Promise of Renewable Energy in the San Diego Region

Renewable Energy Team
Barry Butler, PhD
Richard Caputo
Scott Debenham
Skip Fralick

Integration of 3April2006 and 5June2006 Briefings to SANDAG Resources Committee With Minor Editing

At the San Diego Regional Energy Office

OUTLINE

- San Diego REGION GOALS
- WHY UTILITY SCALE RENEWABLES
- TYPES OF TECHNOLOGY
- COMMERCIAL STATUS
- RESOURCE MAGNITUDE
- SAN DIEGO COUNTY RESOURCE
- POWER/ENERGY PROJECTION for REGION
- CONCLUSIONS
- RECOMMENDED ACTIONS
- References
- Back-up Material

San Diego Region and Goals

- San Diego REGION:
  - San Diego County
  - Imperial County
  - Some Resource Data Is Given for Northern Baja California

- Regional Energy Strategy Goal
  - 15% of Renewable Electricity by 2010 (740 MW)
  - 25% by 2020 (1520 MW)
  - 40% by 2030 (2960 MW)
  - Half from San Diego County

- California Renewable Portfolio Standard Goal for Investor Owned Utility Electricity
  - 20% by 2010
  - 33% by 2020

WHY UTILITY SCALE RENEWABLES

- ECONOMIC
  - Fossil Energy Costs Are Rising and Becoming Increasingly Volatile
  - Central Renewables Costs Are Most Competitive
  - Renewable Energy Costs Continue to Decrease
  - Renewables Shield Against Future Energy Cost Increases
- POLLUTION
  - Can Phase Out Polluting Plants Within City
  - Regional Pollution Causes Californians to Import Energy Which Pollutes the Exporting States
  - Global Warming Is a Significant Threat to the Planet ("It's time to stop talking and to start acting". Governor Schwarzenegger)
- OIL
  - Oil Dependency Is Against Our National Interests for a **Host** of Reasons
  - Credible Analysis Points to Global Oil Production Peaking This Decade
  - Must Shift Huge Transportation Energy Load To Clean Domestic Sources:
    - Example is Nighttime Charging of Pluggable Hybrid-electric Vehicles (Eventually Hydrogen) with Modest Electric Range (10 to 30 miles)
    - These Vehicles Can Plug-In During Day to Back-up Grid

WHY UTILITY SCALE RENEWABLES,continued

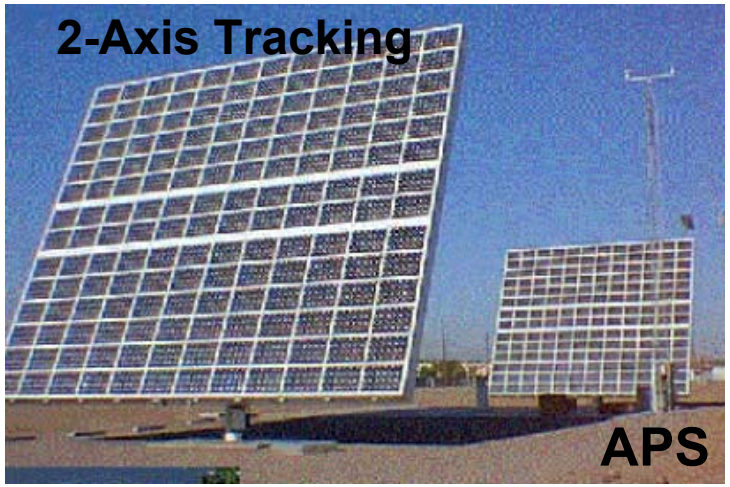
- NEED LARGE RESOURCE
  - 2960 MW Required by 2030 to Meet Goal of 40% Renewables
  - On-Site PV Is Important But Will Provide Only About 5% of Grid by 2020
  - Emerging Transportation Electric Load Will Increase Future Electricity Growth Well Beyond Historic Rates of ~ 2%

- EMPLOYMENT
  - Renewables Are Most Local/Regional Employment Intensive of All Energy Sources With 5 Jobs/$million in Sales Based on Fabrication, Site Construction and Operations.

- FIVE E'S OF RENEWABLE POWER SYSTEMS
  - ENERGY
  - ENVIRONMENTALLY FRIENDLY
  - EMPLOYMENT
  - ENORMOUS RESOURCE WITHIN REGION (37,000MW)
  - EMPOWERMENT of ENERGY INDEPENDANCE

TYPES OF TECHNOLOGY

Amonix Concentrator PV



Solar Two Central Receiver (Power Tower)

The USA's Largest Solar Electric Generating System (SEGS) Over 354MW Operating For Over 20 Years in Kramer Junction, CA

Photo David Rib, Kramer Junction Co.

Central – Kramer Junction (CA) Solar Electric Generating Station

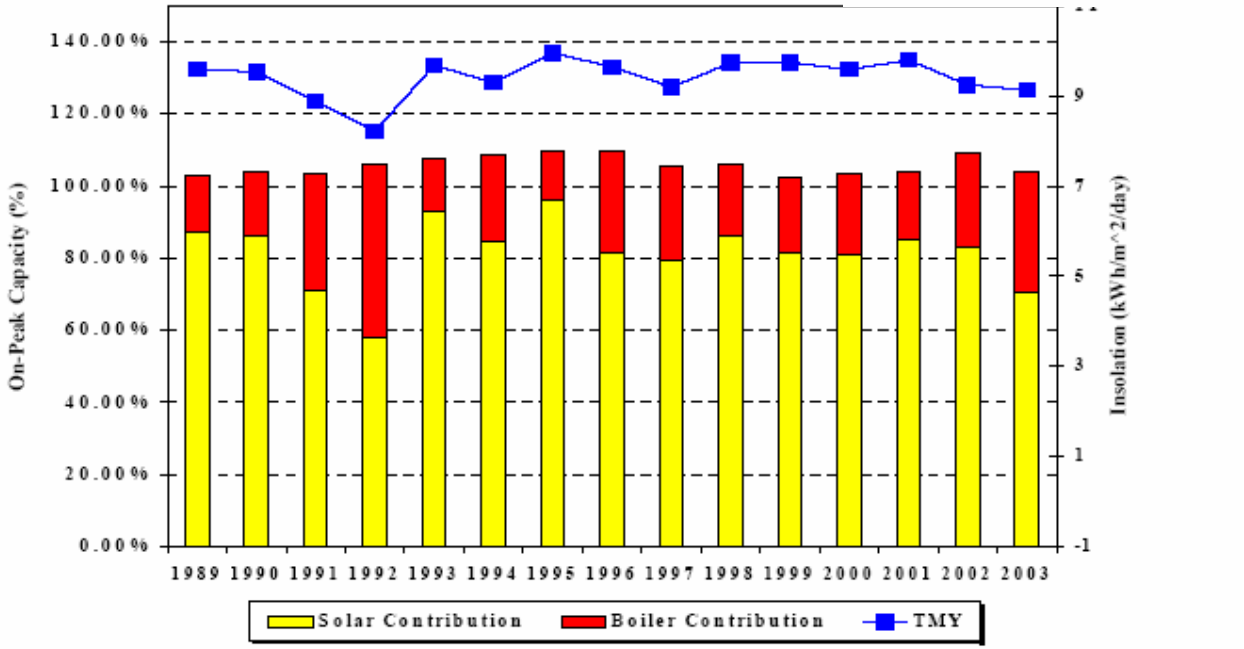


Figure I-4. Performance History of Parabolic Trough Plants at the Kramer Junction Site

TECHNOLOGIES CONSIDERED

- CONCENTRATING SOLAR
  - DISH-STIRLING MODULAR PLANT (5 TO 1000 MW)
    - SOLAR ONLY
    - HYBRID WITH NATURAL GAS, BIO-FUELS OR SELF-GENERATED HYDROGEN
  - PARABOLIC TROUGH PLANT (100 TO 200 MW)
    - SOLAR ONLY
    - HYBRID
    - THERMAL STORAGE (3 TO 12 HRS)
  - CENTRAL RECEIVER PLANT (100 TO 500 MW)
    - SOLAR ONLY
    - HYBRID
    - THERMAL STORAGE (3 TO 12 HRS)
  - TRACKING CONCENTRATOR PV MODULAR PLANT (1 TO 50 MW)
  - TRACKING FLAT PV MODULAR PLANT (1 TO 50 MW)

TYPES OF TECHNOLOGY (Cont.)

WIND

GEOTHERMAL SYSTEM

Condensers and cooling towers rise above a power plant at The Geysers.

- WIND FARMS (50 TO 150+ MW)
- GEOTHERMAL PLANTS (49 TO 340 MW)
- BIO-GAS PLANTS (3 TO 10 MW)
- BIO-MASS PLANTS (10 TO 25 MW)
- HYDRO (< 10 MW)

KEY DEVELOPMENTS IN CONCENTRATING SOLAR POWER

PARABOLIC TROUGH POWER PLANT

- LUZ CORPORATION - 354MW COMMERICAL OPERATING SINCE 1980'S
- Bethel Energy Trough Plants --- 2- 50 MW for SDG&E
- Solargenix New (steam) 64 MW Plant in Boulder, Nevada
- Solargeniz New (organic fluid) 1 MW Plant, Arizona

DOE Dish/Stirling PROGRAM - Starting in mid-70s, Has brought Dish/Stirling to the Edge of Commercial Readiness

- 2 contracts (SCE and SDG&E) for Large Desert Plants up to 1750 MW Total

Luz II Central Receiver Technology

- signed contract with PG&E for 100 to 500 MW Plants (DPT 550)

Concentrating PV - 1MW of Amonix Concentrating PV planned in Nevada

European Union - Commercial Trough, Central Receiver and Dish/Stirling Projects in Spain and Germany

SOLAR POWER PARK with Water, Natural Gas, Power Transmission and Environmental Impact Statement Set Up By State & Nevada Power

ACTIVE CONTRACTORS

(Solar Energy Industries Association
Concentrating Solar Power Division 2006)

Parabolic Troughs

- Solargenix (now Acciona)
- Solel
- Solar Millennium
- FLP Energy
- Industrial Solar Technology
- Luz II
- Bethel Energy
- Ormat International
- Acciona (Spain)

Central Receiver

- Black & Veatch
- UTC (was Boeing)
- Nagel Pumps (now different owner)
- Nexant
- Luz II

Consulting Support

- Kearney & Associates
- Morse Associates
- R. W. Beck Inc.
- Butler Sun Solutions

Dish/Stirling

- SES
- Infinia
- Schleich/Bergeman (German)

Concentrator PV

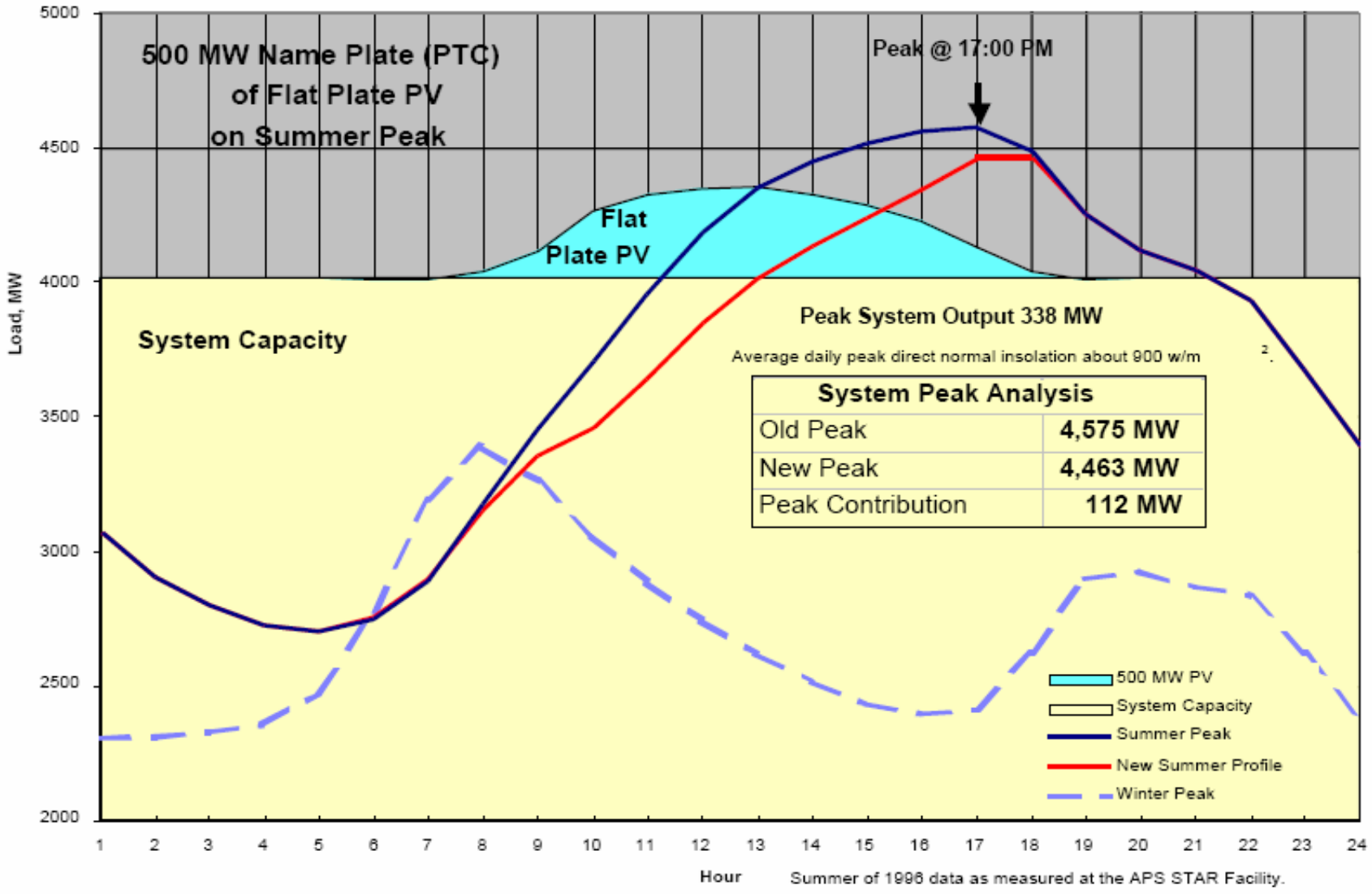
- Sharp
- Amonix in HCPV
- Solar Systems Ltd (Australia)
- Skyfuel (Linear Fresnel)

