ABENGOA SOLAR

Solar Power for a Sustainable World

A Developer's Perspective on Concentrating Solar Power (CSP)

Dr. Fred Morse
Senior Advisor, US Operations, Abengoa Solar
and
Chairman, USP Division, SEIA

Presented at the BLM Renewable Energy Summit
Las Vegas, NV
31 August – 3 Sept 2009

Concentrating Solar Power

Parabolic Trough

Power Tower

Linear Fresnel

Dish Engine

Concentrating PV

CSP Industry active in the US

- Trough – Abengoa Solar, Acciona, NextEra Energy, Solar Millennium, Solel, SkyFuel
- Tower – Abengoa Solar, Bright Source Energy, eSolar, Solar Reserve/UTC
- Dish – SES, Infinia
- Fresnel – Ausra, SkyFuel

The CSP Industry

- Technologies – trough, tower, dish engine, linear Fresnel, and CPV, each of which have variations making the industry very robust
- United States SEIA USP Division has about 90 current members and the European Solar Thermal Industry Association has similar number of members
- 430 MW in commercial operation, 8,389 MW under contract in the US and about 4,000 MW under development in the rest of the world
- Continued market growth is predicted.

CSP Activity in the US (August 2009)

Name or Location	Utility	State	Installed	Contracts & Awards[1]	Technology	Begin Operation	Company
SEGS	SCE	California	354 MW		Parabolic trough	1985 - 1991	FPL Energy
Saguaro	APS	Arizona	1 MW		Parabolic trough	2006	Aciona
Nevada Solar One	NVEnergy	Nevada	64 MW		Parabolic trough	2007	Aciona
Kimberlina Power Plant	PG&E	California	5 MW		Linear Fresnel	2008	Ausra
Sierra Sun Tower	SCE	California	5 MW		Power tower	2009	eSolar
Keahole Solar Power	HELCO	Hawaii	1 MW		Parabolic trough	2009	Sopogy
SES Solar Two – Ph 1	SDG&E	California		500 MW	Dish/engine	2009 - 2012	SES
SES Solar One – Ph 1	SCE	California		300 MW	Dish/engine	2009 - 2012	SES
Carrizo Energy Solar Farm	PG&E	California		177 MW	Linear Fresnel	2010	Ausra
West Texas	CPS Energy	Texas		27 MW	Dish/engine	2010	SES / Tessera Solar
Solana	APS	Arizona		280 MW	Parabolic trough	2011	Abengoa Solar
Harper Lake Solar Plant	(TBD)	California		250 MW	Parabolic trough	2011	NextEra Energy
Mojave Solar Park	PG&E	California		553 MW	Parabolic trough	2011	Solel
Beacon	LADWP	California		250 MW	Parabolic trough	2011	NextEra Energy
Sunland Park, NM	EPE	New Mexico		92 MW	Power tower	2011	eSolar
California	SCE	California		140 MW	Power tower	2011	eSolar
Coalinga	PG&E	California		107 MW	Parabolic trough	2011	Martifer Renewables
Martin Solar Energy Ctr.	FPL	Florida		75 MW	Trough add-on to IGCC	2011	NextEra Energy
SES Solar Two – Ph 2/3	SDG&E	California		600 MW[2]	Dish/engine	2011 - 2013	SES
Lancaster, CA	PG&E	California		92 MW	Power tower	2012	NRG / eSolar
Ivanpah, CA	PG&E	California		300 MW	Power Tower	2012 - 2013	BrightSource Energy
Ivanpah, CA	SCE	California		100 MW	Power tower	2013	BrightSource Energy
Starwood Solar 1	APS	Arizona		290 MW	Parabolic trough	2013	Starwood Solar / Lockheed
Blythe, CA	SCE	California		242 MW	Parabolic trough	2013	Solar Millennium
Kingman, AZ	(TBD)	Arizona		200 MW	Parabolic trough	2013	Albiasa Solar
SES Solar One – Ph 2	SCE	California		350 MW[2]	Dish/engine	2013 - 2014	SES
Nevada	NVEnergy	Nevada		250 MW	Parabolic trough	2013 - 2014	Solar Millennium
Ridgequest, CA	SCE	California		242 MW	Parabolic trough	2014	Solar Millennium
(Multiple plants)	SCE	California		1200 MW[2]	Power tower	Unspecified	BrightSource Energy
(Multiple plants)	PG&E	California		1000 MW[2]	Power tower	Unspecified	BrightSource Energy
California	SDG&E	California		100 MW	Parabolic trough	Unspecified	Bethel Energy
California	SCE	California		242 MW[2]	Parabolic trough	Unspecified	Solar Millennium
		Column Totals	430 MW	7,959 MW			
		U.S. Total	8,389 MW				

1 Agreement signed or award announced

2 Contractual expansion option

Why CSP and Why Now?

- **Necessity** – the utilities' other options (coal, nuclear or NG) have significant long term risks with cost implications
- **Uniqueness** of thermal energy storage
- Favorable **policies,** such as the state RPS and the ARRA incentives (all of which are essential) in the US and Feed-in tariffs elsewhere
- **Public opinion** favors solar

Awareness of CSP

- **Policy makers –** Generally lagging as evidenced by inadequate or unreliable policies at all levels of government
- **Investors** – Growing fast as evidenced by news articles and conferences but lagging wind and PV investments, held back by policy uncertainty and today's financial market situation
- **Utilities** – Growing fast where good DNI and policies exist

Attributes of CSP in the Eyes of Policy Makers

- Very **large domestic resource** potential
- **Carbon free** electricity
- **Potential for cost** reduction
- **Economic benefits** will result from its development
- Increased **public awareness** and support of the benefits of clean energy

