

# 2008 Solar Annual Review Meeting

**Advanced High Temperature Trough Collector Development**

**Session: Thermal Storage**

**Company or Organization: Solar Millennium LLC/Flagsol**

**Funding Opportunity: CSP Advanced Systems Solicitation**



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# Advanced High Temperature Trough Collector Development



## Relationship to DOE Solar Program Goals

### a) Solar Multi-year Program Plan:

- *Development and expansion of next-generation parabolic trough technology for centralized power generation.*

### b) CSP Subprogram Goals:

- *Achieve a design point solar-to-electric efficiency of 25.6% and an annual solar-to-electric efficiency of 15.5%*
- *Make CSP cost competitive in the intermediate power markets by 2015 (~7¢/kWh with 6 hours of storage) and in base load power markets (~5¢/kWh with 16 hours of storage) by 2020*

### c) Joule Targets: **GOAL 1.1 ENERGY DIVERSITY:**

- *Increase our energy options and reduce dependence on oil, thereby reducing vulnerability to disruptions and increasing the flexibility of the market to meet U.S. needs.*

# Advanced High Temperature Trough Collector Development



## Project overview: Objectives

Establish the potential benefits of salt heat transfer fluid

- High operating temperature
- Low freezing temperature
- Single heat transfer and energy storage fluid



Design and demonstrate an advanced geometry parabolic trough collector, capable of operation with oil, molten salt or steam heat transfer fluid

the “NT Pro” Platform

Reduce Parabolic Trough Solar Field Costs and Improve Performance

Demonstrate low freezing temperature salt HTF at a pre-commercial scale

# Advanced High Temperature Trough Collector Development



AndaSol 1 SkaLET Collector (10% improvement over LS3)

NT Pro Collector  
22% Improvement Goal  
compared to current  
technology

- *reduction of the specific collector investment costs (costs per aperture area)*
- *reduction of assembly costs by advanced assembly concepts*
- *Improve the optical performance of the collector*
- *Further gains on overall plant economics with salt HTF*