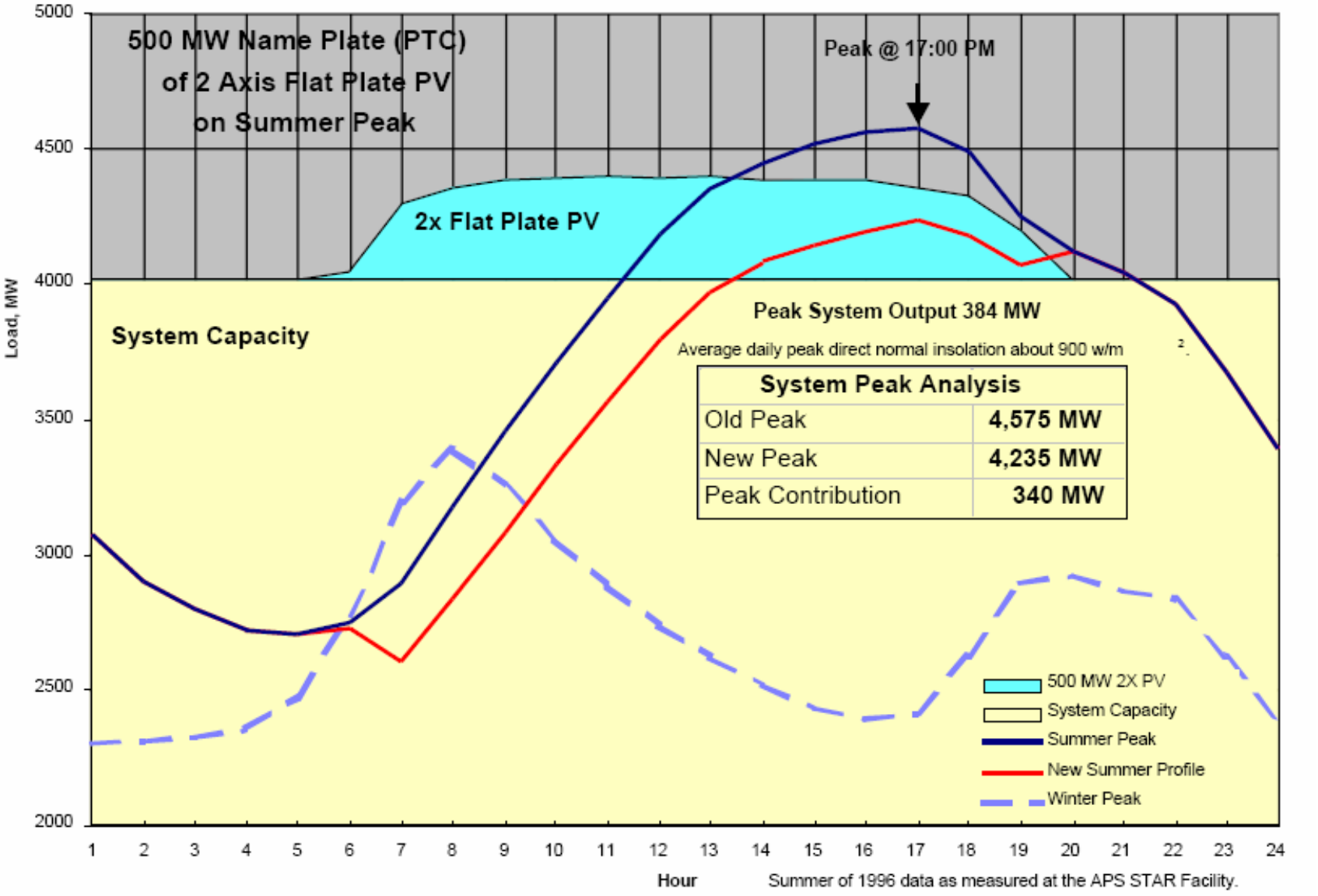
TECHNOLOGY STATUS

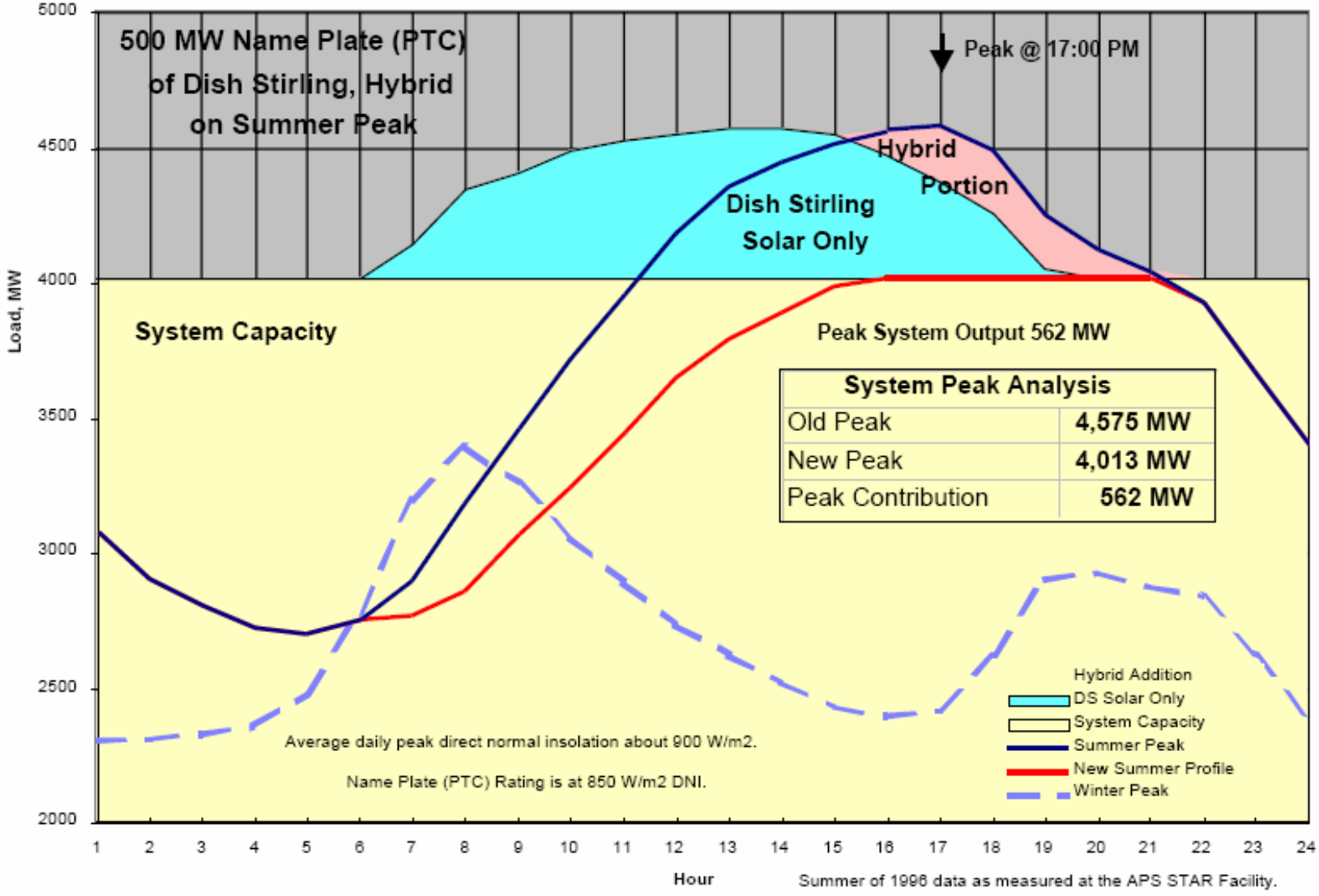
Technology	Commer-cial	Location	Size MW	Years Oper-ation	Active	Suppliers
Parabolic Trough	Yes	Kramer Junction	354	~ 20	Yes	Solargenix
	Yes	Boulder City,NV	64	0	Const	Bethel Energy
	Contract	?	100	0	No	Bethel Energy
Dish-Stirling	No	Sandia,NM	125kw	1	Yes	SES 25kW
	No	Washington	0.1kw	1	Yes	Infinia 3kW
	Contract	North LA	500-850	0	No	SES 25kW
	Contract	Imperial Cty	300-900	0	No	SES 25kW
Central Receiver	No	Barstow,CA	10	4+	No	UTC (Boeing)
	Contract	?	100-500	0	No	Luz II
Concentrating PV	Yes	APS	1	3	Yes	Amonix,
		NV Power	1	0	Yes	Sharp
Flat Plate PV	Yes	Prescott, AZ	0.2	3	Yes	AES, Kyocera,
		Sacramento	0.5	6	Yes	BP, (7 US suppliers)

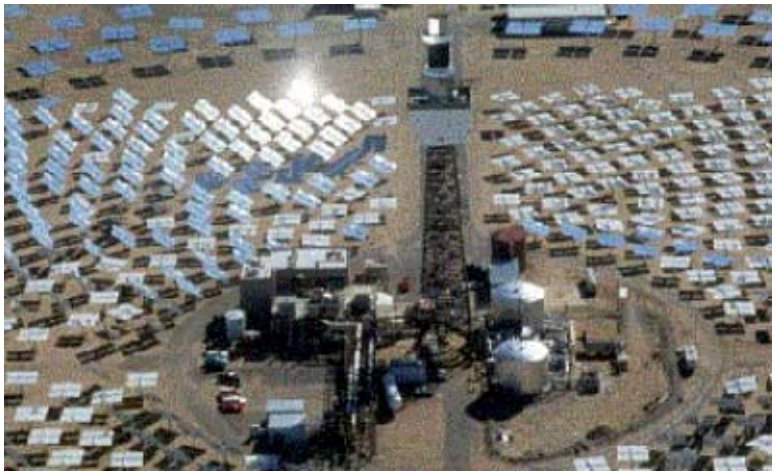
TECHNOLOGY STATUS

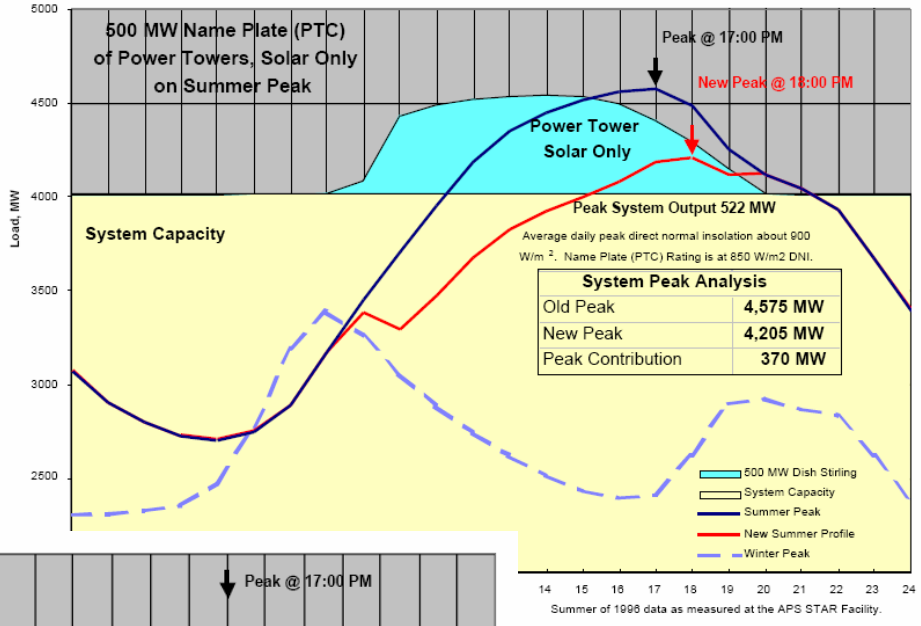
Technology	Commer-cial	Location	Plant Size MW	Years Operation	Active	Developer
Wind	Yes	Campo	50	1	Yes	Superior PPM FPL SeaWest
Geothermal	Yes	Salton Sea	20 - 340	20	Yes	CalEnergy Esmeralda
Bio-Gas	Yes	7 Land Fills	3-10	20	Yes	Solar Turbines
Bio-Mass	Yes	Escondido	50	0	No	?
Small Hydro	Yes	Distributed	10	40	Yes	?

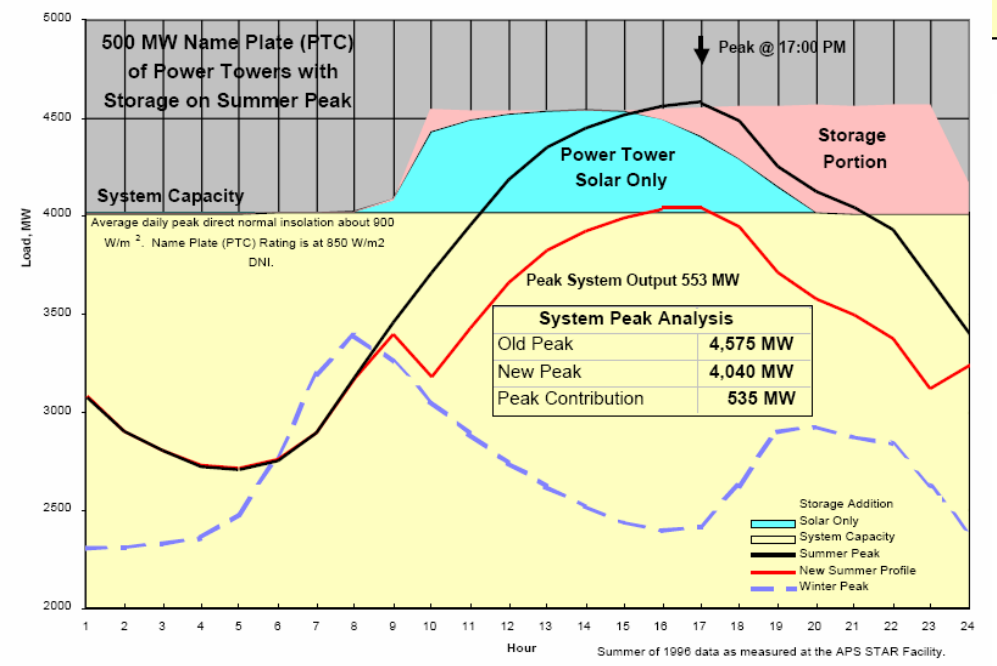

500 MW Name Plate (PTC)
of Flat Plate PV
on Summer Peak
Peak @ 17:00 PM
Flat
Plate PV
System Capacity
Peak System Output 338 MW
Average daily peak direct normal insolation about 900 w/m 2.
System Peak Analysis
Old Peak 4,575 MW
New Peak 4,463 MW
Peak Contribution 112 MW
500 MW PV
System Capacity
Summer Peak
New Summer Profile
Winter Peak
Load, MW
5000
4500
4000
3500
3000
2500
2000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
Summer of 1998 data as measured at the APS STAR Facility.


500 MW Name Plate (PTC)
of 2 Axis Flat Plate PV
on Summer Peak
Peak @ 17:00 PM
2x Flat Plate PV
System Capacity
Peak System Output 384 MW
Average daily peak direct normal insolation about 900 w/m 2.
System Peak Analysis
Old Peak 4,575 MW
New Peak 4,235 MW
Peak Contribution 340 MW
500 MW 2X PV
System Capacity
Summer Peak
New Summer Profile
Winter Peak
Load, MW
5000
4500
4000
3500
3000
2500
2000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
Summer of 1996 data as measured at the APS STAR Facility.

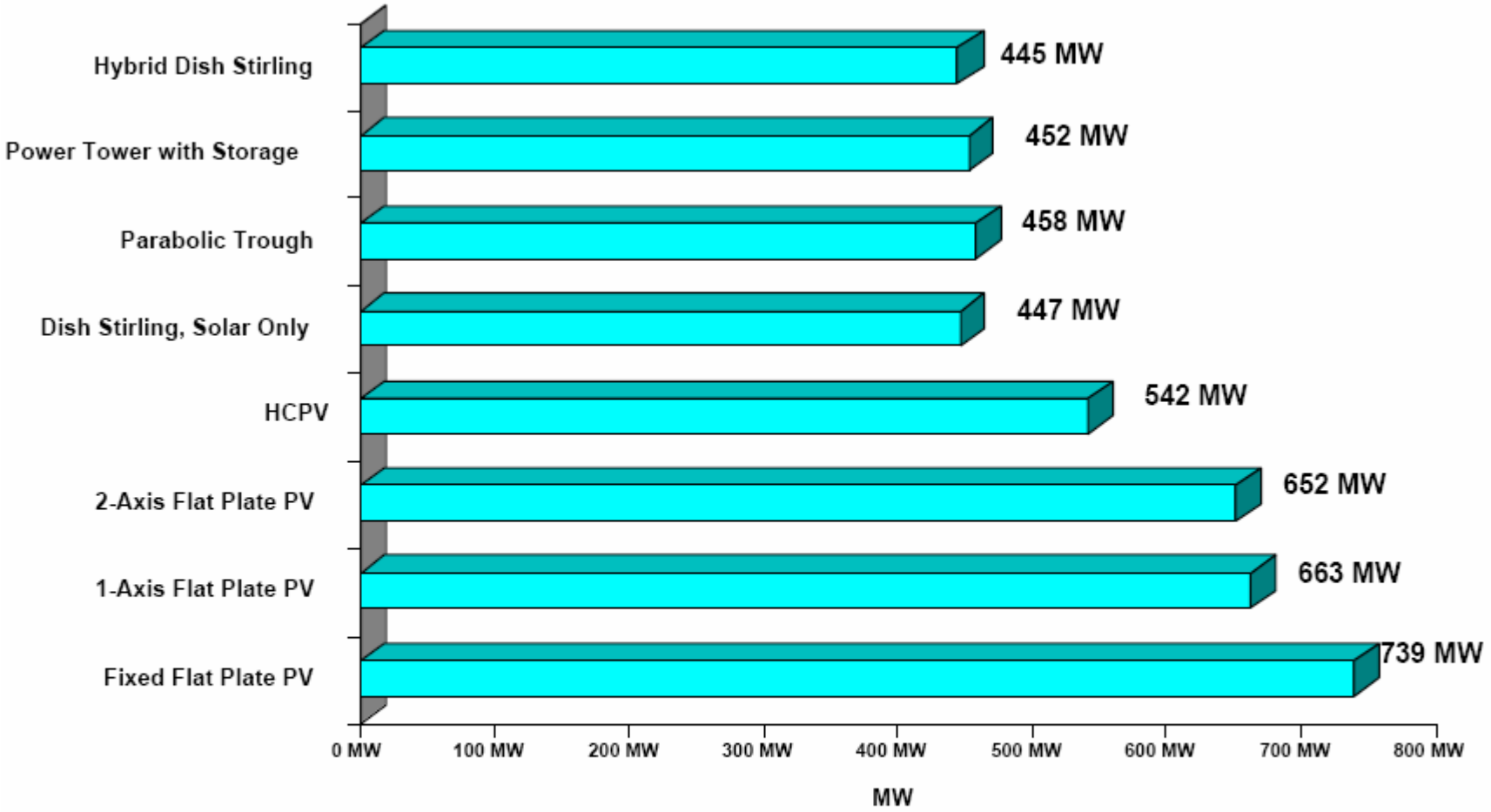

500 MW Name Plate (PTC)
of Dish Stirling, Hybrid
on Summer Peak
Peak @ 17:00 PM
Hybrid
Portion
Dish Stirling
Solar Only
System Capacity
Peak System Output 562 MW
System Peak Analysis
Old Peak 4,575 MW
New Peak 4,013 MW
Peak Contribution 562 MW
Average daily peak direct normal insolation about 900 W/m2.
Name Plate (PTC) Rating is at 850 W/m2 DNI.
Hybrid Addition
DS Solar Only
System Capacity
Summer Peak
New Summer Profile
Winter Peak
Load, MW
5000
4500
4000
3500
3000
2500
2000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
Summer of 1996 data as measured at the APS STAR Facility.