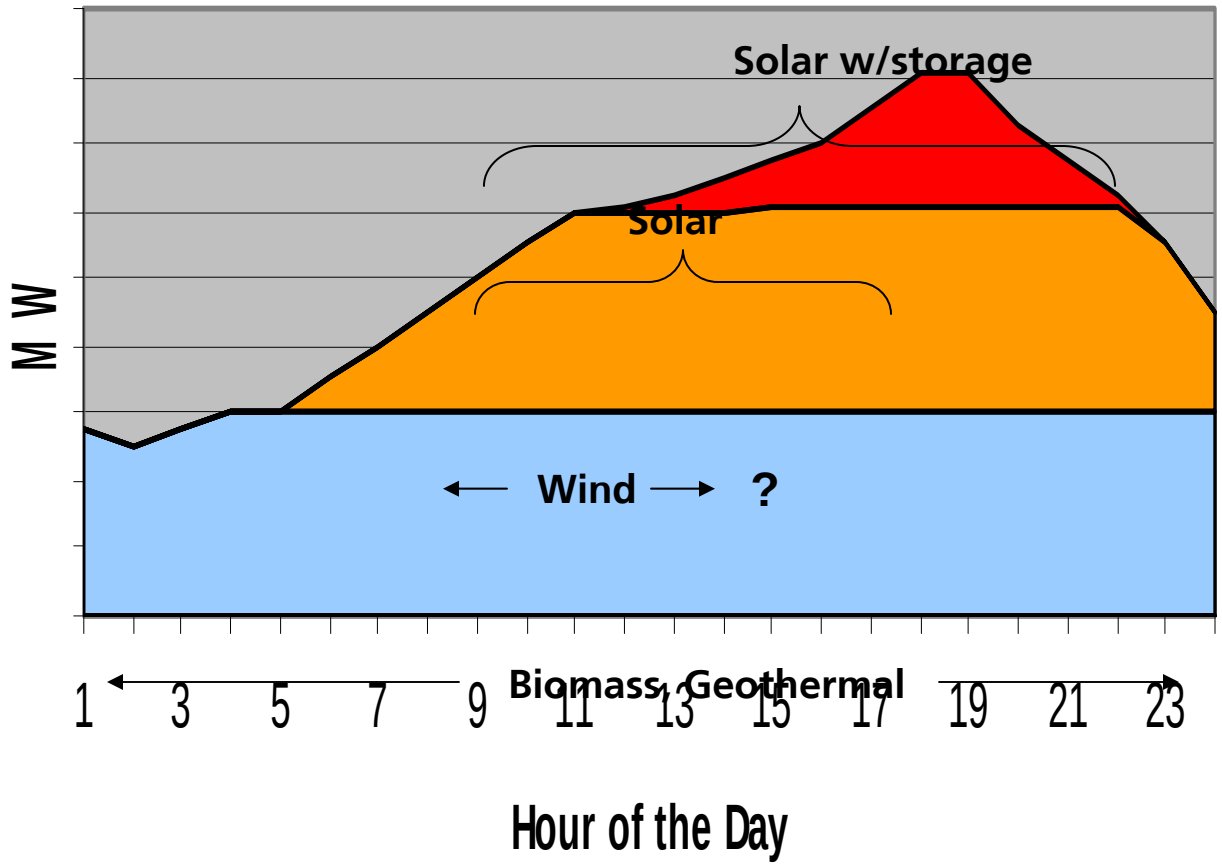
Attributes of CSP in the Eyes of Investors

- **Scalable**
- With a good Power Purchase Agreement, the return on investment can be adequate to encourage **main-stream** equity and favorable debt financing terms.
- Once debt is paid, operates with no fuel – has potential of becoming a **"clean cash cow".**

Attributes of CSP in the Eyes of Utilities

- Utilities are familiar with **steam** generation
- Suitability for utility **scale** installations of 100MW or more
- Stable, known and decreasing costs and zero carbon emissions provide **hedge** against NG price volatility and carbon caps
- Other generation options have significant **risks**
- Ability to provide **firm dispatchable output** which is of **great value** to utilities

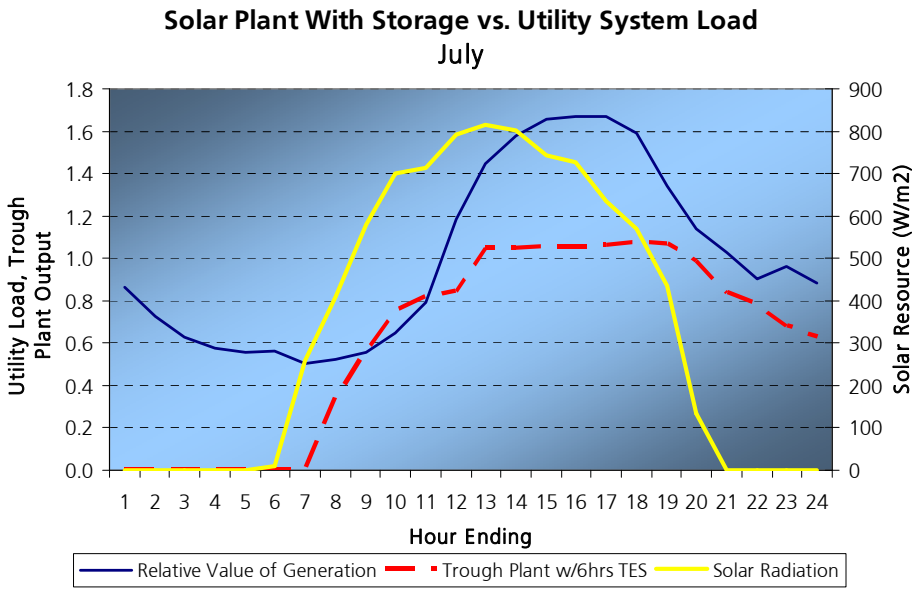
Summer Generation Profile
Renewable Resource Fit



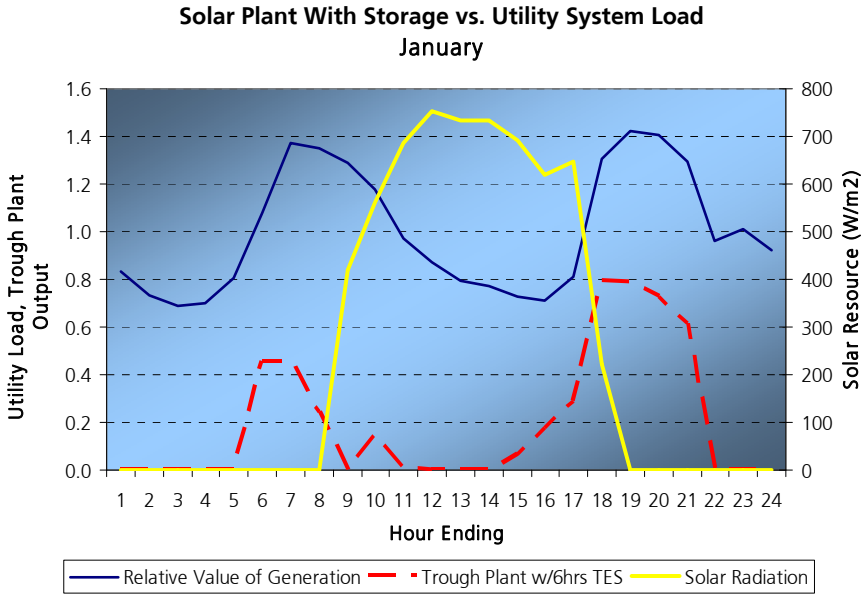
Provided by Barbara Lockwood, APS

Generation from solar plant with storage can be shifted to match the utility system load profile

