Solar Millennium

Solar Millennium LLC

Central Solar Power Forum -

understanding the Development Potential for CSP in Arizona

Choices, Choices –
a CSP Technology Overview

Solar Millennium's 2 x 5 million sq-ft solar fields of its AndaSol Parabolic Trough Plants are in the ground in Spain:

100 MWe firm solar capacity, each with 1,020 MWh thermal storage

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The Andasol Projects

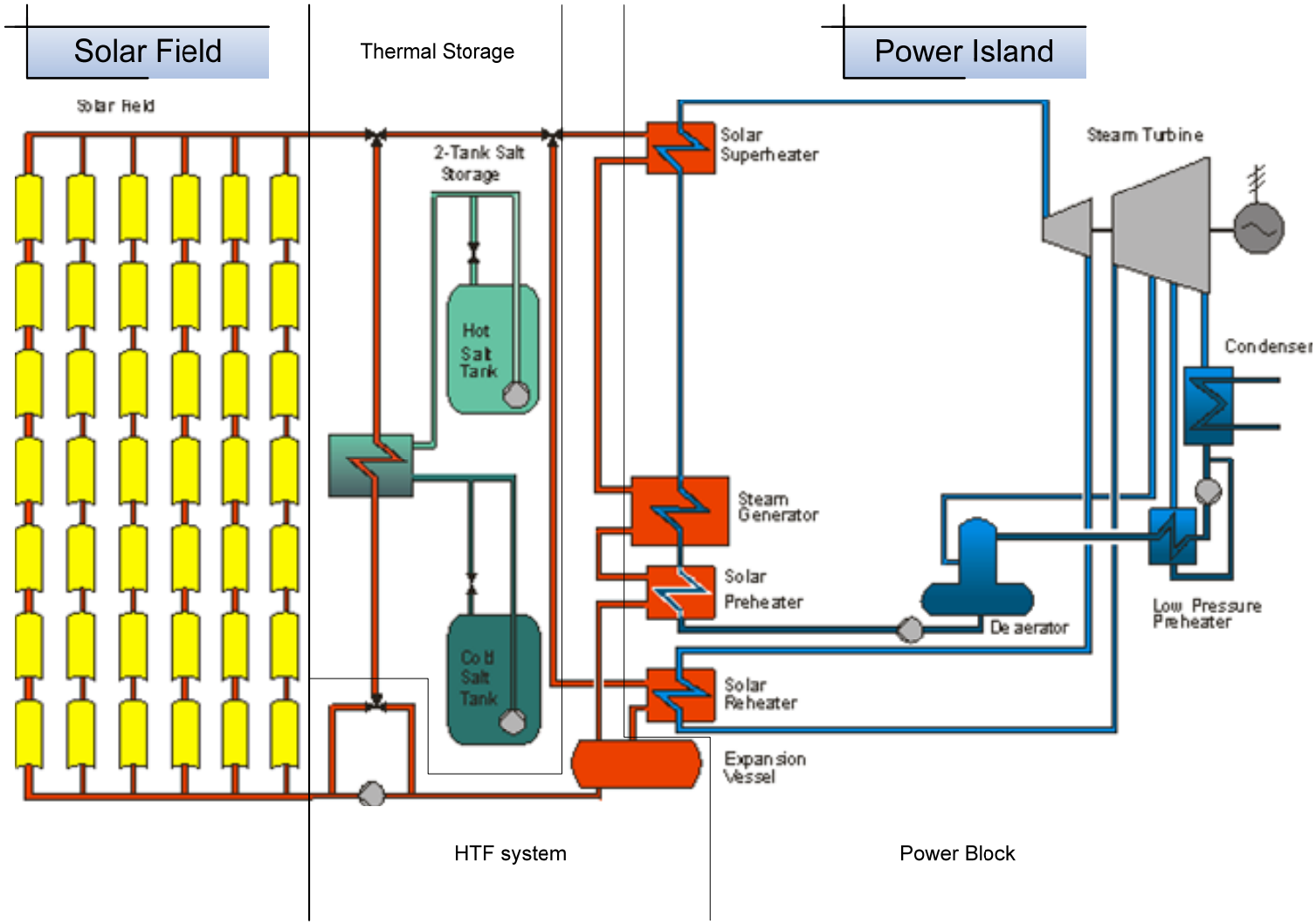
- Technology: Parabolic Trough with Solar Millennium's SKAL ET Design
- Capacity: 3 x 49.9 MWel
- Storage: Molten salt storage for 7.5 full load hours = 3,600 h/yr
- Project Site: Plateau of Guadix, Province Granada, Spain
- Net electricity production: 3 x 180 million kWh/a
- Investment: 3 x € 250 million EPC volume
- Industry/Development Partners:
  - for the first 2 plants: ACS / Cobra
  - for subsequent plants: EdP Group