500 MW Name Plate (PTC)
of Power Towers, Solar Only
on Summer Peak
Peak @ 17:00 PM
New Peak @ 18:00 PM
Power Tower
Solar Only
Peak System Output 522 MW
System Capacity
Average daily peak direct normal insolation about 900
W/m 2. Name Plate (PTC) Rating is at 850 W/m2 DNI.
System Peak Analysis
Old Peak 4,575 MW
New Peak 4,205 MW
Peak Contribution 370 MW
500 MW Dish Stirling
System Capacity
Summer Peak
New Summer Profile
Winter Peak
Load, MW
Summer of 1996 data as measured at the APS STAR Facility.


500 MW Name Plate (PTC)
of Power Towers with
Storage on Summer Peak
Peak @ 17:00 PM
Storage
Portion
Power Tower
Solar Only
System Capacity
Average daily peak direct normal insolation about 900
W/m 2. Name Plate (PTC) Rating is at 850 W/m2
DNI.
Peak System Output 553 MW
System Peak Analysis
Old Peak 4,575 MW
New Peak 4,040 MW
Peak Contribution 535 MW
Storage Addition
Solar Only
System Capacity
Summer Peak
New Summer Profile
Winter Peak
Load, MW
Hour
Summer of 1996 data as measured at the APS STAR Facility.

MWs Required to supply 500MW Peak Output, Arizona Summer Day



Average daily peak direct normal insolation 900 w/m2.
Summer of 1996 data as measured at the APS STAR Facility.

COST

Technology (dry cooling)	EARLY $/KW	PLANTS cents/KWh	LATER $/KW	PLANTS cents/KWh	CapacityFactor (earlier – later)
Parabolic					
- solar only	3820	19.5	3160	15.0	0.28-0.3
- hybrid	4110	20	na	na	0.30
- 6 hr stor	5620	20	4310	14.6	0.4 -0.42
Dish-Stirling					
- solar only	3000	17.0	1800	9.5	0.25-0.27
- hybrid	3300	16.5	2000	10.4	0.30
CENTRAL RECEIVER					
- solar only	4500	22.9	2690	12.8	0.28 - 0.30
- hybrid	na	na	na	na	
- 6 hr stor	6600	23.5	3660	12.4	0.40 - 0.42

- 18% increase in energy cost for use of Dry vs Wet Cooling
- For Consistency, Nominal Levelized Cost of Energy (LCOE) or Market Price Is Used Throughout with Simplified Costing Formula where cents/KWh = 0.125 x $/KW / (CF x 87.5)

COST

Technology	EARLY (2006) ……$/KW	PLANTS cents/KWh	LATER (2017) $/KW	PLANTS cents/KWh	Capacity Factor
Concentrating PV	3,500	18	2,500	13	0.28
Flat Plate PV	7,000	40	3,500	20	0.20
Wind	1,500	5 - 7	$1,000	3.5 - 4.5	0.31-0.4
Geothermal	2950	5 – 7	2400	4 – 5.5	0.95
Bio-Gas	1200-1500	4 - 5	na	3.7	0.8
Bio-Mass	2,500	8 – 10	na	7 – 8.5	0.8 - 0.95
Small Hydro	1700-5000	10 – 28	na	8 – 18	0.25

SD Region RESOURCE MAGNITUDE, MW

TECHNOLOGY	GROSS POTENTIAL	TECHNICAL POTENTIAL	CURRENT
CONC SOLAR, Total (San Diego)	296,000 (35,000)	31,900 (3,500)	Zero
WIND, Total (San Diego Cty) (Baja California)	2,500 to 2,800	1,680 to 1,830 (up to 960) (up to 300)	50 MW
GEOTHERMAL,Total (Baja California)	?	2,500 to 3,400 (840)	1257 MW (720)
BIO-MASS	?	44 to 106	5 MW
BIO-GAS	?	72	18 MW
Small HYDRO, Total (San Diego Cty) (Imperial Cty) (Baja California)	?	170 (10) (up to 86.5) (up to 75)	8.3 MW (8.3)

SD County Resource Magnitude

- Only 12% of TOTAL Renewables Potential In SD Cty
- 60% of Regional Wind Resource in SD Cty
  - 2020 Estimate Predicted 200 MW Installed
- Other (bio-mass, bio-gas and small hydro) Projected at 70 MW by 2020

QUESTION:

- How to Achieve SANDAG Goal of 50/50 Balance of Renewables for In/Out of SD County?
- Can Less Intense Solar Resource Be Used in San Diego County ?

Solar Plant Land Characteristics

- For Small Plant that is Commercially Viable:

Plant Type	Power, MW	Area,acres	Shape
Dish-Stirling/ConPV*	~ 5	30	Irregular
Parabolic Trough	~50-100	~ 600	Rectangular
Central Receiver	~100-200	~ 600	~ Oval

- Land Treatment:
  - Dish Stirling/ConPV Land Can Be Up to 5 degree Slope and Low Ground Cover Is Not Removed
  - Parabolic Trough Land Needs to be Scraped and about 1 degree slope limit
  - Central Receiver In Between Above

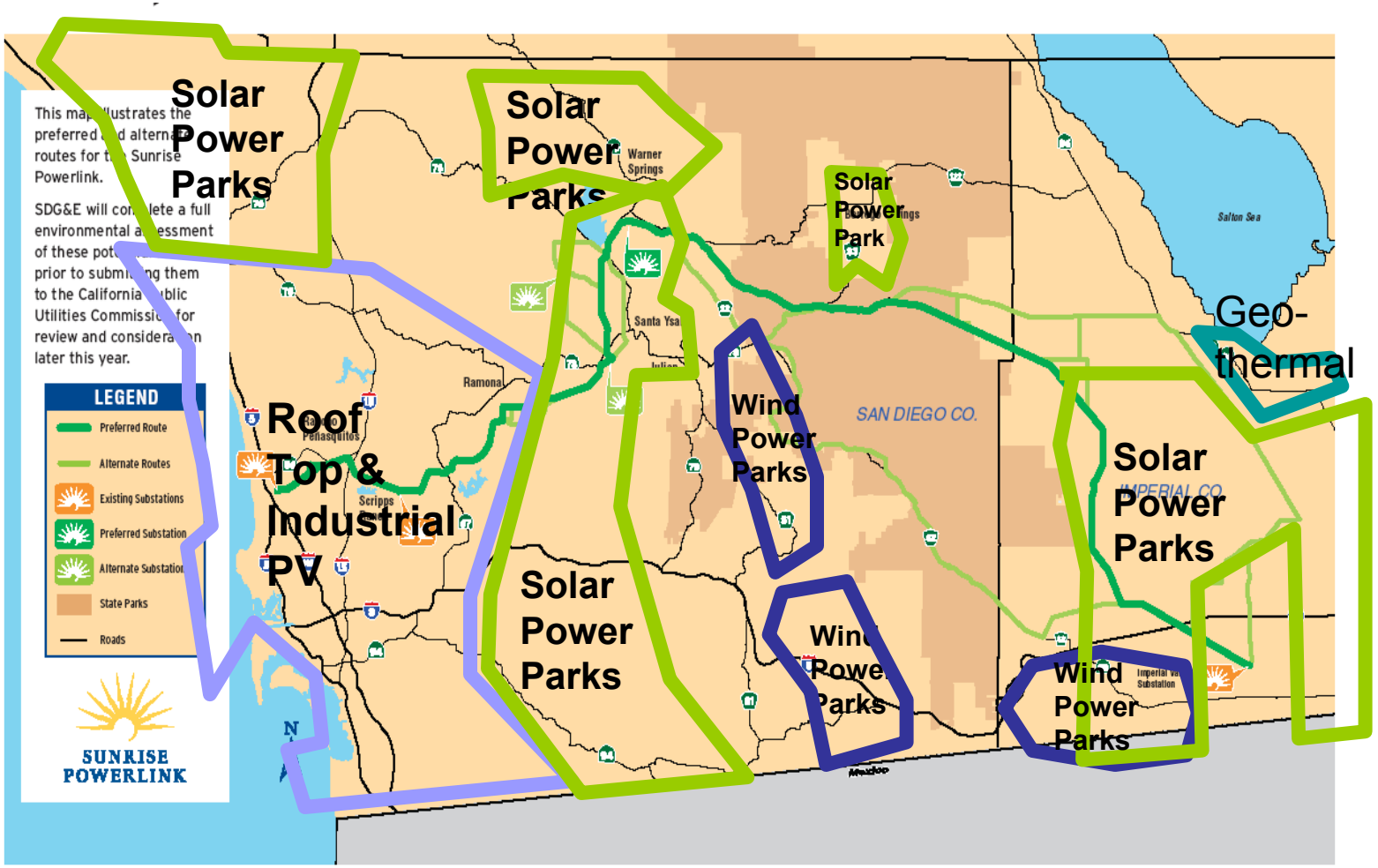
* CONCENTRATING PV

APPROACH to Finding Magnitude of SOLAR in SAN DIEGO CTY

- Use Dish-Stirling/ConPV Technology:
  - Smaller Parcel Required (> 30 acre)
  - Irregular Shape
  - w/o Disturbing Low Ground Cover
  - Compatible with Grazing (Dual Use)
  - Potential No Extra Cost to Hook-up to Local Grid with Small Power Plant
- Find Amount of Land in Parcels 30 to 100 acres
- Assess Land Availability:
  - For Sale
  - Ranching Land

Potential San Diego County Land

- About 5,000 acres Currently for Sale in Parcels Greater Than ~ 30 acres in Back County (multiple listing, June 06)
  - 50 Total Locations
  - 19 Locations Greater Than 100 acres
    - 2 in Boulevard (near Rt 8) at 150 and 160 acres
    - 2 in Jamul at 535 and 100 acres
    - 2 in Julian at 300 and 130 acres
    - 1 in Ranchita at 320 acres
    - 1 in Mesa Grande at 175 acres
    - 1 in Warner Springs at 150 acres
    - 4 in Ramona at 220, 160, 120 and 110 acres
    - 6 in Valley Center at 220, 130, 120, 120, 105 and 105 acres
- About 202,000 acres in Grazing (SD Cty Farm Bureau)
- About 2000 acres of Citrus Farming in Borrego Springs Which Are Depleting Only Water Supply Aquifer
- Unknown Acreage in Fallow Farm Land


Solar Power Parks
Solar Power Parks
Solar Power Park
Geo-thermal
Roof Top & Industrial PV
Wind Power Parks
Solar Power Parks
Wind Power Parks
Solar Power Parks
Wind Power Parks
This map illustrates the preferred and alternate routes for the Sunrise Powerlink.
SDG&E will complete a full environmental assessment of these potential routes prior to submitting them to the California Public Utilities Commission for review and consideration later this year.
LEGEND
Preferred Route
Alternate Routes
Existing Substations
Preferred Substation
Alternate Substation
State Parks
Roads
SUNRISE POWERLINK
Warner Springs
Santa Ysa
Ramona
Scripps
SAN DIEGO CO.
IMPERIAL CO.
Salton Sea

Central Solar Potential in SD Cty

- If Land Use Potential Is 10% of Available (sum of back country land for sale and grazing dual-use lease)
  - 20,740 acre Total Land
  - **~ 3700 MW Potential**
- Borrego-Springs (San Diego Cty Desert) Has Some Potential of 10 to 50 MW Based On:
  - Purchasing Citrus Farm Land to Reduce Water Overdraft
  - Not Require Additional Transmission Capability
- Total of 1600 MW of Solar Power Estimated by 2020 (April SANDAG Briefing)
  - 1000 MW Dish-Stirling
  - 500 MW Parabolic Trough/Central Receiver
  - 100 MW Concentrating PV
- Technology Mix Can Be Varied Depending on Real Commercial Status
- Move Some of This Total To San Diego Back County to Meet 50/50 Goal
- Note: For Scale, 900 MW Planned for Desert Plant in Imperial Cty Will Occupy about 5000 acres

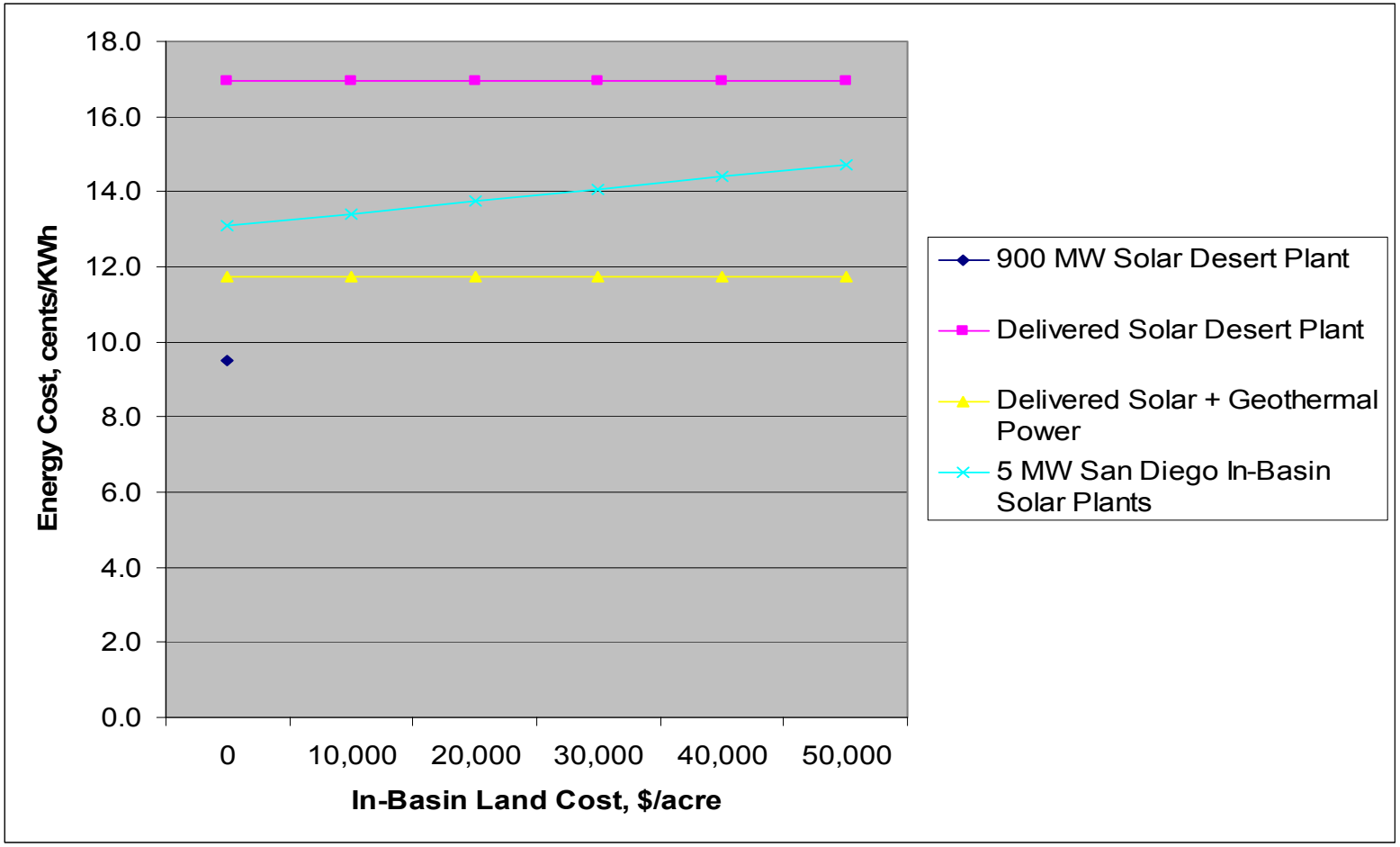
Cost of Desert Solar Delivered to City versus In-Basin Solar Plants