Summer



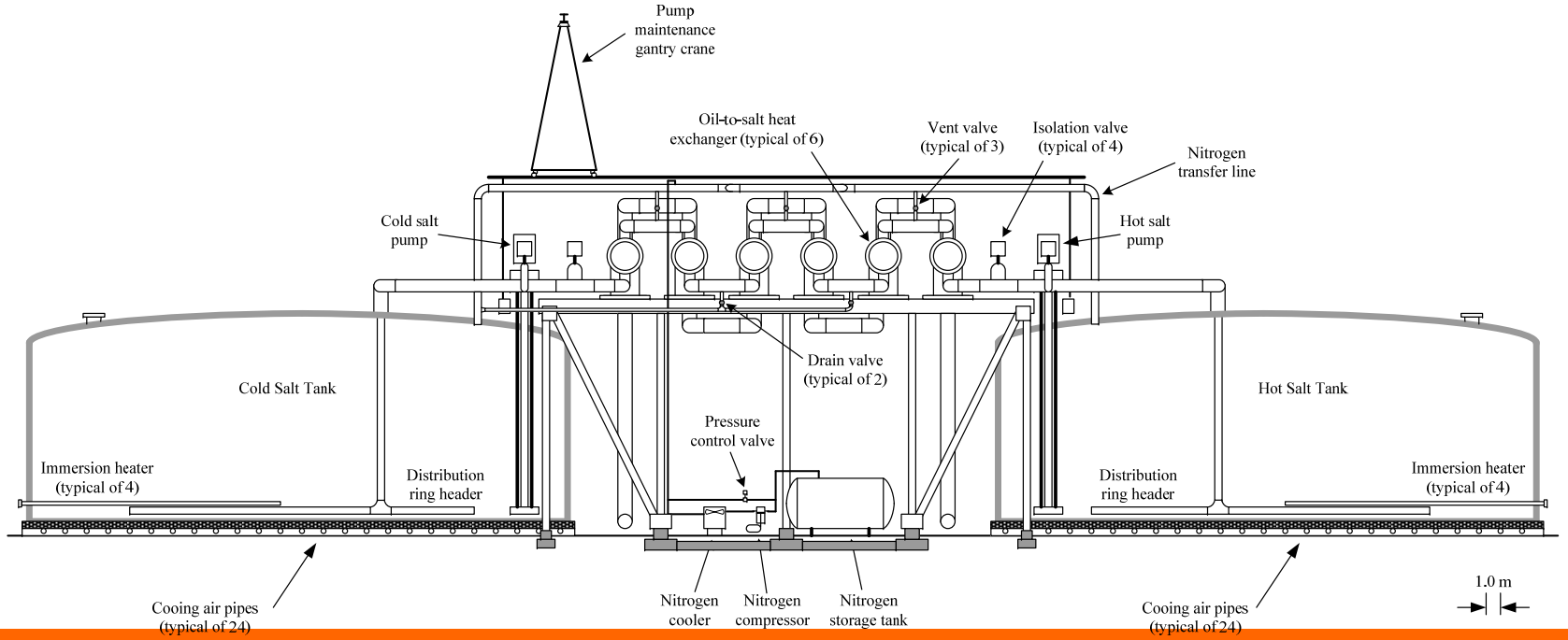
Winter



Key: - Solar
- Demand
- Generation

Thermal Energy Storage

- Based on Solar Two molten-salt power tower experience
- Indirect 2-tank molten-salt design for parabolic trough plants
- Uses oil to salt heat exchangers to transfer energy to and from storage