AndaSol-1 & -2: The biggest CSP Plants ever built- each has 5.5 million sq –ft solar field size

Commercial Operation of AndaSol-1 is June 2008, AndaSol-2: 9 month later; AndaSol-3 a year later:

First large-scale thermal storage ever deployed commercially in CSP plants

Plant Schematic



Solar Millennium CSP Experience

SEGS I – IX Plants in the California Mojave Desert:

Solar Millennium's subsidiary company Flagsol & strategic industry partners, such as Schott, Solel & Flabeg participated in all 9 SEGS plants with an accumulated capacity of 354 MWe since 1984

Solar Millennium CSP Experience (cont'd)

- 1988: Pilkington/Flachglas subsidiary Flagsol teamed-up with LUZ for joint project development in Brazil, Morocco, India, and Italy.
- 1991: LUZ vanished
- 2002: Pilkington left business after 10 yrs w/o new projects.
- 1999: Solar Millennium entered CSP business with private investors, took over Flagsol & established strategic business alliances with EPC, financing and development partners

Solar Millennium CSP Experience (cont'd)

Solar Millennium concentrated on parabolic trough project development in Spain, particularly on regulation

- In 2002, the Spanish Real Decreto for CSP passed, further improved 2004

Solar Millennium also focused on technical Improvements

- Largest new trough system installed since 1990 (~2.3 MWt) built in full cooperation with KJC and, since 2005, FPLE in Kramer Jct., CA

Solar Millennium qualified Engineering & Construction Team (ACS-Cobra/Sener)

- Successful development (2002 – 2006) and implementation (since 2006) of the first parabolic trough power plants in Southern Spain

Solar Millennium‘s CSP Achievements

- Andasol 1: under construction since June 2006
- Andasol 2: under construction since February 07
- Andasol 3: financial closure in spring 2008

(each project with 510,000 m2 solar field 1,020 MWh thermal storage, worth € 300 million – 80% debt financed)