ASSUMPTIONS:

- 300 MW Dish-Stirling Built to Establish Commercial Readiness
- Use “Later” Dish-Stirling Plant Design and Cost of $1800/KW*
- Desert Plant
  - Transmission Link Costs $1.2 B
  - Plant Capacity Factor
    - Solar is 0.27
    - Geothermal is 0.95
    - Combined is 0.90
  - Power Transmitted is 900 MW
- San Diego Back County Plants
  - Capital Cost Increment is 10% for Smaller Plant
  - Energy Cost Increment is 20% for 15% Lower Direct Beam Isolation
  - Energy Parks Concept Implemented and Preliminary Site Approvals Completed
- Financial Costs Same for Solar and Geothermal Plants as well as for Transmission Link
- In-Basin Transmission/Distribution Costs Ignored for Both Plant Locations
- Land Purchase Cost Is Typically $5,000 to $15,000 per acre

* ConPV could have relatively similar land and cost characteristics to Dish-Stirling

Energy Cost of Desert Plant Delivered To In-Basin and In-Basin Dish-Stirling Power Plants



Cost Comparison Results

- SIMILAR Costs for Desert Power Delivered to San Diego Compared To In-County Smaller Dish-Stirling Plants

COST ISSUES:

- Would the Extra Costs of 50 to 150 Solar Plants Become Excessive Due to Grid Connections, Permits, Approvals, other Utilities, EIS, etc ?
- Economic Comparisons Based on Simplified Assumption That the Cost of Financing is the Same for Solar Plants and Transmission Link
- Different Sources of Funds for Private Solar Plants and Public Transmission Line –- Difficult to Compare Directly

Other Issues for Distributed Solar Plants in SD County

- Not 1 Plant But 50 to 150 Plants Needed To Generate About 1000 MW
- How Much Power Could Low Capacity Back County Distribution Lines Carry Without Significant Cost Increments
- Would Enough Ranchers Support Leasing of Land for Dual-Use?
- Will About 100 Sets of Zoning Changes, Permits, Environmental Assessments, etc Be an Insurmountable Obstacle to This Resource?

Energy Parks

- Need to be Established to Expedite Multiple Plants in Back-County
- Designed to Overcome “Issues”
- Energy Parks Would:
  - Pre-arrange Sites For All Renewable Power Plant Developers
  - At a specific site, Establish Maximum Power Capability of Local Grid
  - Identify Appropriate Land Area and Location
  - Provide Sites via Land Purchases or Leases with Ranchers
  - Obtain Zoning Changes and Other Permits
  - Initiate Environmental Assessment
  - Provide Power Lines Connections and Other Utilities
- Put the Sites in the “Energy Bank”

Energy Park Issues

- What Entity Would Set Up Energy Parks?
- Where Would Funds (~5% of total cost) Come From?
- How Much of Permitting and Approvals Could be Obtained Based on “Generic” Power Plant
- Possible Entities Are:
  - SDG&E
  - SD County
  - SANDAG
  - CEC
  - 3rd Party
- Which Approach Would Be Most Effective?

Projection of San Diego COUNTY Renewable Resource by 2020

- Wind Resource
  - 200 MW Producing 540 GWh/y our of total of 325 MW
- Other (bio-mass, bio-gas and small hydro)
  - 70 MW Producing 480 GWh/y
- Borrego Springs Desert Solar
  - 25 MW Producing 70 GWh/y
- Distributed Dish-Stirling Plants
  - 1000 MW Producing 2,800 GWh/y
- Concentrating PV
  - 100 MW Producing 230 GWh/y
- TOTAL Central Renewables from San Diego County:
  - 1400 MW Producing About 4125 GWh/y
  - ~ 44% of All Renewables Power in 2020 (~ 26% Energy)
  - ~ 23% of Total Power Demand in Region in 2020
  - Could be Increased by Adding Concentrating Solar Systems Up to Maximum of Approx 3700 MW

San Diego County Projection, continued

- SANDAG Renewables Goal of Half in San Diego County and Half Elsewhere in Region CAN BE ACHIEVED
  - Main Assumptions
    - ~100 Smaller Dish-Stirling or Concentrating PV Commercial Plants Located Around East County
    - These ~100 Energy Parks Developed With Grid Connections, Permitting and Leases Arranged Prior to Energy Plant Development

- Goal Achieved by Combination of 9 Central Technologies

- To Account for TOTAL of All Renewables by 2020,

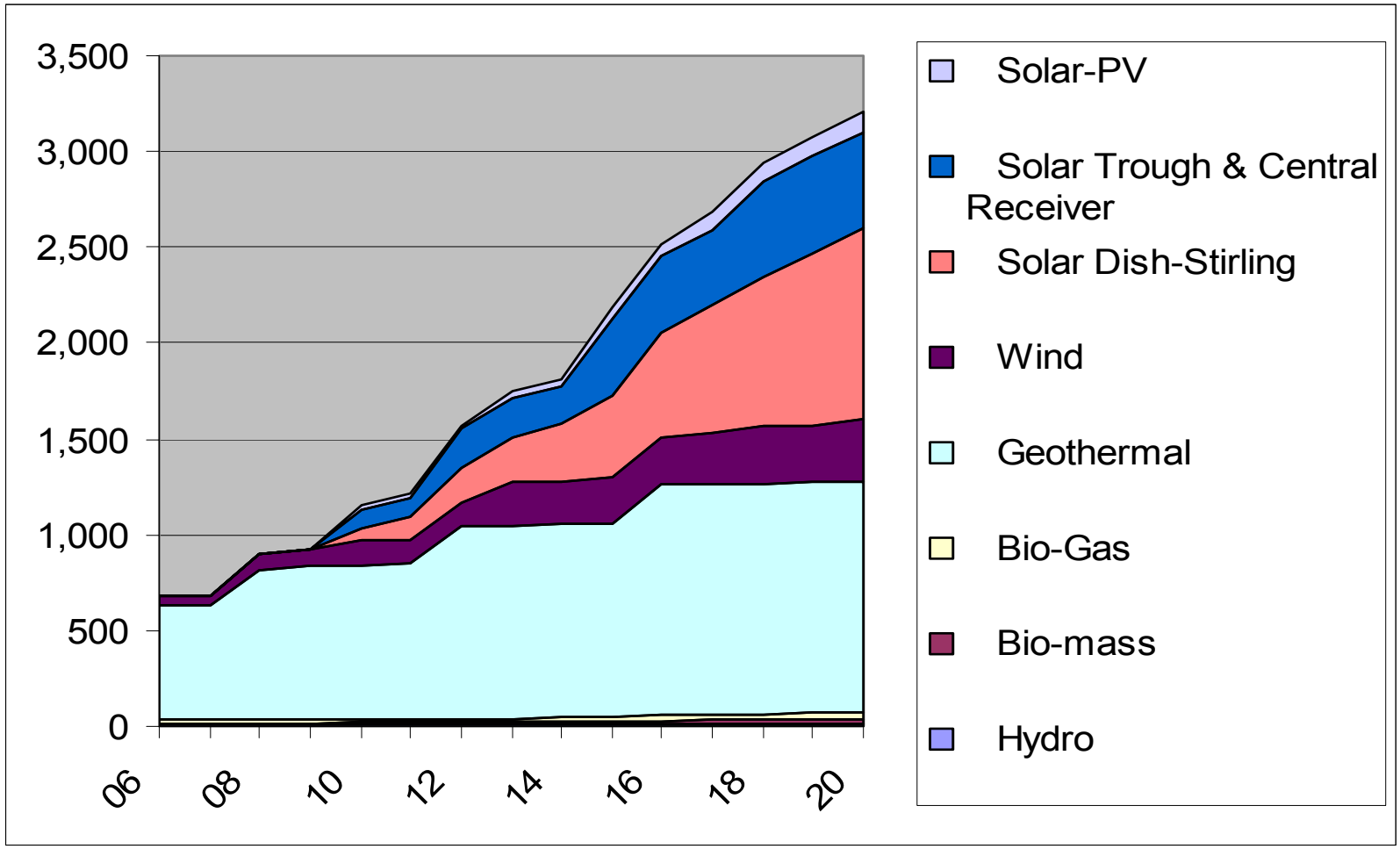
Add **Distributed Solar** to Central Technologies:

  - 285 MW Roof Top PV (2% total energy and 5% power)
  - Hot Water for Residential
  - AC and Hot Water for Commercial Buildings
  - Low and Mid-temperature Solar Industrial Heat
  - Industrial Solar Electric/Heat Combined Cycle

Projection of San Diego REGION Renewable Resource by 2020

- NINE TECHNOLOGIES
  - GEOTHERMAL
  - CONCENTRATING SOLAR
    - DISH-STIRLING
    - PARABOLIC TROUGH
    - CENTRAL RECEIVER
    - PV
  - WIND
  - BIO-GAS
  - BIO-MASS
  - HYDRO
- IMPERIAL and SAN DIEGO COUNTY

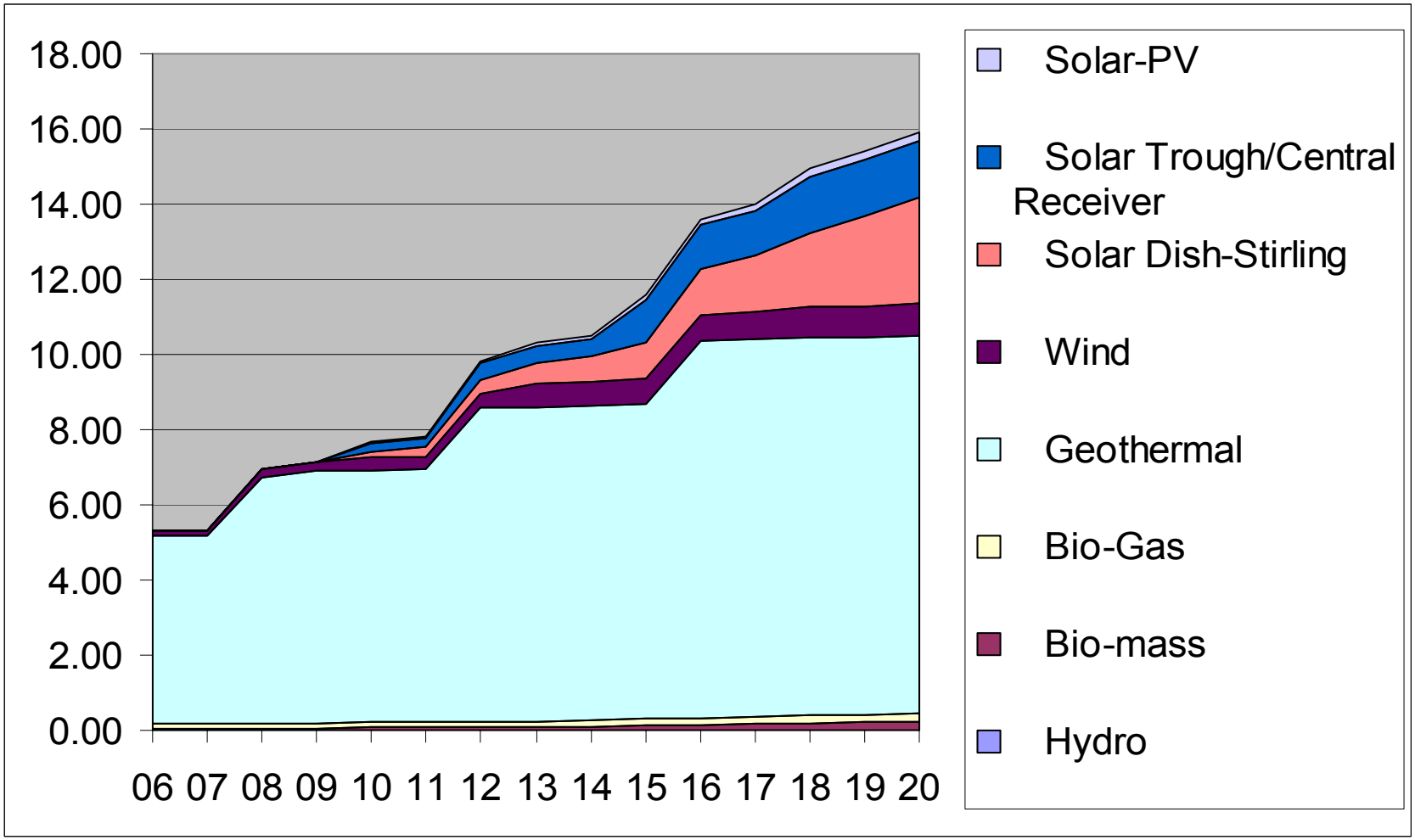
Installed POWER of Central Renewable Energy in San Diego Region, MW



POWER of Central Renewables in San Diego Region, MW

Technology yr	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Hydro	8	8	8	10	10	10	10	10	10	10	12	12	12	12	12
Bio-mass	5	5	5	5	8	8	8	9	12	15	17	19	22	25	29
Bio-Gas	18	19	20	21	21	22	23	23	24	25	27	28	29	31	32
Geothermal	600	600	785	805	805	805	1005	1005	1005	1005	1205	1205	1205	1205	1205
Wind	50	50	80	80	125	125	125	225	225	250	250	270	300	300	325
Solar Dish-Stirling	0	0	0	0	60	120	180	240	300	420	540	660	780	900	1000
Solar Trough & Central Receiver	0	0	0	0	100	100	200	200	200	400	400	400	500	500	500
Solar-PV	0	0	0	0	20	20	20	40	40	60	60	90	90	100	100
Total	**681**	**682**	**898**	**921**	**1149**	**1210**	**1571**	**1752**	**1816**	**2186**	**2511**	**2685**	**2939**	**3073**	**3204**

ENERGY GENERATED by Central Renewables in San Diego Region, GWh/y thousands



ENERGY GENERATED by Central Renewables in San Diego Region, GWh/y thousands

Technology	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Hydro	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Bio-mass	0.04	0.04	0.04	0.04	0.06	0.06	0.06	0.07	0.09	0.11	0.13	0.15	0.17	0.19	0.23
Bio-Gas	0.13	0.13	0.14	0.15	0.15	0.15	0.16	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23
Geothermal	5.0	5.0	6.5	6.7	6.7	6.7	8.4	8.4	8.4	8.4	10.0	10.0	10.0	10.0	10.0
Wind	0.14	0.14	0.22	0.22	0.34	0.34	0.34	0.61	0.61	0.68	0.68	0.73	0.81	0.81	0.88
Solar Dish-Stirling	0	0	0	0	0.13	0.26	0.39	0.54	0.68	0.96	1.2	1.5	2.0	2.4	2.8
Solar Trough/Central Receiver	0	0	0	0	0.22	0.22	0.46	0.46	0.46	1.2	1.2	1.2	1.5	1.5	1.5
Solar-PV	0	0	0	0	0.04	0.04	0.04	0.09	0.1	0.1	0.1	0.2	0.2	0.2	0.2
Total	**5.3**	**5.3**	**6.9**	**7.1**	**7.7**	**7.8**	**9.8**	**10.3**	**10.5**	**11.6**	**13.6**	**14.0**	**14.9**	**15.4**	**15.9**