TES Test Facility

Additional Utility Attributes

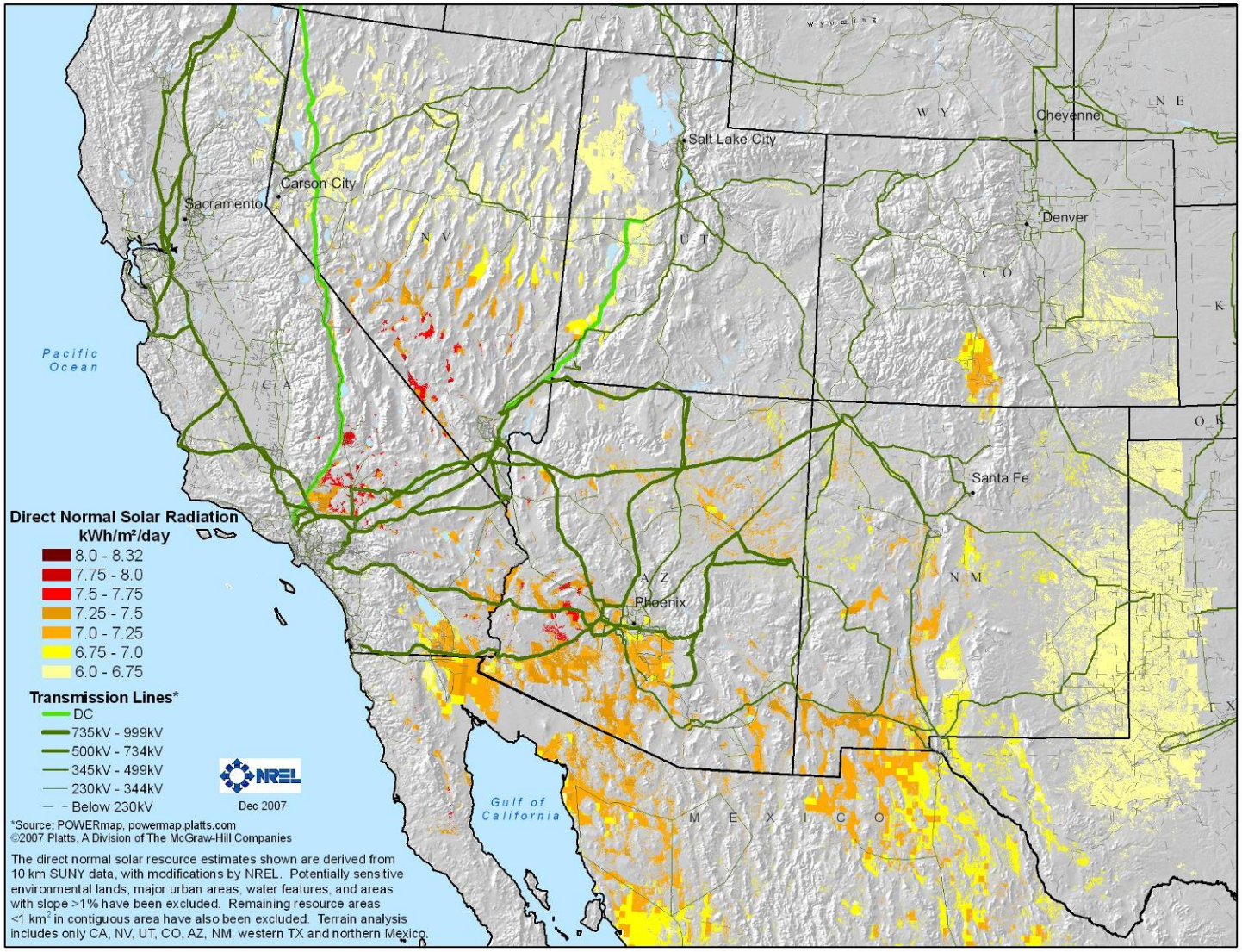
- **Large, multi-national corporations are now involved in every part of chain**
  - Project and Technology Developers
  - Utilities and Independent Power Producers
  - Engineering and Construction Companies
- **Quality counterparties reduce overall CSP project risk**
  - Large balance sheets
  - Power and construction expertise
  - Strategic technology deployment


Solana Generating Station
West of Gila Bend, AZ

Land Requirements

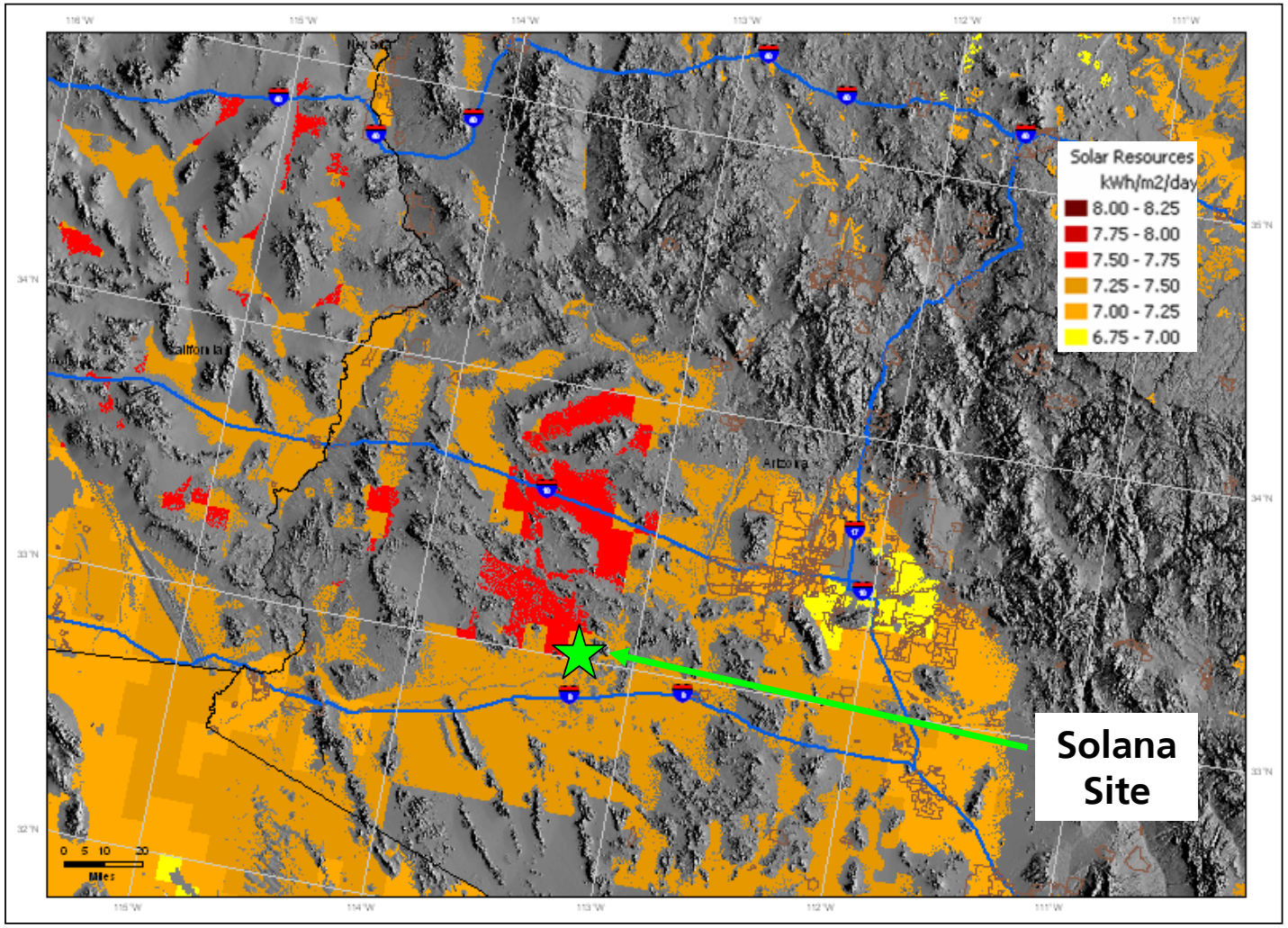
- Typically 5-8 acres per MW
- 1GW is about 10 square miles
- Flat (<1-3% slope), near transmission, near roads and labor pool, environmentally and otherwise acceptable area
- Former agricultural lands attractive
- Considerable interest in public land and in zones (BLM, WGA, RETI and some states)