# Molten Salt Heat Transfer Fluid

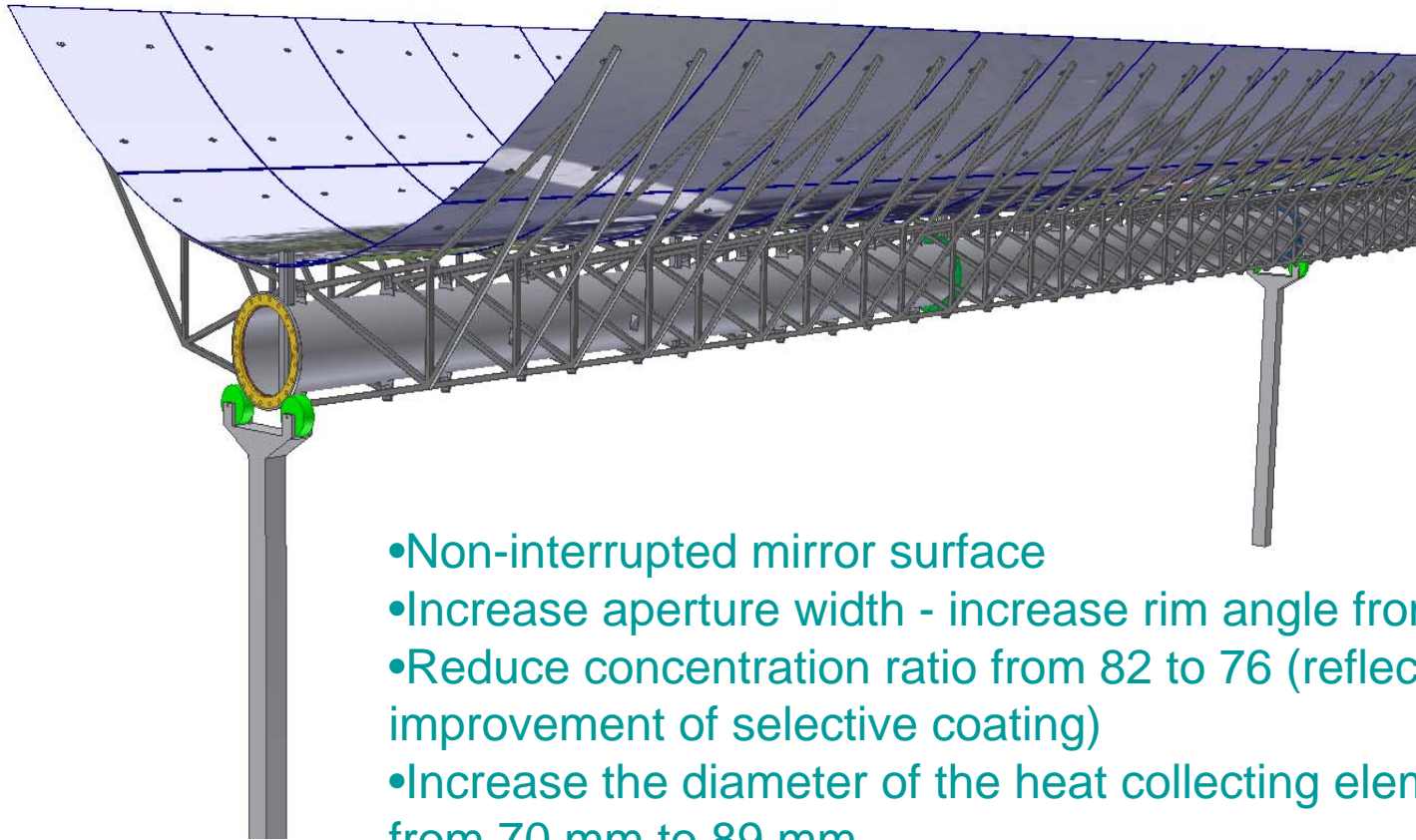


Andasol-1 & 2 plants in Spain: 1,020 MWh, 7.5 full load hrs, 31,000 tons of molten salt

- Solar Millennium has been investigating advanced HTF fluids for several years.
- Patent application for a multinary salt based on nitrates/nitrides
  - low degradation up to 500 °C (932 °F)
  - freezing point below 100 °C (212 °F).
  - low cost
  - easy to handle, non-toxic and non-flammable.



# NTPro Collector



- Non-interrupted mirror surface
- Increase aperture width - increase rim angle from  $80^\circ$  to  $89^\circ$
- Reduce concentration ratio from 82 to 76 (reflects improvement of selective coating)
- Increase the diameter of the heat collecting element (HCE) from 70 mm to 89 mm.
- Reduce pressure drop through collector

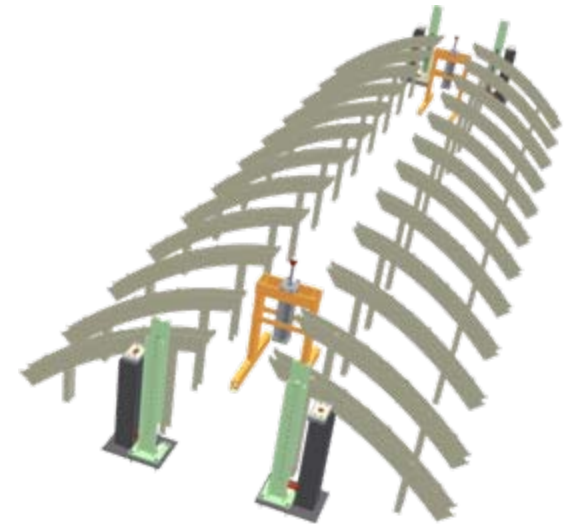
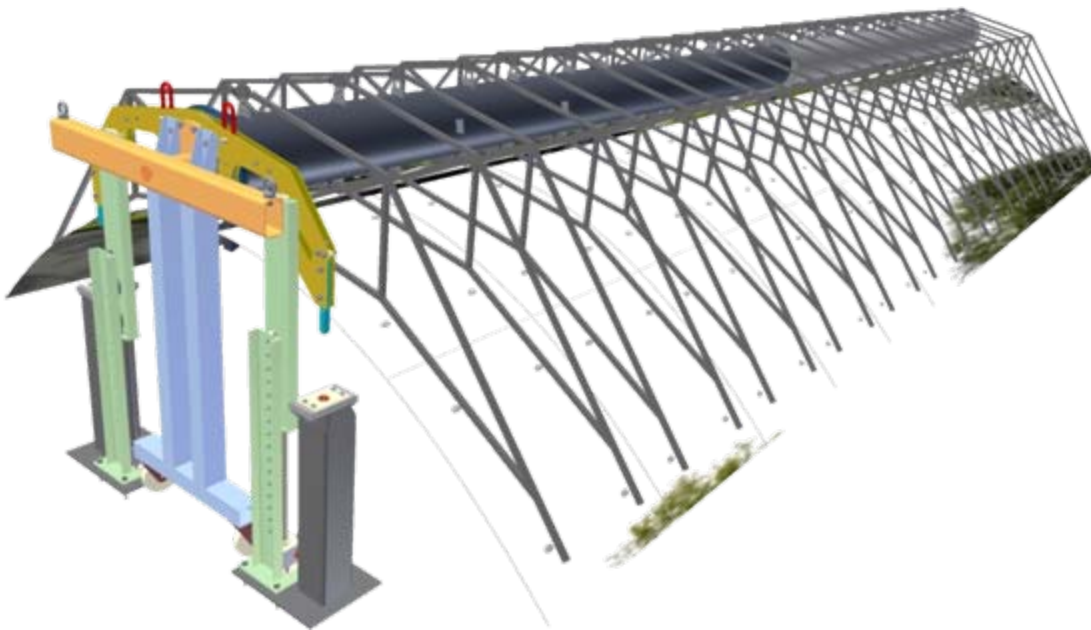