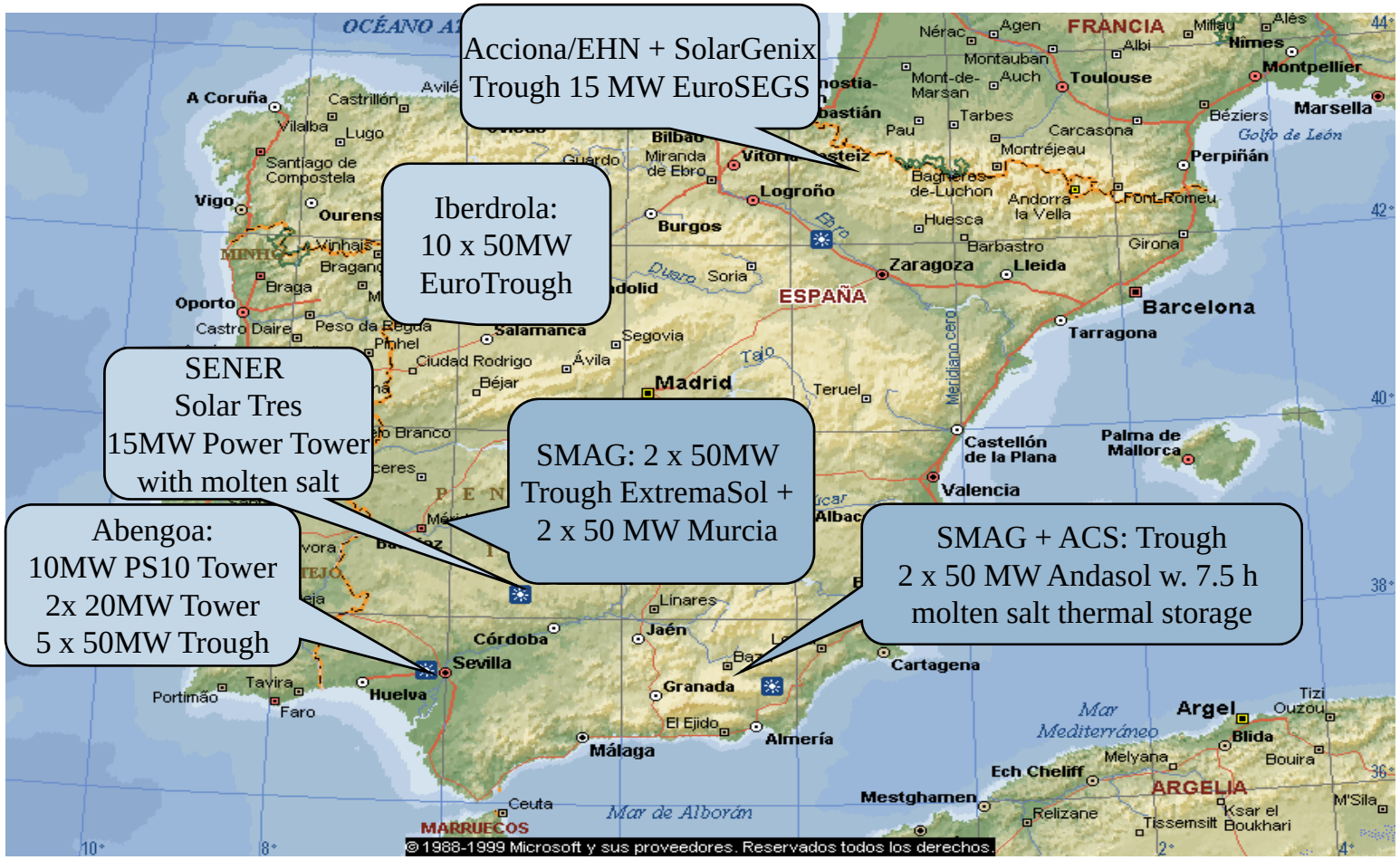
CSP Achievements (cont'd)

Partner companies:

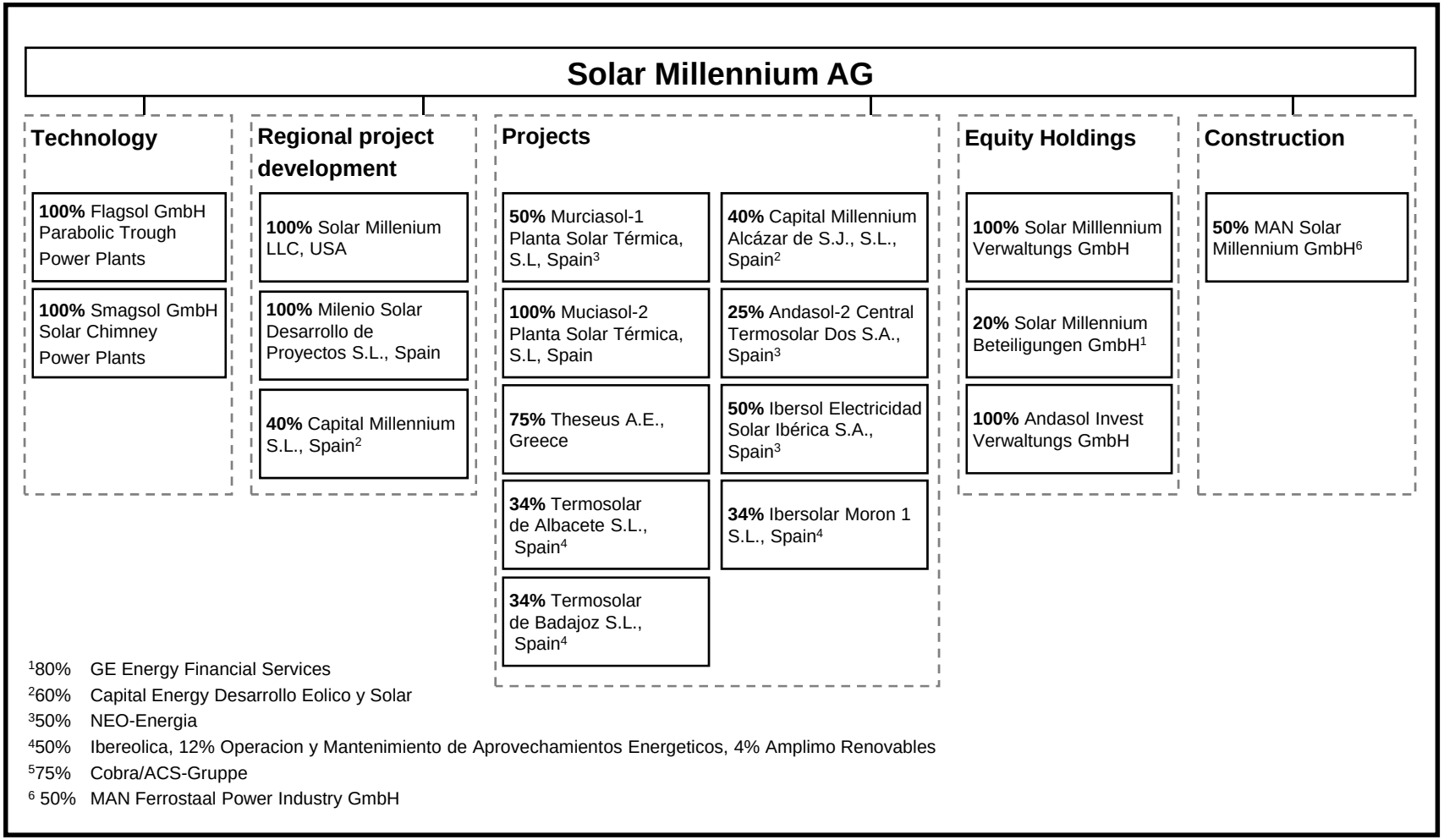
- with ACS/Cobra group: two 50 MWe plants with 1,020 MWh thermal storage under construction (equivalent to 100 MWe under CA Mojave solar radiation condition)
- with EDP group: five more 50 MW plants in Spain in advanced development stage
- Framework agreement signed with two Chinese manufacturing companies & the National Energy Ministry in China for a total of 1,000 MW

The Spanish Market

Market Pull through Feed-In Law => 800 MWe



Solar Millenium Group Structure



[1]80% GE Energy Financial Services
[2]60% Capital Energy Desarrollo Eolico y Solar
[3]50% NEO-Energia
[4]50% Ibereolica, 12% Operacion y Mantenimiento de Aprovechamientos Energeticos, 4% Amplimo Renovables
[5]75% Cobra/ACS-Gruppe
[6] 50% MAN Ferrostaal Power Industry GmbH

Demonstration loop of Flagsol

Skal-ET Collectors at KJ

- ET 1 & 2 development at Plataforma Solar de Almeria 1996-2002
- SKAL-ET demonstration loop at Kramer Junction erected in 2002-2003 with continuous commercial operation to date
- ~2.3 MWt 5,000 m2 loop exceeding last-built LS-3 performance by >10%
- Basic & detailed solar field engineering for Andasol-1 has been completed by Flagsol

North American Market

Development Strategy:

- Seeks Utility Customer Base and Quality Sites that enable large developments at each site (300 MW to 600 MW Sites)
  - Take advantage of logistics and economies of scale
  - Site infrastructure
  - Procurement Logistics
  - Utilize the Solar Field construction force for large, multi year effort
  - Maximize Efficiencies of Operation and Maintenance and Spare Parts Inventory