Southwest Solar Resources
Previous Plus Slope < 1% and Topography



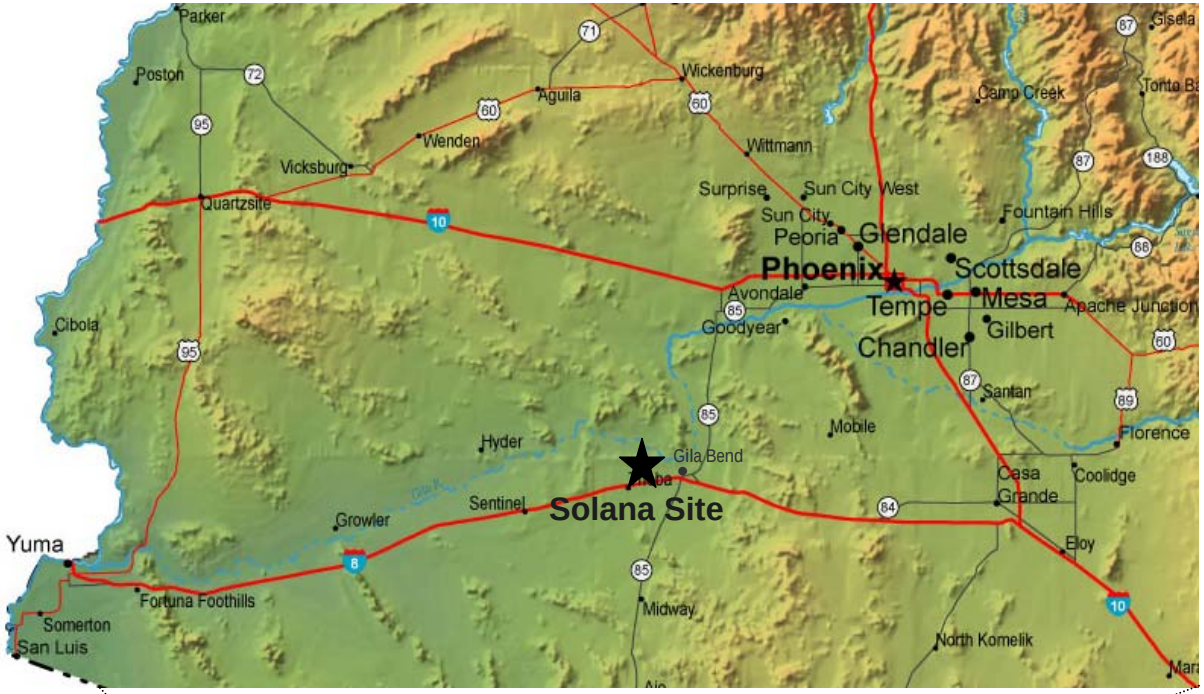
Overview: Solana Site Selection

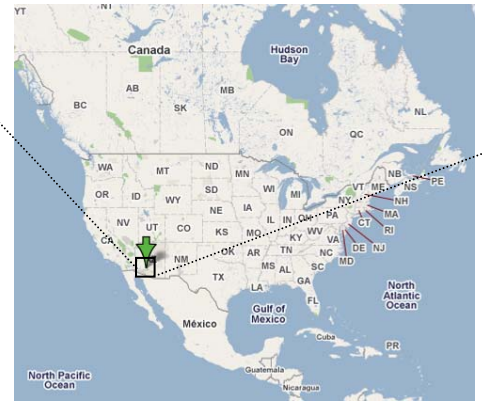
- High solar resource
- Minimal slope
- Proximity to electric grid
- Proximity to transportation corridors
- Water availability
- Previously disturbed land



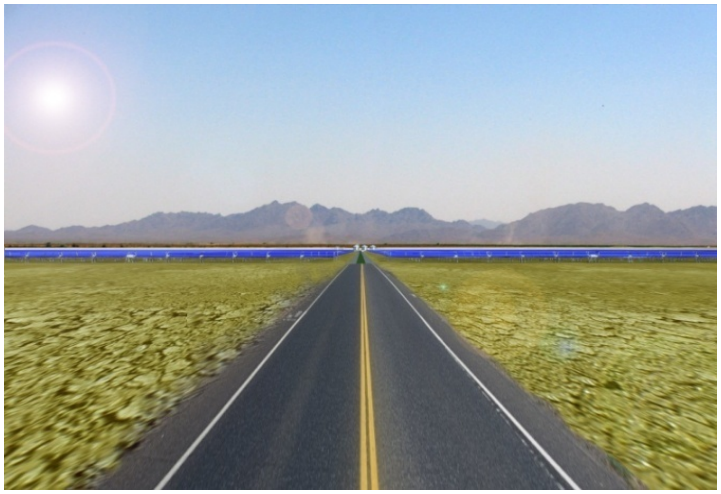
Site Location:

The Solana site is located west of Gila Bend, AZ, approximately ~70 miles southwest of Phoenix.





Map extent



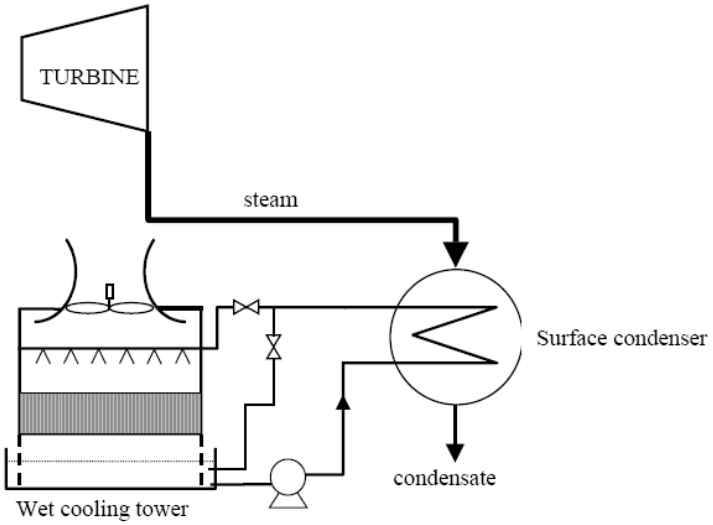
Project Facts

- 280 MW gross output with conventional steam turbines
- "Solar Field" will cover 2000 acres (3 square miles) and contain ~ 2,900 trough collectors
- Collectors are ~ 19 ft wide, 410 ft long, and the rotation axis is 10ft above the ground
- Plant water consumption approximately eight times less than previous agricultural use
- Thermal storage tanks allow electricity to be produced on cloudy days or several hours after sunset