SD County Share of Total Renewables

	Current		2010		2020	
CENTRALIZED, MW	**SD Cty**	**Region**	**SD Cty**	**Region**	**SD Cty**	**Region**
Concentrating Solar, CSP	0	0	180	180	1,100	1,600
Geothermal	0	600	0	805	0	1,205
Wind	0	50	50	125	200	325
Other	31	31	38	38	71	73
Biomass	5	5	8	8	29	29
Landfill Bio-Gas	18	18	21	21	32	32
Small Hydro	8	8	9	9	10	12
Total MW	**31**	**681**	**268**	**1,148**	**1,371**	**3,203**
DISTRIBUTED SYSTEMS , MW						
Roof Top PV	**29**	**29**	**94**	**94**	**285**	**287**
On-site CSP	0	0	?	?	?	?
Total MW	23	23	?	?	?	?
THERMAL SYSTEMS,	MM Therms/yr					
Residential H2O	**0**	**0**	**13**	**13**	**45**	**45**

Commercial Hot Water & AC plus Industrial Heat Unknown at this time

SUMMARY	**Centralized + Decentralized =**		**Total**	by 2020
SD County MW =	**39%**	**8%**	**48%**	Plus Thermal and On-Site CSP

CONCLUSIONS

- FAMILY OF RENEWABLE RESOURCES CAN PROVIDE OVER 3,000 MW in SAN DIEGO REGION BY 2020
  - OVER 50% of PROJECTED POWER and ENERGY
  - MEETS SANDAG 2030 GOAL of 2960 MW but in 2020

- CONCENTRATING SOLAR POWER SYSTEMS HAVE THE MOST POTENTIAL --- 32,000MW

- DISTRIBUTED PV CAN ADD about 285 MW By 2020 which adds about 5% Power and 2% Energy

- DISPATCHABILITY USING HYBRID FUELS OR THERMAL STORAGE ENHANCES CONCENTRATING SOLAR POWER SYSTEMS ABILITY TO MEET UTILITY SUMMER PEAK LOADS

- SAN DIEGO IN-COUNTY SOLAR LAND RESOURCE USING LESS INTENSE SUNLIGHT, CAN PROVIDE ENOUGH SOLAR POWER TO HAVE ABOUT HALF OF RENEWABLE COME FROM SD COUNTY

CONCLUSIONS, continued

- WIND IS NOT A UTILITY STABILITY ISSUE UNTIL LARGE USE IN GRID
  - More than 20% to 30% Total
  - Pumped Hydro and Compressed Air Storage Are Available To Stabilize Grid

- WHEN PLUGABLE HYBRID VEHICLES START TRANSITION FROM IMPORTED OIL, THEN WIND RESOURCES IS WELL MATCHED TO THIS HUGE NEW EVENING ELECTRIC LOAD WITHOUT ANY GRID STORAGE

- PLUGABLE HYBRID VEHICLES CAN BACKUP-UP GRID WITH STANDBY AND EVEN PROVIDE PEAK POWER DURING DAY

- RENEWABLES ADDRESS:
  - ENERGY DEMAND GROWTH
  - GLOBAL WARMING
  - LOCAL AIR POLLUTION
  - JOB CREATION
  - ENERGY SECURITY

RECOMMENDED ACTIONS

1. Increase Regional Renewable Energy Goal:
   - from 25% to 50% by 2020
   - from 40% to 70% by 20

2. To Achieve 50/50 Balance, Build ENERGY PARKS Especially in East San Diego County to Overcome Barriers of Needing 50 to 150 Sites for Smaller Power Plants
   - Establish Entity to Implement and Funding Mechanism
   - Include All Stakeholders to the Establishing Parks

RECOMMENDED ACTIONS, continues

3. Address Values Beyond Least Cost of Generation and Develop Metrics To Quantify The Utility Values of:
   - Local Energy Availability
   - Global Warming
   - Local Air Pollution
   - Job Creation and
   - Energy Security

4. Implement Utility Loading Order to Ensure That Renewables Will be Given Higher Priority Than Fossil Fuels

5. Support Federal, State and Local Incentives to Reduce the First Cost of Renewable Power Systems
   - Especially Support Long Term (~10 yr) Production Tax Credit (PTC) for Wind and Other Renewables
   - Direct Low-Cost Government Loans
   - Loan Guarantee Programs
   - Interest-Rate Buy-Downs

References

•Utility Perspective, Solar Thermal Electric Technologies Scott McLellan, Arizona Public Service Company, Solar Energy Forum 1997, Updated, January 22, 1998

•Geothermal Today Magazine, DOE, www.nrel.gov/docs/fy00osti/27820.pdf

•Western Governors www.westgov.org/wga/initiatives/cdeac/index.htm

•Potential for Renewable Energy in the San Diego Region, San Diego Regional Energy Group, Scott Anders, et al, August 2005

-Value of Solar Thermal and Photovoltaic Power Plants to Arizona Public Service Company, Paul A. Smith, ASME Joint Solar Engineering Conference, 1994

-Comparative Cost of California Central Station Electricity Generation Technologies, 100-03-001F, CEC, June, 2003

-An Initial Comparative Assessment of Orbital and Terrestrial Central Power Systems, Richard Caputo, Jet Propulsion Laboratory, 900-780, March, 1977

-EIA for Fossil Fuel Prices

-Briefings to Resource Committee of SANDAG Energy Working Group, Renewable Energy Team, 3April2006 and 5June2006 at SDREO

Back-up Materials

ROOF TOP PV

- IMPORTANT PART OF RENEWABLE ENERGY FAMILY
- MANY ADVANTAGES TO GENERATE POWER DURING DAY WITHIN DISTRIBUTION PART OF GRID AT LOW POWER LEVEL
- IF CA. SOLAR INITIATIVE FULLY IMPLEMENTED by 2017, ~ 214 MW OF ON-SITE PV WILL BE INSTALLED
  - Current Installation Rate is about 4 MW/YR
  - This is Important but is ~ 4% of Grid Power and ~ 2 % of Grid Energy
- Project 285 MW by 2020 with Extension of SBI Program
- CURRENT PV COST IS EXPENSIVE
  - Now ~ $8/w Total ($4.25/w to Residential Customer after Rebate, Tax Credits/Deductions)
  - Assuming 35% Global PV Growth till 2010 and then 30% Growth with 20% Panel Cost Reduction per Doubling (10% for Rest-of-System), then
    - Installed Residential PV Cost in 2020 ~$3.6/w and ~ 21 cents/KWh
- NEED MORE SUBSTANTIAL AND CHEAPER SOURCES of RENEWABLE ENERGY TO MEET REGIONAL ENERGY STRATEGY GOALS Of 40% RENEWABLES by 2030
- **CONCLUSION: DISTRIBUTED PV IS NOT A SUBSTITUTE FOR THE REST OF THE RENEWABLE ENERGY FAMILY**