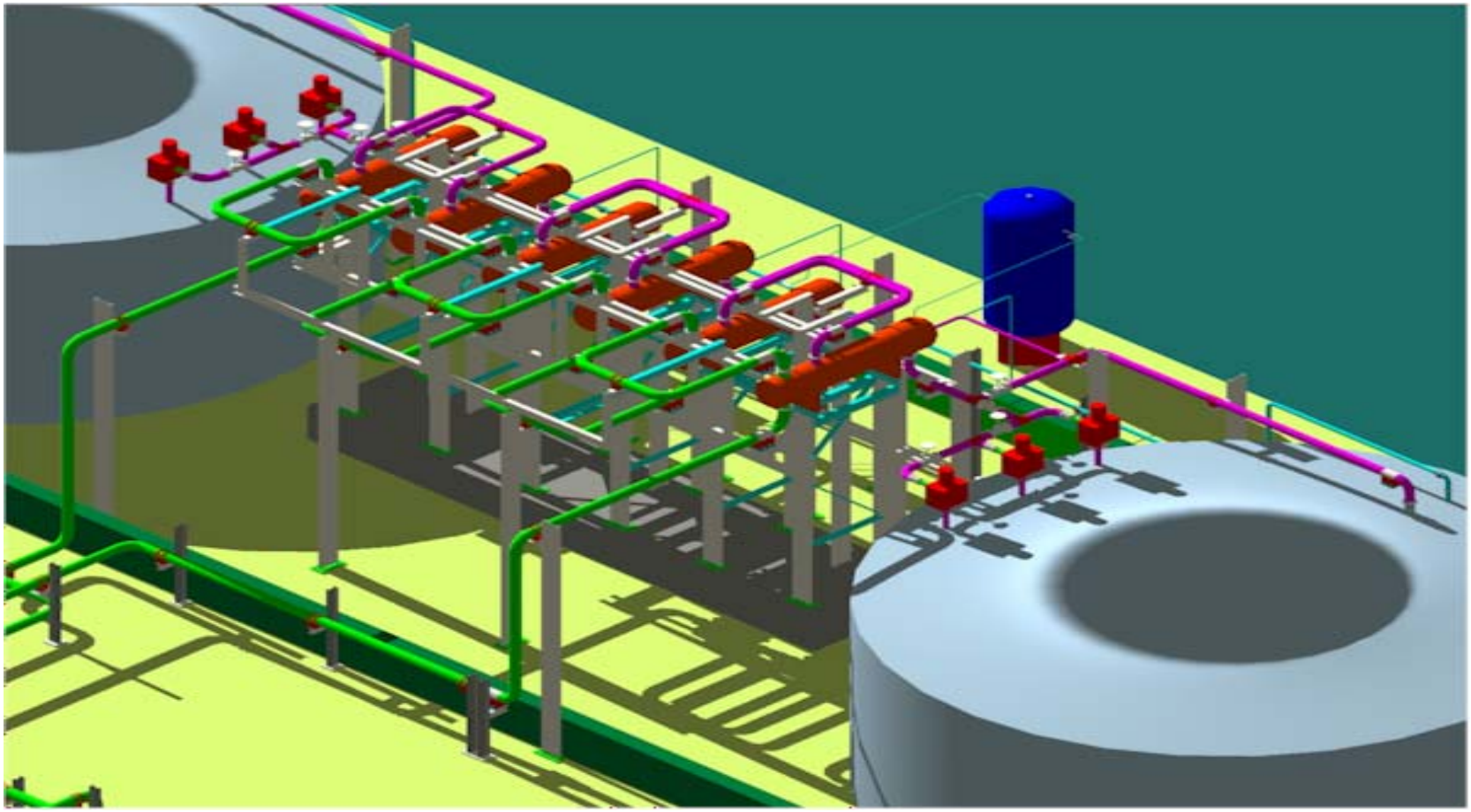
- Offers turn-key supply of solar boilers (collectors + HTF system) w. or w/o thermal storage (with full wrap-up warranty & guarantee) or complete CSP plants
- Offers and helps building-up strong EPC consortia with US partners – including formation and training of O&M companies
- Offers joint project development and ownership with US partners

SM Southwest U.S. Technology Elements

- Steam Rankine Cycle with parabolic trough solar field
- Planning focused on a “convoy” of 3 – 5 plants x 150-300 MWe plants per site
- Includes two-tank molten salt thermal storage being used and being proven in Spanish project
- Utilizes the SM / Flagsol advanced *SKAL-ET* and, from 2011 on, the NT-Pro next generation parabolic trough solar field technology

Thermal Storage System

Illustration of AndaSol-1 (1,020 MWh thermal)



Thermal Storage

Value to meet Peak Demand

- Plots below show effect of 6-hour storage for typical July daily load in PNM service territory, which presumably is similar to Arizona load
- Curves show the ability to shift generation to the peak period
- The solar field size increased, raising the annual CF to over 40%