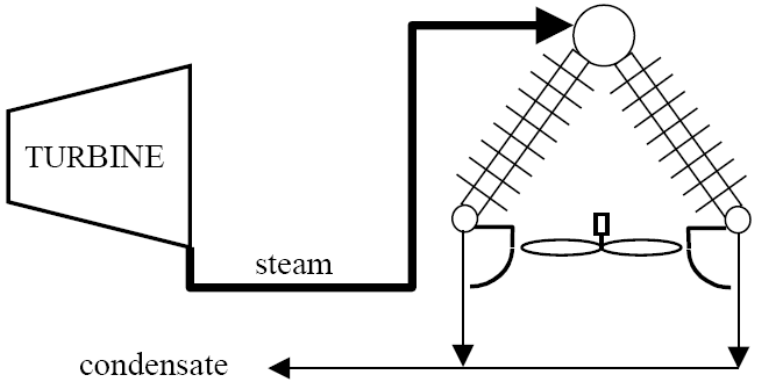
Water Requirements

- Trough and Tower utilize thermal power cycles and therefore must reject heat to condense the exhaust steam
- Water cooling is more efficient and dry cooling is least efficient
- Dish Engine and PV are not thermal cycles and can rely on dry cooling

Wet Vs. Dry Cooling Technology



Wet Cooling



Dry Cooling

Wet Vs. Dry Cooling Technology

Wet Cooling

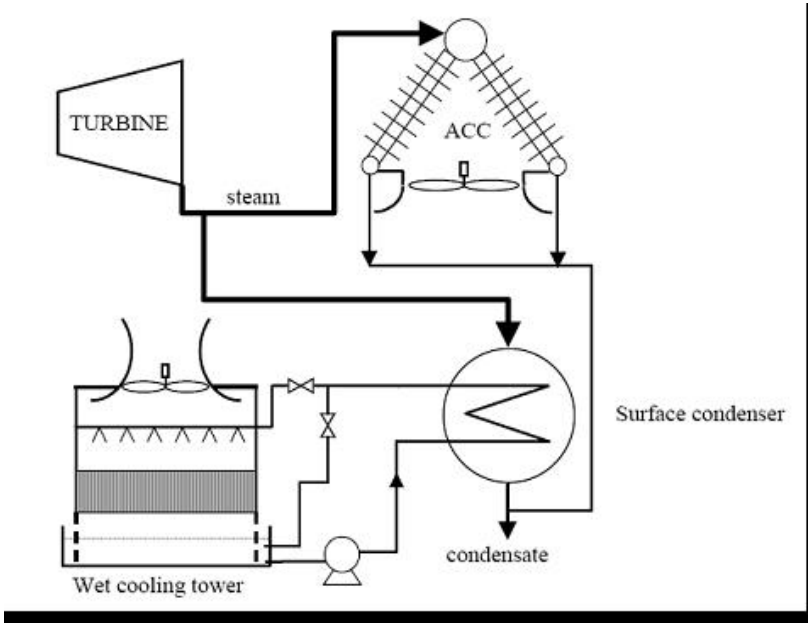
- Uses 3.5 m^3 water per MWh
  - **~90%** for cooling
  - The rest for the steam cycle and washing

Dry Cooling

- Reduces plant water consumption by ~90%
- Increases plant capital cost ~5%
- Reduces annual net output >5%
  - Significant reduction during hot periods
- Increases cost of electricity ~10%

Hybrid Cooling Technology

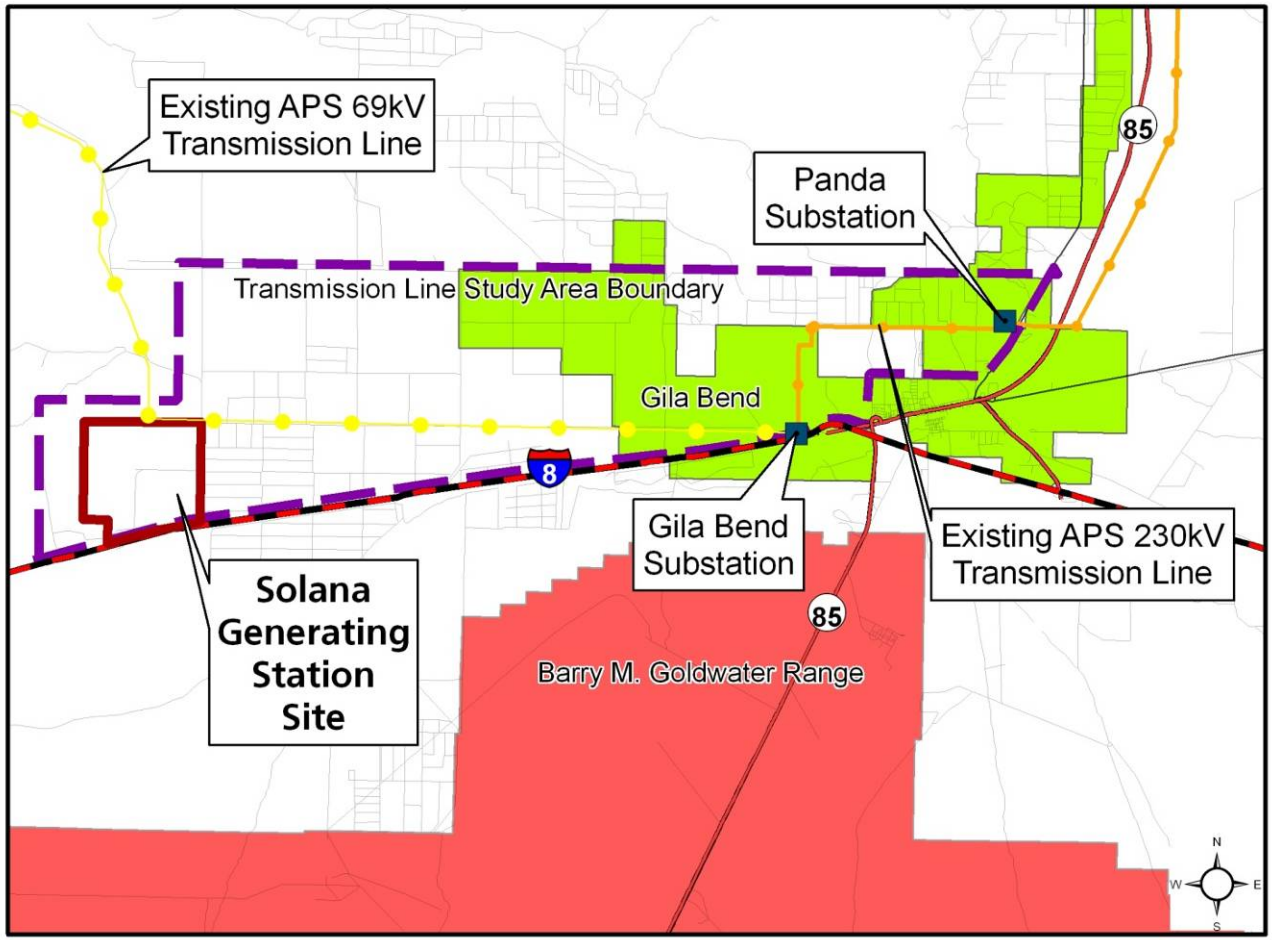
- A "hybrid" mix of wet and dry cooling
- A number of approaches are possible
- Commercially available option
  - Includes both dry and wet cooling towers
  - Relative size of wet and dry cooling towers determines water use