SOLAR RESOURCE, raw data

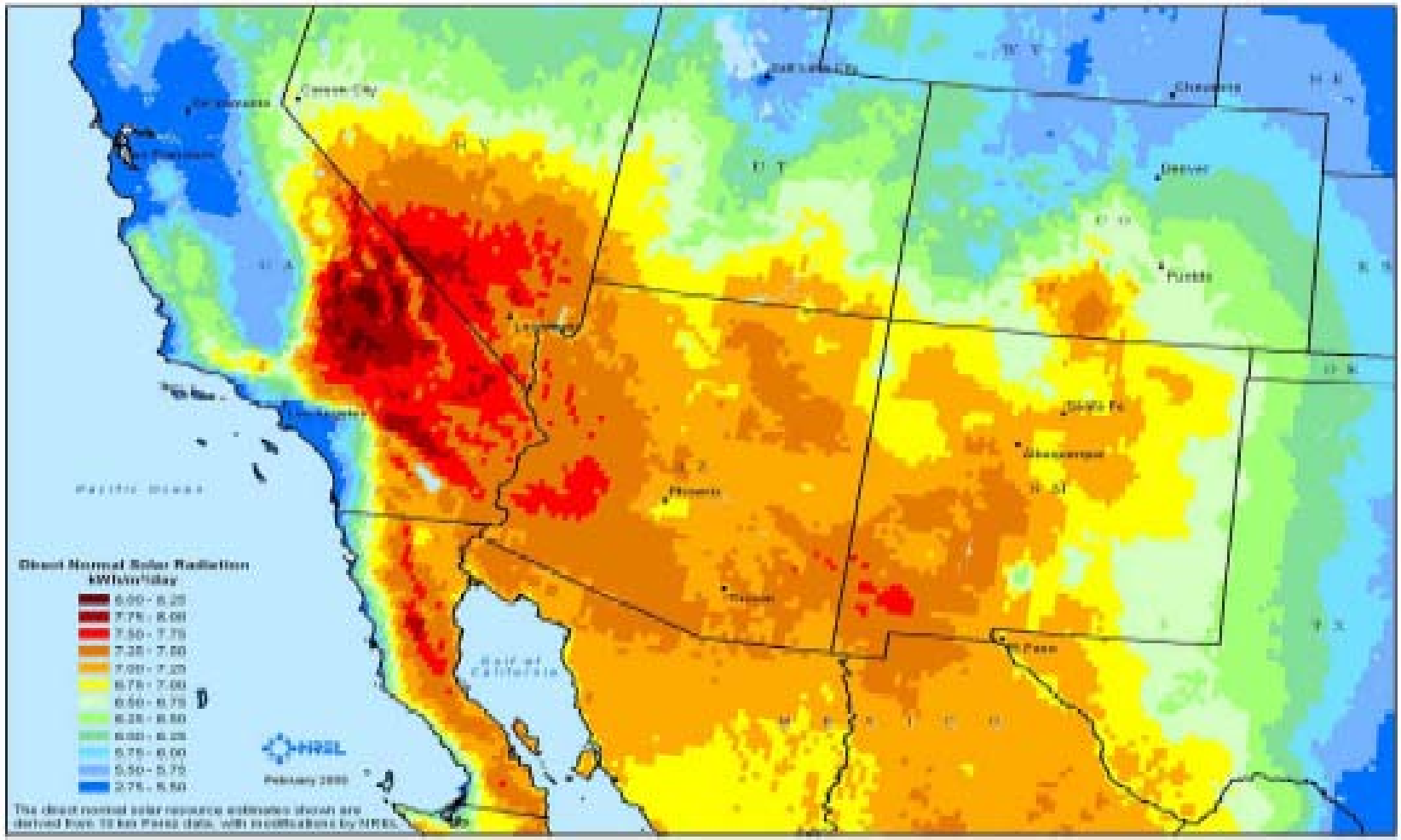


Figure I-3. Direct Normal Solar Radiation in the Southwest

SOLAR RESOURCE, after filters

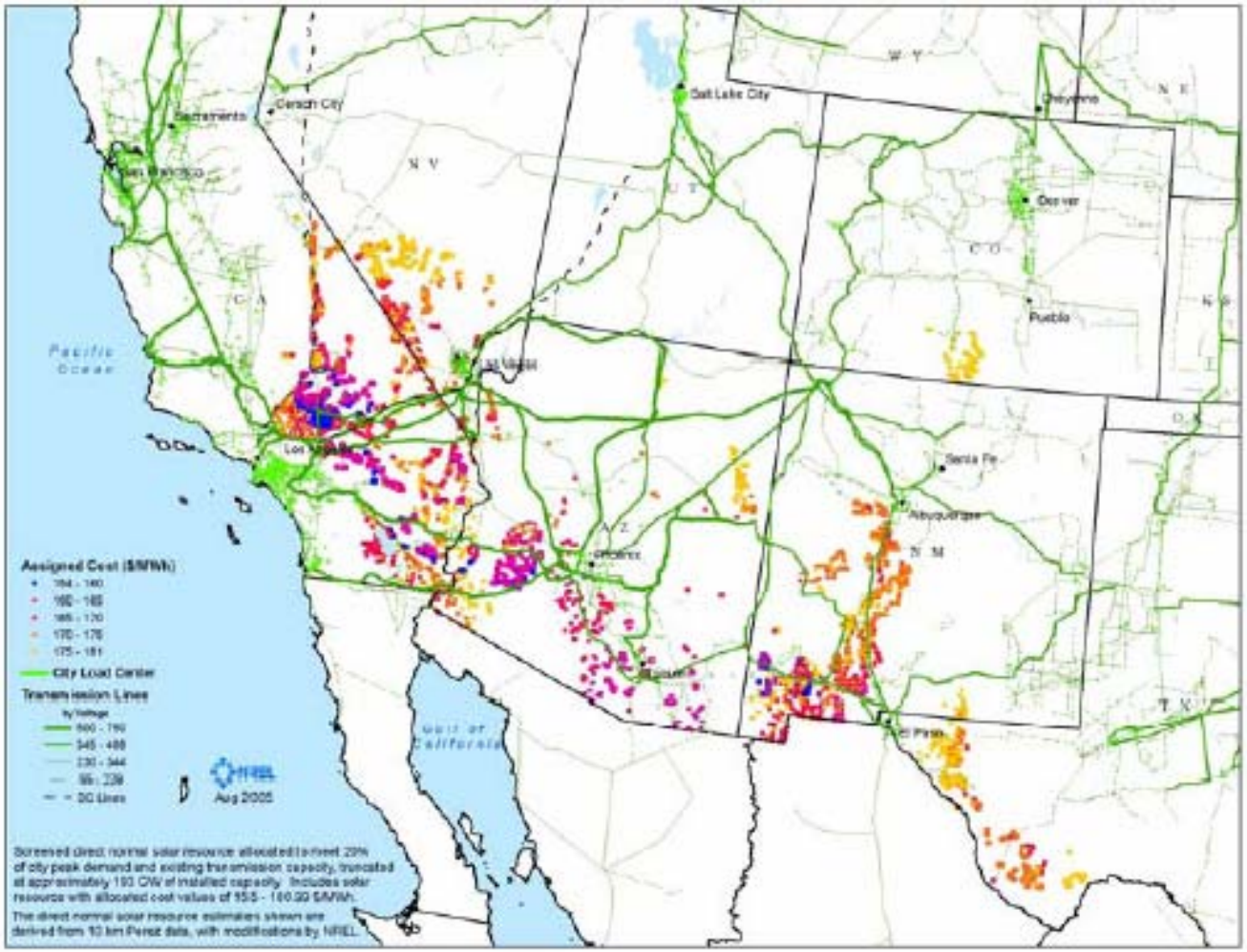
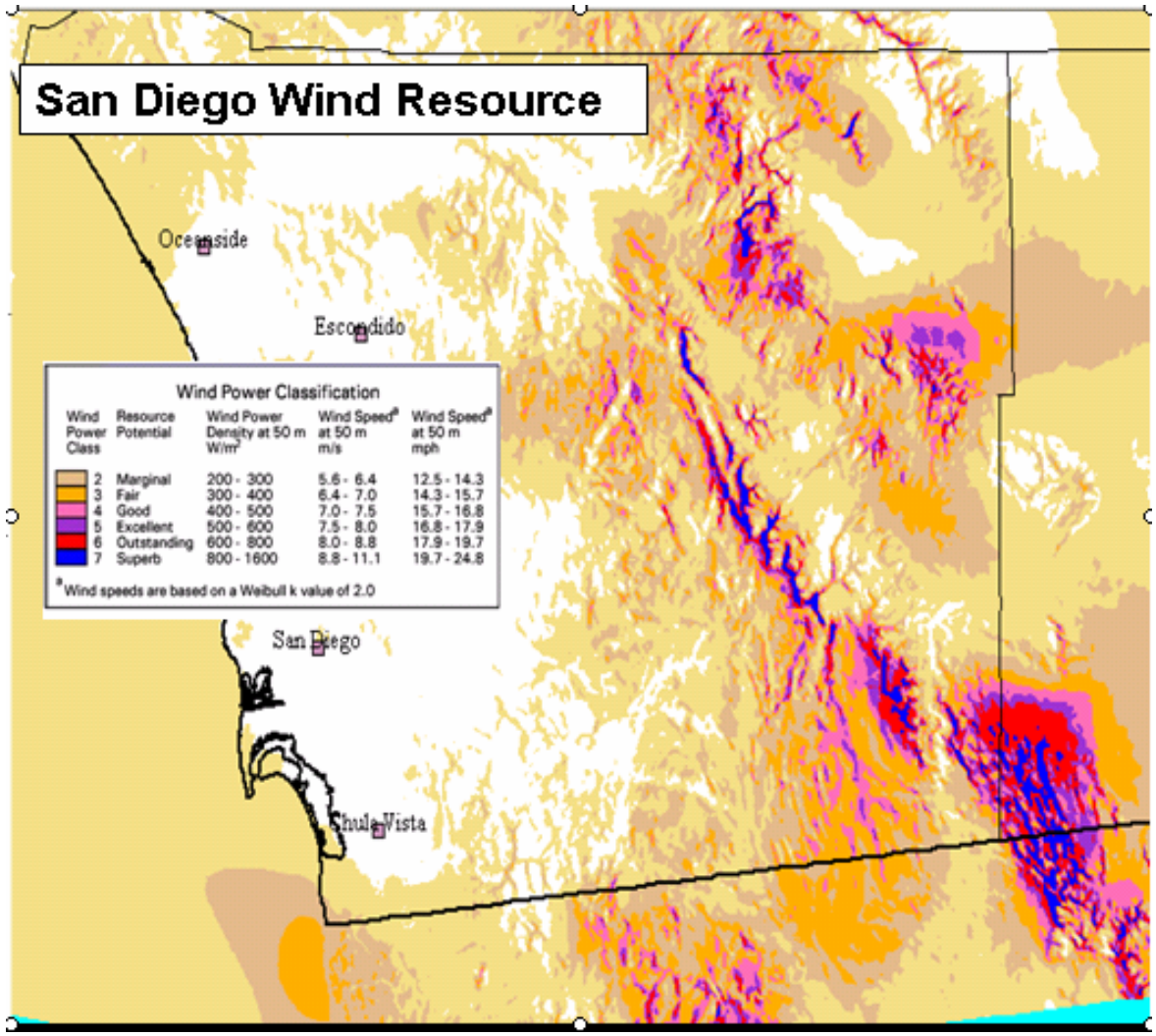
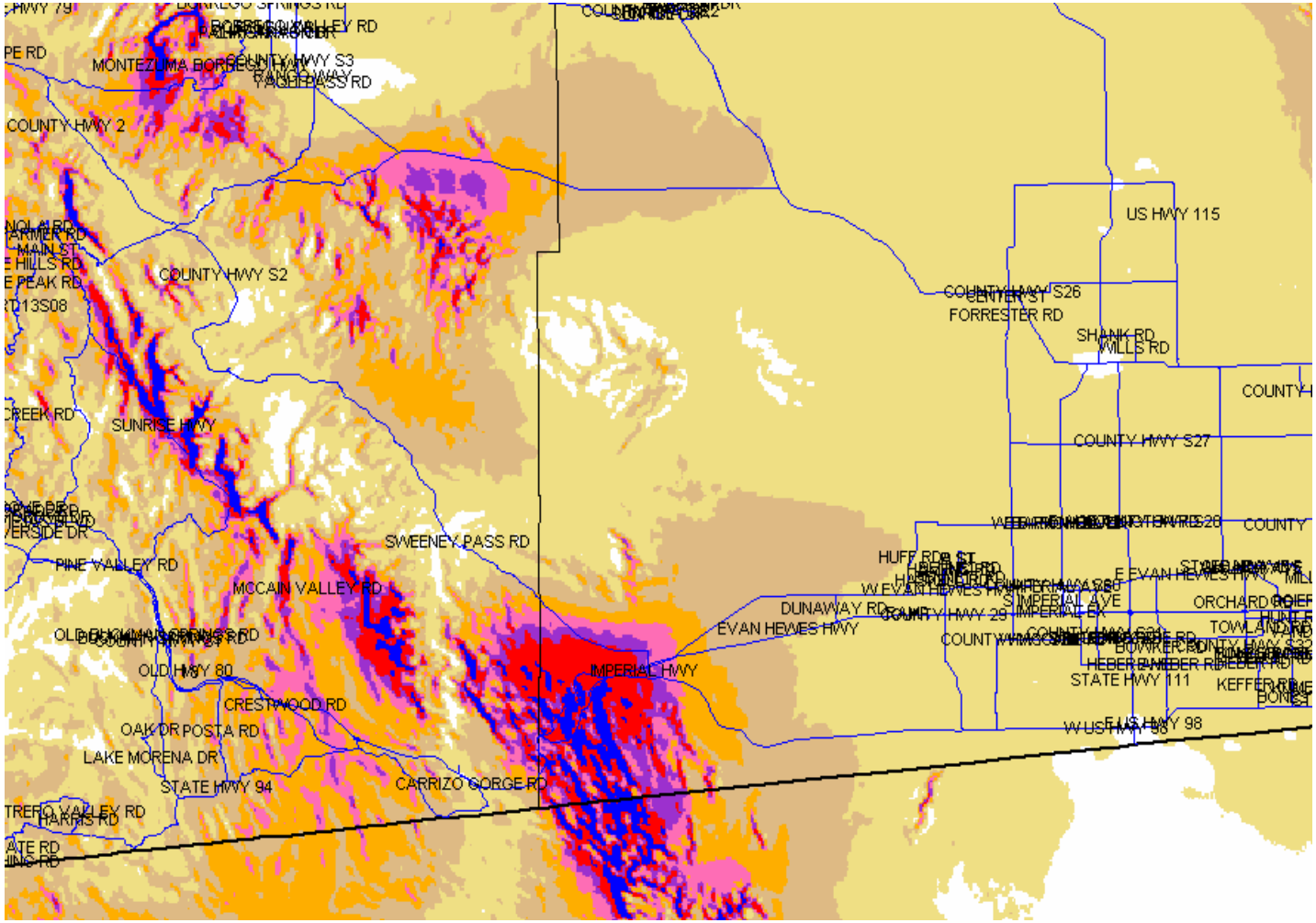


Figure I-2. Optimal CSP Sites in the SW using GIS Mapping

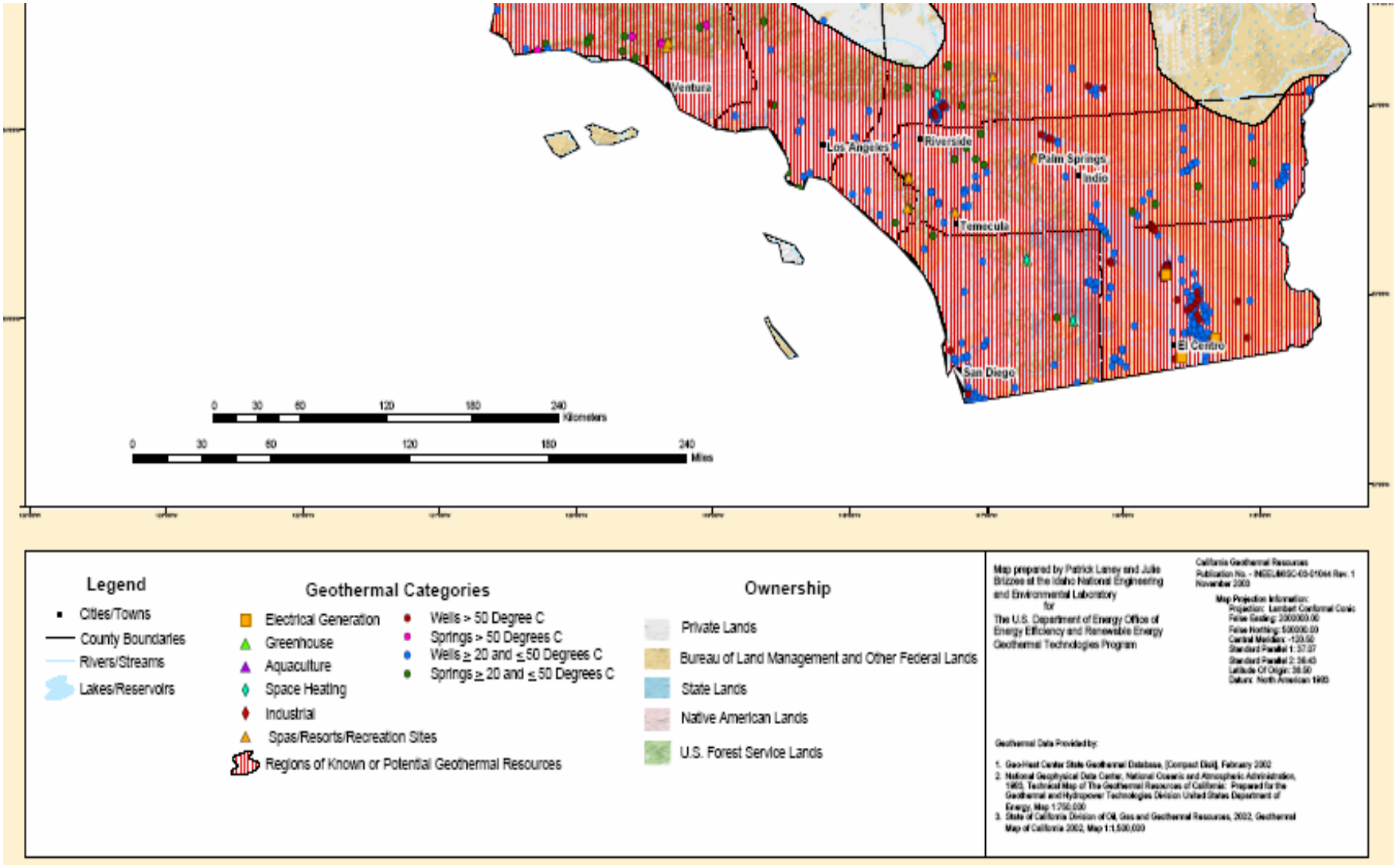
WIND RESOURCE, raw data



WIND RESOURCE, raw data



SOUTHERN CALIFORNIA GEOTHERMAL RESOURCES



Solar Power Systems Performance Comparisons

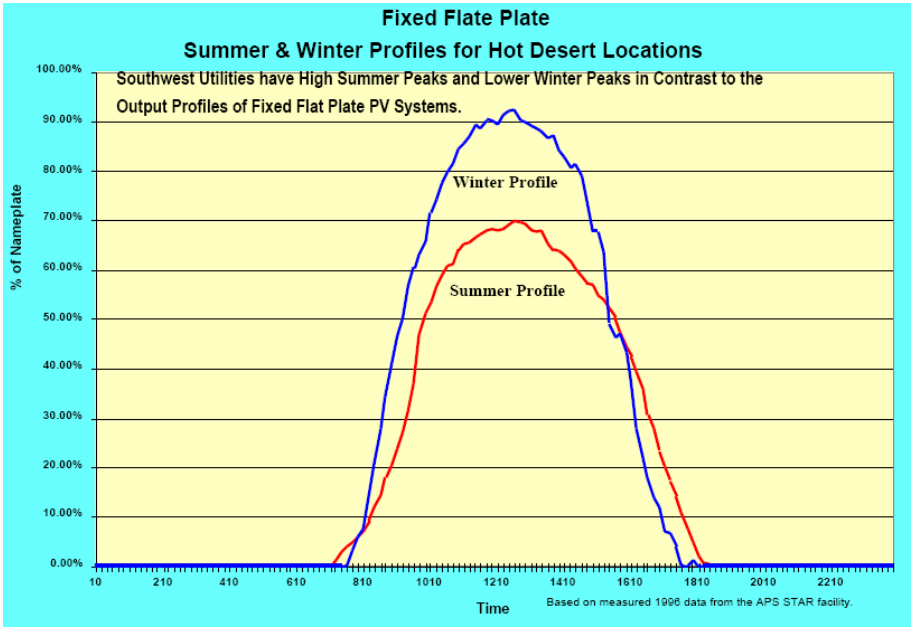
System Comparison Method

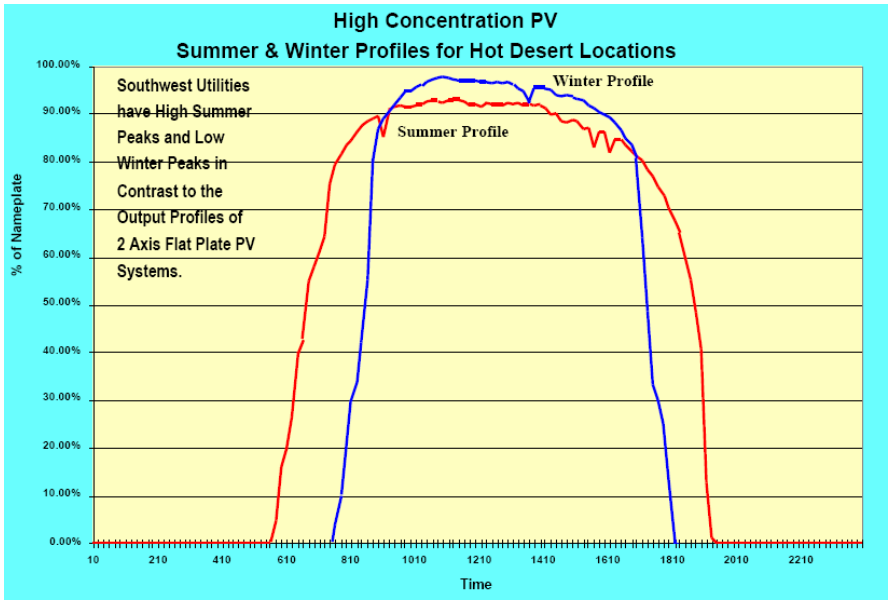
- All systems were compared using actual Summer 1996 STAR solar insolation data and PV System Performances.
- Systems were re-rated using the PVUSA Test Procedure, 850 W/ m^2 for concentrating systems
  1000 W/m^2 for flat plate systems. 25^0 C ambient temperature.

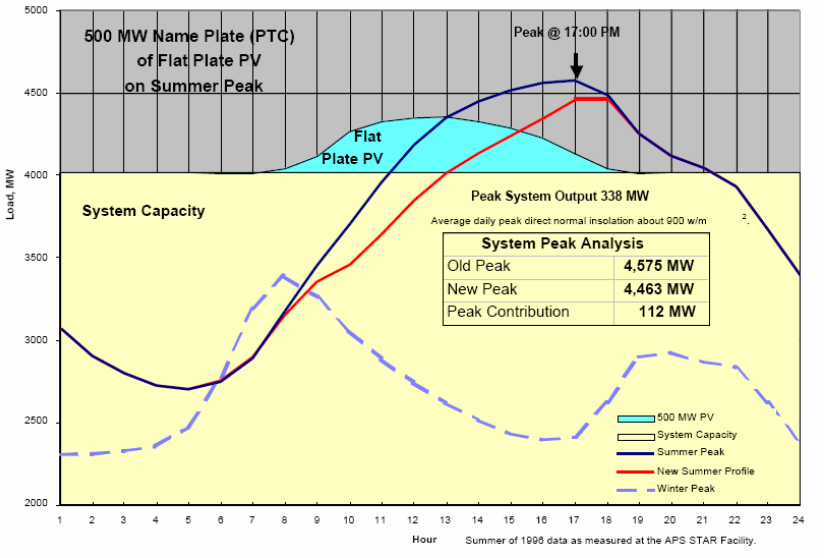
Summary of Test Results

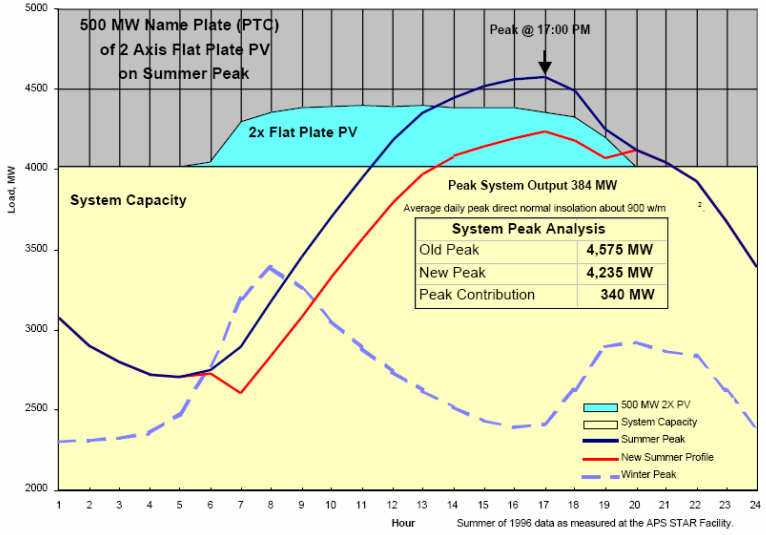
- Solar Thermal Systems earned the highest scores due to their ability to augment solar insolation with fuel or storage.
- Typical Arizona Summer Temperatures cause poor performance of Flat Plate PV Systems.

