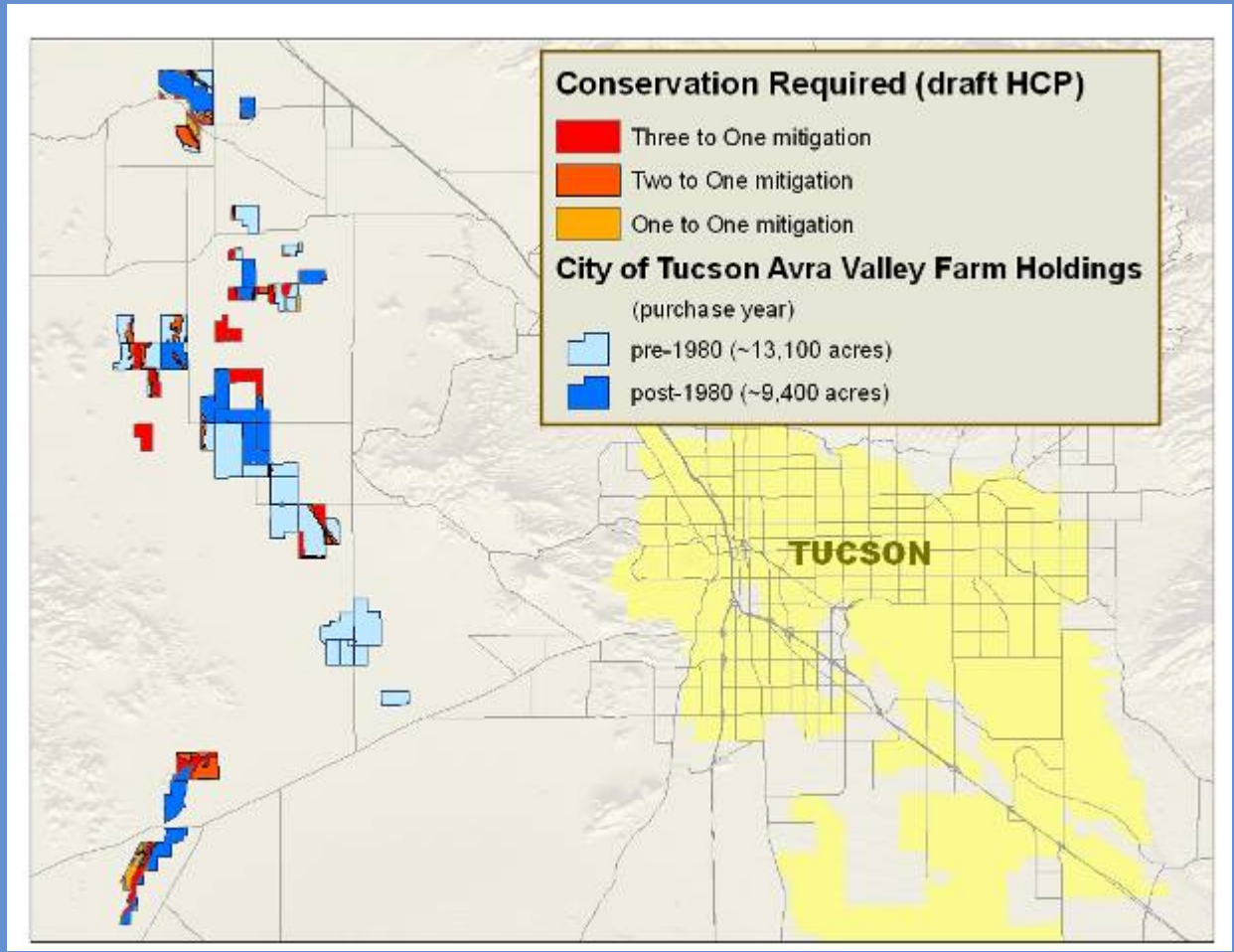
- Contact from 3 solar developers
  - Responding to TEP's 2007 and 2008 RFPs
  - Proposing to lease City's Avra Valley land
  - Requesting City endorsement for proposal to TEP

- City staff response
  - Working group: City Attorney's Office, Tucson Water, General Services, Mayor's Office, Real Estate, OCSD
  - Issued non-binding, non-exclusive letters of interest (at this time, only US Solar holds an active letter from the City for the 2008 RFP process)

Water Rights Considerations*



Habitat Considerations



Case for COT-TW involvement

- City of Tucson residents are customers of Tucson Electric Power, and pay a surcharge on their bills to fund new renewable energy resources
- Tucson Water holds significant suitable acreage in Avra Valley that is not likely to be developed for other purposes
- Utility-scale solar on City land would help achieve Tucson's *Solar America City* goals

Case for COT-TW involvement

- Any solar development in Avra Valley must be carefully located, designed and operated to:
  - Preserve City water rights and the Clearwater Recharge & Recovery operations (necessary for Tucson's Assured Water Supply)
  - Protect habitat (which may involve environmental mitigation)

Tucson Water / City of Tucson Solar Initiatives

Thank you!

Questions?