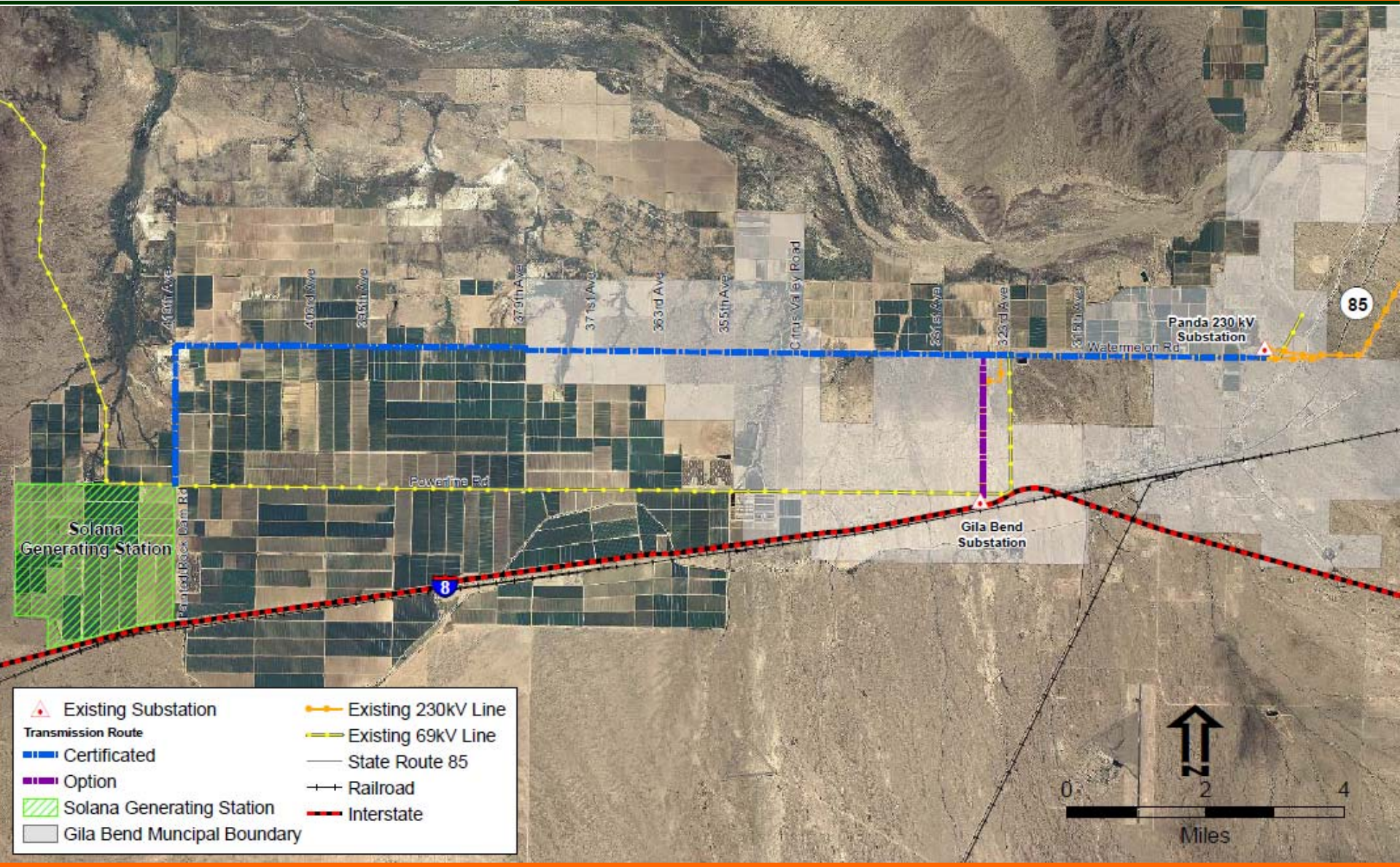
Constructing Solana will require over 80,000 tons of steel – enough to build a second Golden Gate Bridge.