APS
Commitment. Innovation. Energy.

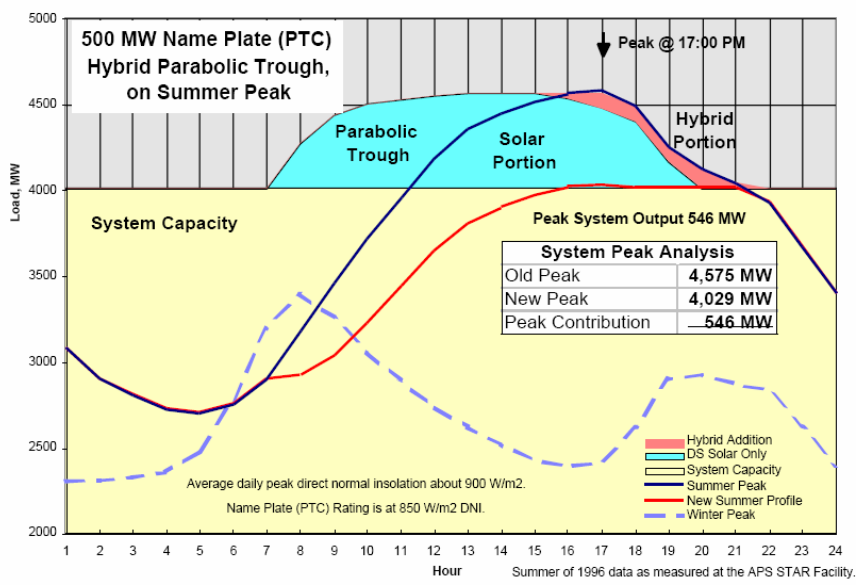

Fixed Flate Plate
Summer & Winter Profiles for Hot Desert Locations
Southwest Utilities have High Summer Peaks and Lower Winter Peaks in Contrast to the Output Profiles of Fixed Flat Plate PV Systems.
Winter Profile
Summer Profile
% of Nameplate
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
10
210
410
610
810
1010
1210
1410
1610
1810
2010
2210
Time
Based on measured 1996 data from the APS STAR facility.


High Concentration PV
Summer & Winter Profiles for Hot Desert Locations
Southwest Utilities have High Summer Peaks and Low Winter Peaks in Contrast to the Output Profiles of 2 Axis Flat Plate PV Systems.
Winter Profile
Summer Profile
% of Nameplate
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
10
210
410
610
810
1010
1210
1410
1610
1810
2010
2210
Time





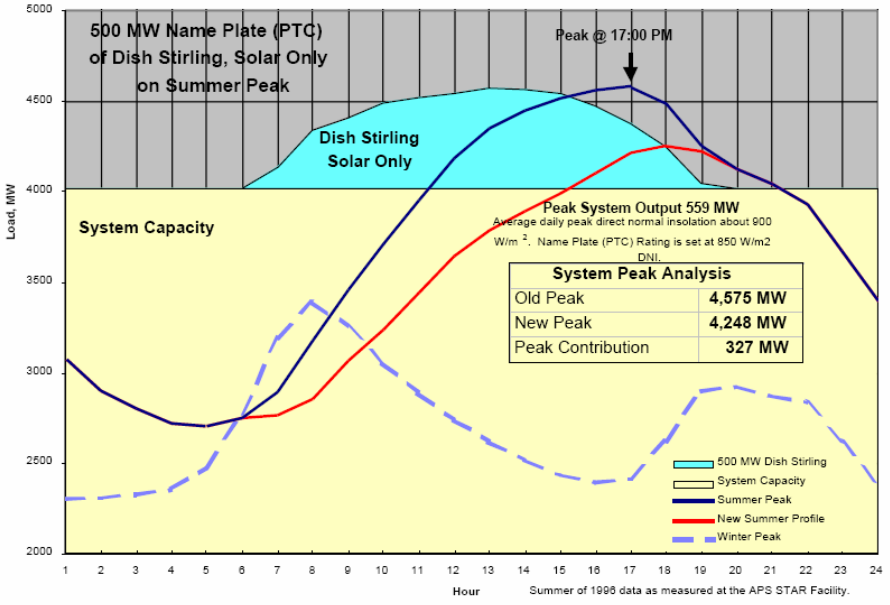
Murcia, Spain [RenewableEnergyAccess.com] A 5 MW solar tracking PV plant with a total surface exceeding 3.5 million sq. ft. using 500 2-axis solar trackers will be installed in Caravaca de la Cruz (population: 22,880) in Murcia, Spain by Soltec Energias Renewables.

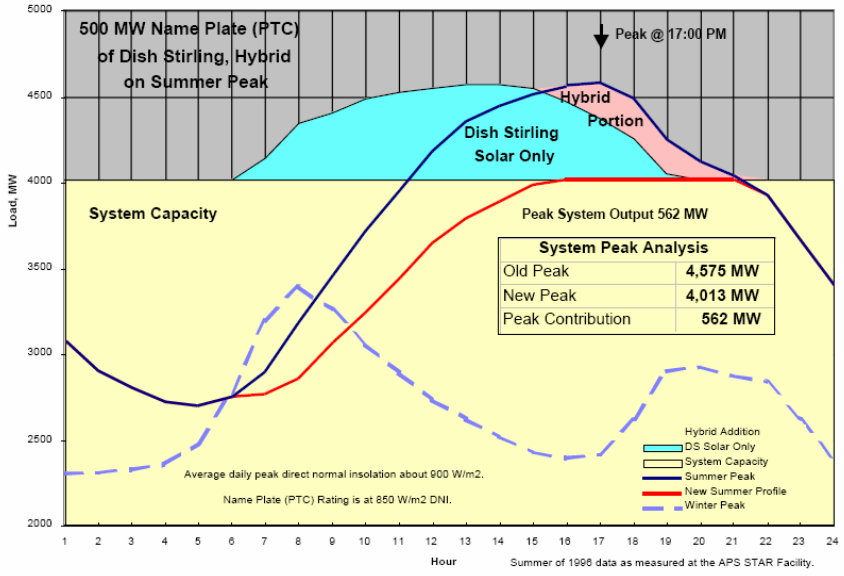


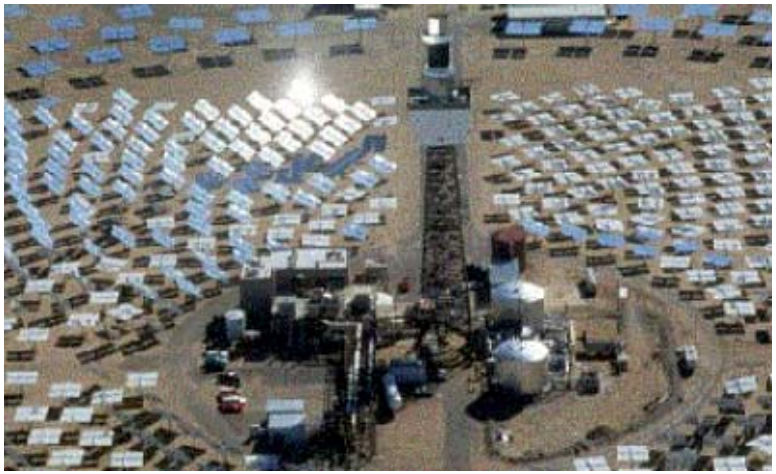
The world's largest solar power facility consists of five solar electric generating systems with a combined capacity of 150 MW, enough to power 150,000 homes.
PHOTO: DAVID RIB, KRAMER JUNCTION CO.

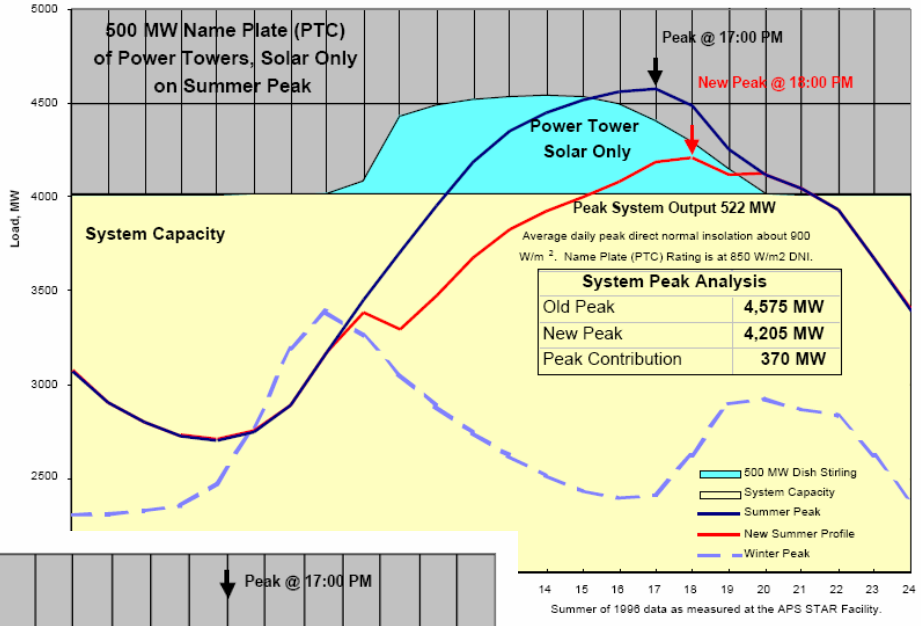
Kramer Junction, CA Solar Power Plant

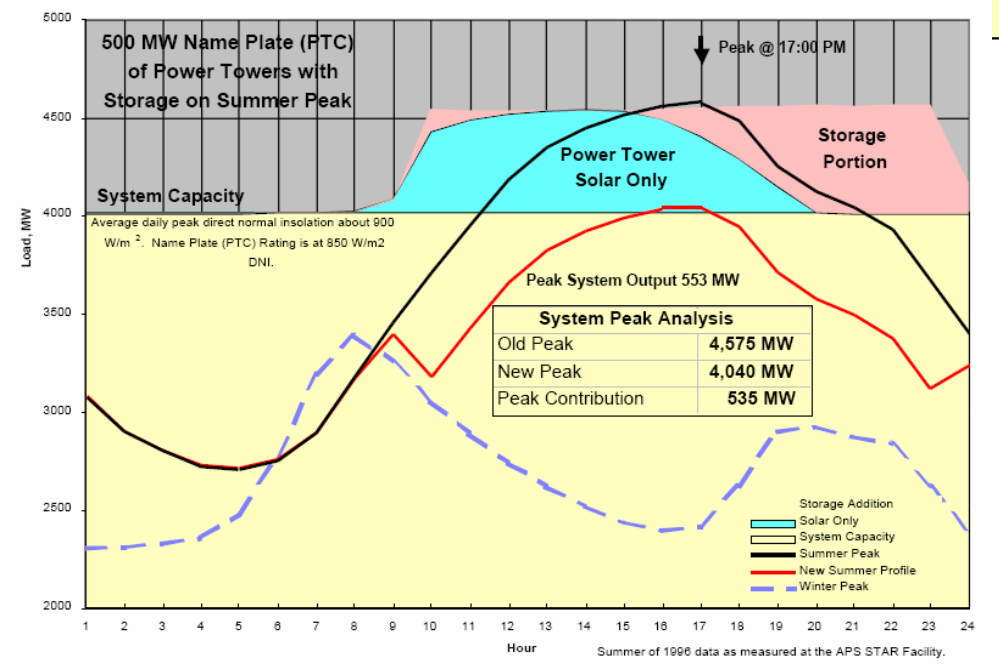

SAIC and SES Solar Dish Systems
in Operation
UNLV Installation, 8/17/01


500 MW Name Plate (PTC)
of Dish Stirling, Solar Only
on Summer Peak
Peak @ 17:00 PM
Dish Stirling
Solar Only
System Capacity
Peak System Output 559 MW
Average daily peak direct normal insolation about 900
W/m 2. Name Plate (PTC) Rating is set at 850 W/m2
DNI.
System Peak Analysis
Old Peak 4,575 MW
New Peak 4,248 MW
Peak Contribution 327 MW
500 MW Dish Stirling
System Capacity
Summer Peak
New Summer Profile
Winter Peak
Load, MW
Hour
Summer of 1996 data as measured at the APS STAR Facility.

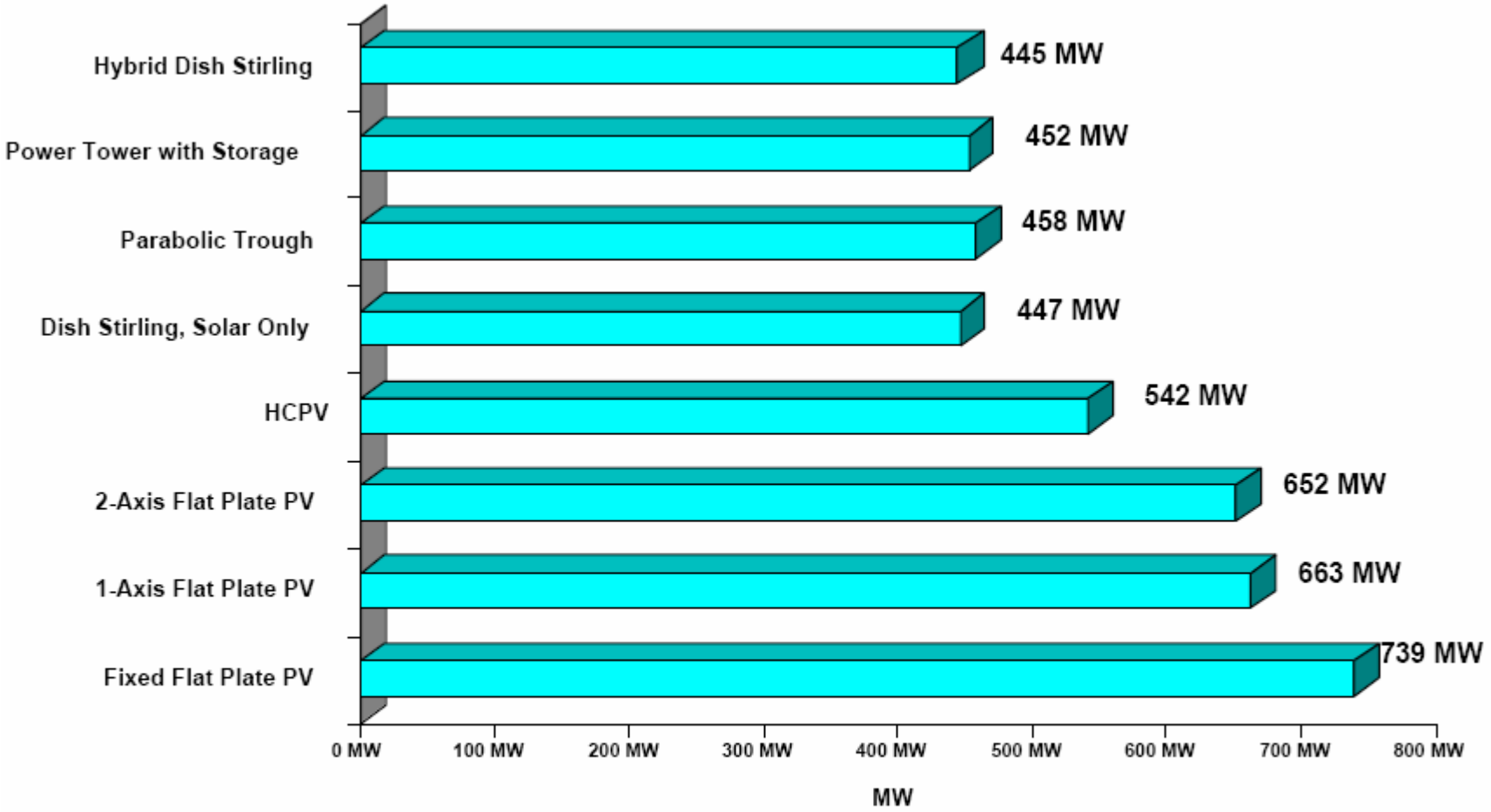

500 MW Name Plate (PTC)
of Dish Stirling, Hybrid
on Summer Peak
Peak @ 17:00 PM
Hybrid
Portion
Dish Stirling
Solar Only
System Capacity
Peak System Output 562 MW
System Peak Analysis
Old Peak 4,575 MW
New Peak 4,013 MW
Peak Contribution 562 MW
Average daily peak direct normal insolation about 900 W/m2.
Name Plate (PTC) Rating is at 850 W/m2 DNI.
Hybrid Addition
DS Solar Only
System Capacity
Summer Peak
New Summer Profile
Winter Peak
Load, MW
Hour
Summer of 1996 data as measured at the APS STAR Facility.



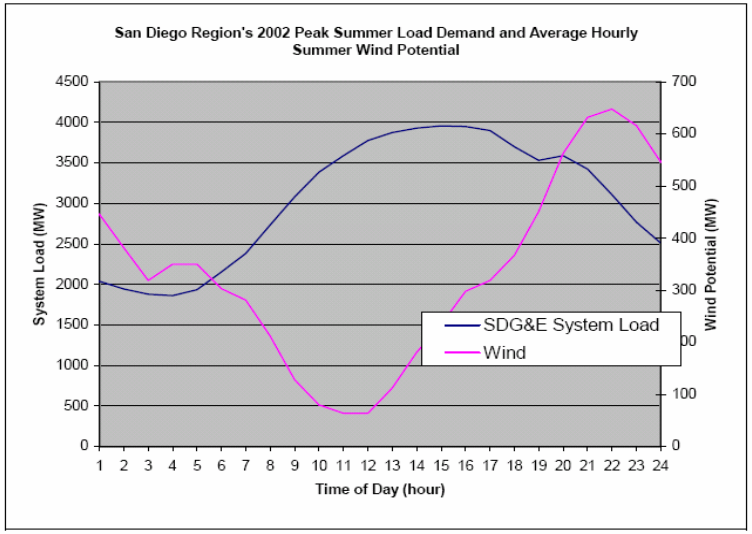

500 MW Name Plate (PTC)
of Power Towers, Solar Only
on Summer Peak
Peak @ 17:00 PM
New Peak @ 18:00 PM
Power Tower
Solar Only
System Capacity
Peak System Output 522 MW
Average daily peak direct normal insolation about 900
W/m 2. Name Plate (PTC) Rating is at 850 W/m2 DNI.
System Peak Analysis
Old Peak 4,575 MW
New Peak 4,205 MW
Peak Contribution 370 MW
500 MW Dish Stirling
System Capacity
Summer Peak
New Summer Profile
Winter Peak
Load, MW
Summer of 1996 data as measured at the APS STAR Facility.


500 MW Name Plate (PTC)
of Power Towers with
Storage on Summer Peak
Peak @ 17:00 PM
Storage
Portion
Power Tower
Solar Only
System Capacity
Average daily peak direct normal insolation about 900
W/m 2. Name Plate (PTC) Rating is at 850 W/m2
DNI.
Peak System Output 553 MW
System Peak Analysis
Old Peak 4,575 MW
New Peak 4,040 MW
Peak Contribution 535 MW
Storage Addition
Solar Only
System Capacity
Summer Peak
New Summer Profile
Winter Peak
Load, MW
Hour
Summer of 1996 data as measured at the APS STAR Facility.

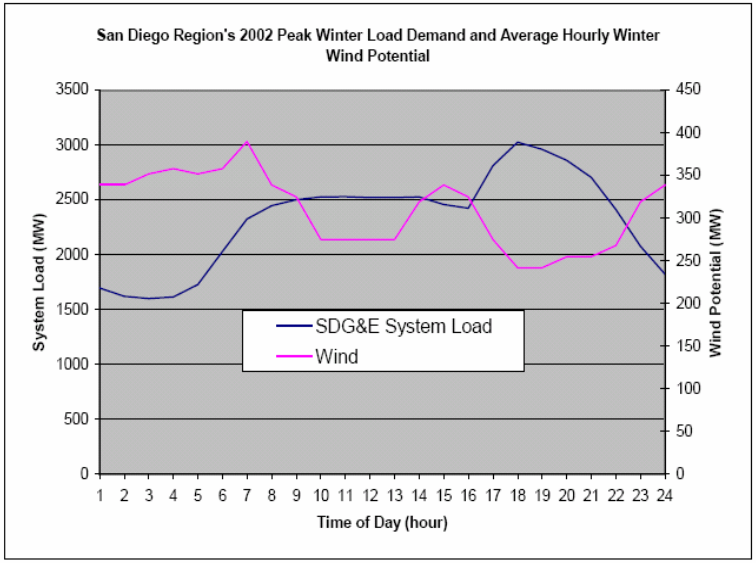
MWs Required to supply 500MW Peak Output, Arizona Summer Day



Average daily peak direct normal insolation 900 w/m2.
Summer of 1996 data as measured at the APS STAR Facility.



Summer Peak



Winter Peak

TECHNOLOGY	ATTRACTIVE FEATURES	BARRIERS
BOTH TROUGH and CENTRAL RECEIVER	- Very Large Resource - Good Peak Power with Heat Storage or Hybrid Operation	- Capital Intensive - Significant Environmental Land Impacts (scrapes all land) - Needs Transmission Lines - Needs Water for Wet Cooling - Needs Flat Land (<1%slope) - Hybrid Efficiency Lower (~30%)
PARABOLIC TROUGH	-Installed Cost, O&M, Operation Are Known -Thermal Storage OK	- Eventual Commercial Cost Must Be Reduced - Cost Effective in 100 MW Size - Minimum Land is 0.86 - 1.5 mi2
CENTRAL RECEIVER	-Thermal Storage OK -- Eventual Commercial Cost Less Than Trough	-Initial Commercial Cost Is Higher Than Trough -Cost Effective in 200 MW Size and Minimum Land Is 1.9 mi2

TECH-NOLOGY	ATTRACTIVE FEATURES	BARRIERS
DISH-STIRLING	- Very Large Resource - No Cooling Water Needed in Desert - Good Hybrid Peak Power (when dual fuel engine developed) -Hybrid Efficiency as High as Large Fossil Power Plant (~ 38%) - Two Large Commercial Contracts - Modular Approach Has Best Low Cost Potential - Can Use Irregular Land with Steeper Slope (up to 5 degrees) - No Site Grading and Use Large Tire Vehicles for Plant Assembly and O&M - Wide Range of Commercial Size (5-1000 MW) - Can Integrate into Load Center as Part of Industrial Site or > 1500 Home Development	-Capital Intensive - Needs Transmission Lines for Large Plants - Commercial Cost and O&M Not Proven - Need to Develop Dual Fuel Engine Using CH4 or Biofuels for Hybrid Operation

TECH-NOLOGY	ATTRACTIVE FEATURES	BARRIERS
WIND	- Large Resource - Proven Commercial Technology - Low Capital and Energy Costs - Reciprocal Availability to Solar - Displace Evening Burning of Fossil Fuels - Provide Energy During Off-Peak to Power Emerging Huge Load of Charging Hybrid-Electric Vehicles	- Almost No Peak Displacement Unless Linked With Storage - Limited Dispatching with Wind Forecasting - Impacts Viewscape (good or bad) - Environmental Impacts Such as Bird/Bat Kills (can be mitigated with good layout design) - Wind Farm Sound Needs Minimum Separation Distance to Residences (~ 0.5 to 1 mile)
Concentrating PV	- Reduce Land Use Compared to Fixed PV Due to High Efficiency - Better Summer Peak Power	- Production Scale Up Needed To Reduce Commercial Cost
FLAT PV	- Installed Cost, O&M, Operation Are Known	- Need Production Scale-up -Current Commercial Cost Is High - Summer Peak Reduced 20% Due to Hot Weather - Poor peak load reduction

TECH-NOLOGY	ATTRACTIVE FEATURES	BARRIERS
GEOTHERMAL	- Renewable Source (if properly managed) -Capacity Factor Can = 1.0 -Commercially Available	-Need to Manage Impacts - Scrubbers for Air Pollution - Dispose of Spent Brine - Waste Drilling Fluids and Tailings -Needs Transmission Line for > 300 MW -Can Be Depleatable
BIO-GAS	-Disposes of Significant Green-house Gas - Disposes of bad smelling gas - Disposes of gas contributing to local smog - Reliable & Renewable Fuel Source - All Land Fields Are Required to Collect Gas	- Must Mitigate Exhaust Pollutants
BIO-MASS	-Renewable -Commercially Available	- Must Mitigate Exhaust Pollutants - Limited and Variable - Labor Intensive
HYDRO	-Renewable -Commercially Available	- Need to Manage Impacts Especially Fisheries, Wildlife, Cultural, Recreational & Scenic

RENEWABLE POTENTIAL ACHIEVED in 2020

(based on pp.30 – 33 results)

TECHNOLOGY	POWER in 2020 MW	Technical MW	Potential % Achieved
HYDRO	12	170	7
BIO-MASS	29	70	42
BIO-GAS	32	72	45
GEOTHERMAL	1,200	3,000	40
WIND	325	1,700	19
DISH-STIRLING	1,000	31,900	5
TROUGH and CEN RECEIVER	500	"	"
SOLAR PV	100	"	"
TOTAL	3,200	36,900	9

ACCESS TO RESOURCE

- Highest Intensity SOLAR RESOURCE PRIMARILY IN IMPERIAL CTY (29,000 MW)
- Lower Intensity SOLAR RESOURCE IS WEST OF ANZA-BORREGO PARK (3700 MW and USES MANY SMALLER SCALE PLANTS (> 5 MW)
- LARGE WIND RESOURCE IN EASTERN SAN DIEGO CTY and SW Corner of IMPERIAL CTY
- GEOTHERMAL RESOURCE AT Southern SALTON SEA
- SIGNIFICANT SOLAR and WIND RESOURCE IN NORTHERN BAJA (not considered in projection)
- AVERAGE DISTANCE from IMPERIAL CTY TO LOAD CENTER IS ABOUT 130 MILES
- LIMITED EXISTING TRANSMISSION FROM EAST CTY & IMPERIAL CTY
  - ABOUT 300 MW CAN BE ADDED NOW WITHOUT NEW TRANSMISSION LINE
  - EXCEPTION IS SW CORRIDOR with 500KV Line
- RELATIVELY SMALL AMOUNTS OF BIO AND HYDRO ARE FAIRLY WELL INTEGRATED INTO GRID
- CONCLUSION: BASED ON PROJECTIONS TO 2020,
  - TO CAPTURE LARGE RESOURCE IN IMPERIAL CTY, A MAJOR TRANSMISSION LINE IS NEEDED
  - ABOUT HALF THE RENWABLES ARE IN-COUNTY SAN DIEGO AND DO NOT REQUIRE A LONG DISTANCE TRANSMISSION LINE
  - IN-COUNTY RENEWABLES CAN BE BALANCED WITH OUT-OF-COUNTY RENEWABLES UP TO THE LIMIT OF ABOUT 3700 MW FROM BACK-COUNTY MULTIPLE SITES

Example: Trend in Wind Energy Cost

1979: 40 cents/kWh

2000:
4 - 6 cents/kWh

- Increased Turbine Size
- R&D Advances
- Manufacturing Improvements

2004:
3 - 5 cents/kWh

NSP 107 MW Lake Benton wind farm
4 cents/kWh (unsubsidized)

Wind and Storage

- If Small Wind Energy Penetration Into Grid That Is Less Than 20%
  - Fluctuations Treated Like “Negative Loads”
  - Wind Gets Low Capacity Credit
  - No Additional Costs
- If Large Wind Energy Penetrations -- Greater Than 20 to 30%
  - Need System Storage or Backup Generation
  - Need Strengthened Transmission Lines
- Or, **Alternate Strategy** Is Needed

Electric Storage Options

Source: Schainker, 1997 (reproduced in PCAST, 1999)

Technology	Capacity ($/kW)	Storage ($/kWh)	**Cost of 20 hrs. storage ($/kW)**
Compressed Air Energy Storage (CAES) (350 MW)	**350**	**1**	**370**
Pumped hydroelectric	900	10	**1100**
Advanced battery (10 MW)	120	100	**2100**
Flywheel (100 MW)	150	300	**6200**
Superconductor (100 MW)	120	300	**6100**

CAES is clear choice for:

- Several hours (or more) of storage
- Large capacity (> ~100 MW)

CAES: Low cost bulk storage

- Large unit size (100s of MW)
- Long storage time (10-100s of hours)
- Lowest cost storage media:
  - $0.1/kWh aquifer
  - $1-2/kWh salt dome
  - $10-30/kWh hard rock

} **Widespread geology**

- Energy output > input (added NG)
- Round-trip electrical efficiency ~80%

San Diego Reservoirs
Pumped Storage for Wind

- Lake Ellsinore Pumped Storage Project Is Underway
  - 500 MW Daytime Load Following Capability
  - Short Transmission Links Both North and South

- San Diego and a Chula Vista Based District Have Joined Forces to Create a $300 million Pipeline Network That Would Connect 4 Isolated Reservoirs
  - San Vicente, El Capitan, Loveland (Cuyamaca) and Murray Reservoirs

- Rep. Duncan Hunter, R Alpine, Secured Unanimous Support in the House of Representatives for a $3 million Feasibility Study

- The funding measure, HR 1190, now moves to the Senate.

- http://www.signonsandiego.com/news/metro/20060310-9999-2m10water.html

Alternate Strategy to Avoid Wind Storage

- Background
  - Transition Away from Oil in Transportation Sector Will Start To Accelerate This Decade
    - Instability of Mid-East Oil Supply
    - Peaking of Global Oil Production
    - Global Warming Becoming Recognized by National Government As a Serious Problem
  - One Technology for Initial Part of Transition Will Be to Introduce Pluggable Hybrid-Electric Vehicles with 10 to 30 mile All Electric Range
- Alternate Strategy
  - Plan Large Wind Projects To Coincide with New Load of Nighttime (off-peak) Charging of Pluggable Hybrid Vehicles
- Future Long Term Technology To Continue Transition Away from Oil Will Be to Generate Hydrogen Which Has Good Storage Capability

Renewables Long Term Cost Trends

- Wind
  - Annual Growth Rate --- 25%
  - Cost Reduction per Doubling of Production --- 28%
  - Time to Reduce Costs by 1/2 = 6.25yrs
- PV
  - Annual Growth Rate --- 30%
  - Cost Reduction per Doubling of Production --- 20%
  - Time to Reduce Costs by 1/2 = 8 yrs
- Geothermal, Small Hydro, Biogas & Biomass
  - Stable Costs
- Solar Thermal Electric
  - No Long Term Commercial Cost Record
  - Expected Learning Curve Is Approx 20% Cost Reduction per Doubling

COMPARISON TO TRADITIONAL ENERGY

TECHNOLOGY	CAPITAL COST $/kw	CAPACITY FACTOR	CENTS/KWh
Peaking Gas	600	0.09	
- 5 $/MBtu			21
-10 $/Mbtu			33
-15 $/Mbtu			35
Combined Cycle	600	0.9	
- 5 $/MBtu			5.6
-10 $/Mbtu			9.8
-15 $/Mbtu			14.1
Coal	Needs to be	“clean” coal for use	in CA
Nuclear	Needs to solve	long term storage	for CA use