Trough Frame Assembly Factory

Project Study Area



Interconnection



Interconnection

- Feasibility Study — complete
- System Impact Study — complete
- Facilities Study — in progress

- LGIA expected: — by December 2009

Key Environmental Permits

State siting permit (Arizona corporation commission)	approximately 12 months
Air permit non-title V (Maricopa County air quality department)	approximately 7-13 months
Aquifer protection permit (Arizona department of environmental quality)	approximately 10-16 months
Cultural resources clearance (Arizona state historic preservation office)	approximately 60-90 days
Arizona pollutant discharge elimination system (Arizona department of environmental quality)	may be required depending on storm water runoff

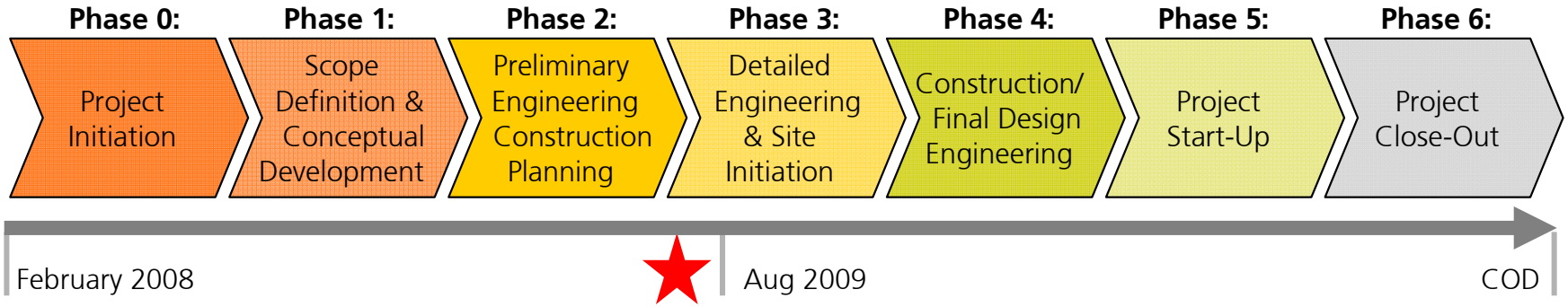
Key Project Activities & Schedule

Comprehensive plan amendment	approximately 6-9 months
Special use permit (Maricopa County planning and zoning)	approximately 8-10 months
Encroachment permit (Arizona department of transportation)	approximately 60-90 days
Temporary construction permit (Maricopa County planning and zoning)	approximately 30 days
Temporary power permit (Maricopa County planning and zoning)	approximately 30 days
Building permits (Maricopa County planning and zoning)	approximately 60-90 days
Permit to drill (Arizona department of water resources)	approximately 30 days

Major Steps to Bring a CSP Plant On-Line

- Site control, PPA negotiation, regulatory approval, interconnection agreement and financial close (some in parallel) – 12-24 months
- Permitting and engineering (in parallel) – 18 – 24 months
- Procurement and Construction (via EPC contractor) – 18 – 24 months
- Total time – 4-6 years

Overall Progress Status August 2009



- Contract award
- Program set-up
- Team selection
- Technical Studies
- Permitting start
- Reporting frameworks

- Conceptual, preliminary, and detailed engineering
- Financing
- Permitting
- Interconnection
- Site preparation
- Procurement
- Construction

- Commissioning, testing and start-up
- Systems coordination
- Project completion reports
- Commercial operation
- Ongoing compliance

Broad Support for Solana

"You can create jobs, you can put Arizona at the forefront of new technology that can be sold around the world and you can help the environment at the same time".

-Governor Janet Napolitano

WHERE TO FIND great steak + Weekend festivals to highlight Japan, Scotland, India ALL IN CALENDAR

THE ARIZONA REPUBLIC

azcentral.com THURSDAY, FEBRUARY 21, 2008

Plant to brighten state's solar future

Broad Support for Solana

stakeholder meeting and open house summary			
Date	**Venue / Location**	**Notice**	**Attendance**
March 27, 2008	phase 1 stakeholder meeting	Invitation mailer, courtesy calls	9
April 10, 2008	phase 1 open house Elks Lodge	Zip code mailing, local posters, Gila Bend Sun and AZ Republic ads	114
June 5, 2008	phase 2 stakeholder meeting	Mailer, courtesy calls	27
June 19, 2008	phase 2 open house Elks Lodge	Zip code mailing, local posters, Gila Bend Sun and AZ Republic ads	51
April 22, 2009	Solana project update Phoenix Wyndham	Mailer, Courtesy calls	25

Stakeholder Participation

- Gila Bend residents and neighbors
- Town officials
- Environmental groups
- Agencies, regulators, legislators
- Schools & universities
- County officials
- Local tribes
- Interested contractors, providers

Environmental Benefits

Annual emissions abated:

- Over 475,000 tons carbon dioxide
- 1,065 tons of nitrogen oxides
- 520 tons of sulfur dioxide

This is the equivalent to removing almost 80,000 cars from the road each year, or half the vehicles that travel on the Valley's US Highway 60 every day.

Project Benefits

- Jobs
  - 1,500 – 2,000 during construction phase
  - 85 – 100 skilled for operating
- Total Arizona benefit
  - Over $1B in direct investment
- $300M to $400M in 30-year tax revenues
- Need for U.S. manufacturing of CSP components is an AZ opportunity

Source: Work supported by the Western Governors' Association, 2007

What's in USP's Way?

- **Policies** – Stable and effective policies are essential – even the ARRA incentives very short-term
- **Cost** – "Relatively" high cost of electricity but gap is closing fast – carbon price will help
- **Transmission** – Inadequate or not available, slow and costly to build
- **Land** – Need access to good sites and each ownership type has its own challenges
- **Permitting** – Can be slow and costly
- **Environmental** – Growing concern in some places over access to the desert regions needed for USP

CSP Forecast

- **Carbon limits** are coming – will partially or totally close the cost gap
- CSP can **scale up fast** without critical bottleneck materials (we hope) making it a good response option
- **Price** for CSP power is in commercial range and **costs will come down** with increased capacity and will fall below natural gas in the next few years
- **Many technologies options** add certainty to cost reduction projections
- **US and EU R&D programs** will continue to grow in size and value
- Economic development and environmental **benefits** will drive political support
- In a very few years, the CSP market in the SW US can grow to **2-4 GW per year** and a comparable rate in the rest of the world

Conclusions

- **CSP is a Unique Renewable Technology**
  - Large resource in many countries
  - Ability to store energy to fit utility need
  - Near-term potential for cost competitiveness
- **The Market is Rapidly Developing**
  - Utilities interest in CSP is growing in many countries
  - Large credible, financially stable developers
  - Real (financeable, buildable and reliable) projects are being offered
- **Policy Decisions will Maintain Momentum**

Contact Information

Fred Morse
Senior Advisor, US Operations, Abengoa Solar
and Chairman, USP Division, SEIA

236 Massachusetts Avenue, NW, Suite 605
Washington, DC 20002
Tel: +1-202-543-6601
FredMorse@MorseAssociatesInc.com