# Advanced High Temperature Trough Collector Development

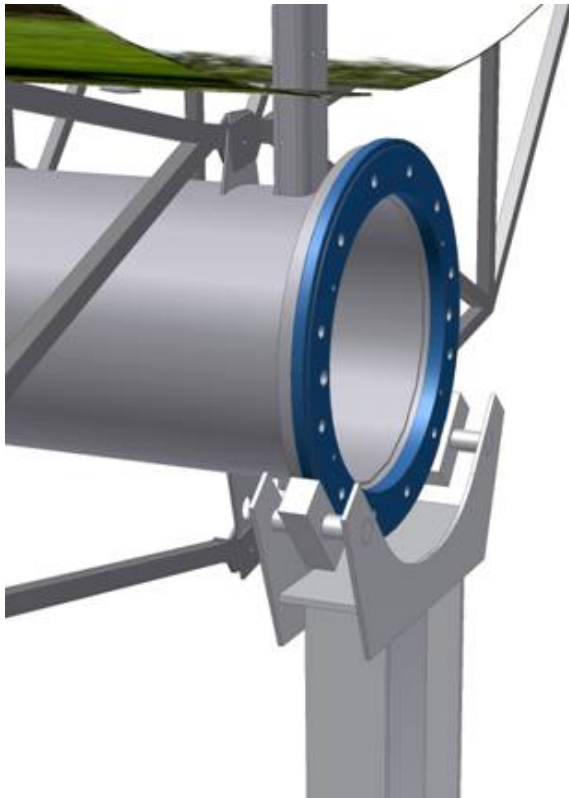


## New assembly concept

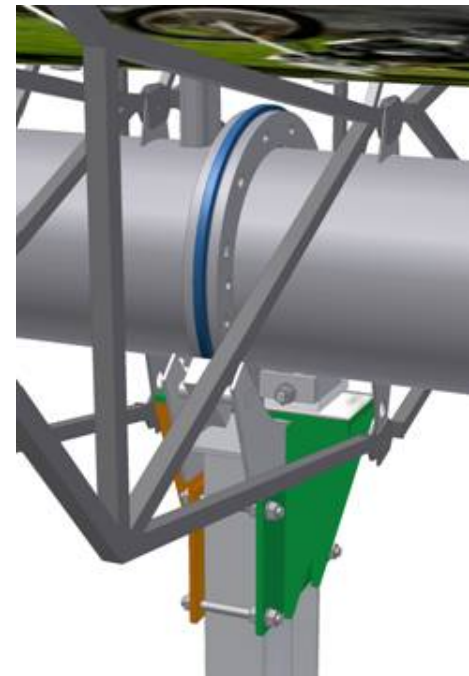
- Reduced field labor requirements
- Increase length of a solar collecting element (SCE) from 12 m to 19 m;
- Increase length of the HCE to 4.722 m (4 HCE's per SCE)



# Assembly of two Solar Collector Elements using bearing flanges



Increase the total length  
of one solar collector  
assembly from 148 m  
to 192 m.





# Advanced High Temperature Trough Collector Development



## Major FY08 Activities

- Investigate the benefits and issues associated with use of molten salt as the HTF in parabolic trough power plants
  - *Conceptual design of molten salt systems*
  - *Operation strategy for molten salt systems*
  - *Investigate the thermodynamics of the high temperature cycle*
  - *Identification of new components*
  - *Cost, performance and economic analysis (salt vs. oil plants)*
  - *Risk analysis*

# Advanced High Temperature Trough Collector Development



## Major FY08 Activities

- Complete design and construction of the NTPro VP1 Demonstration Loop at Kramer Junction



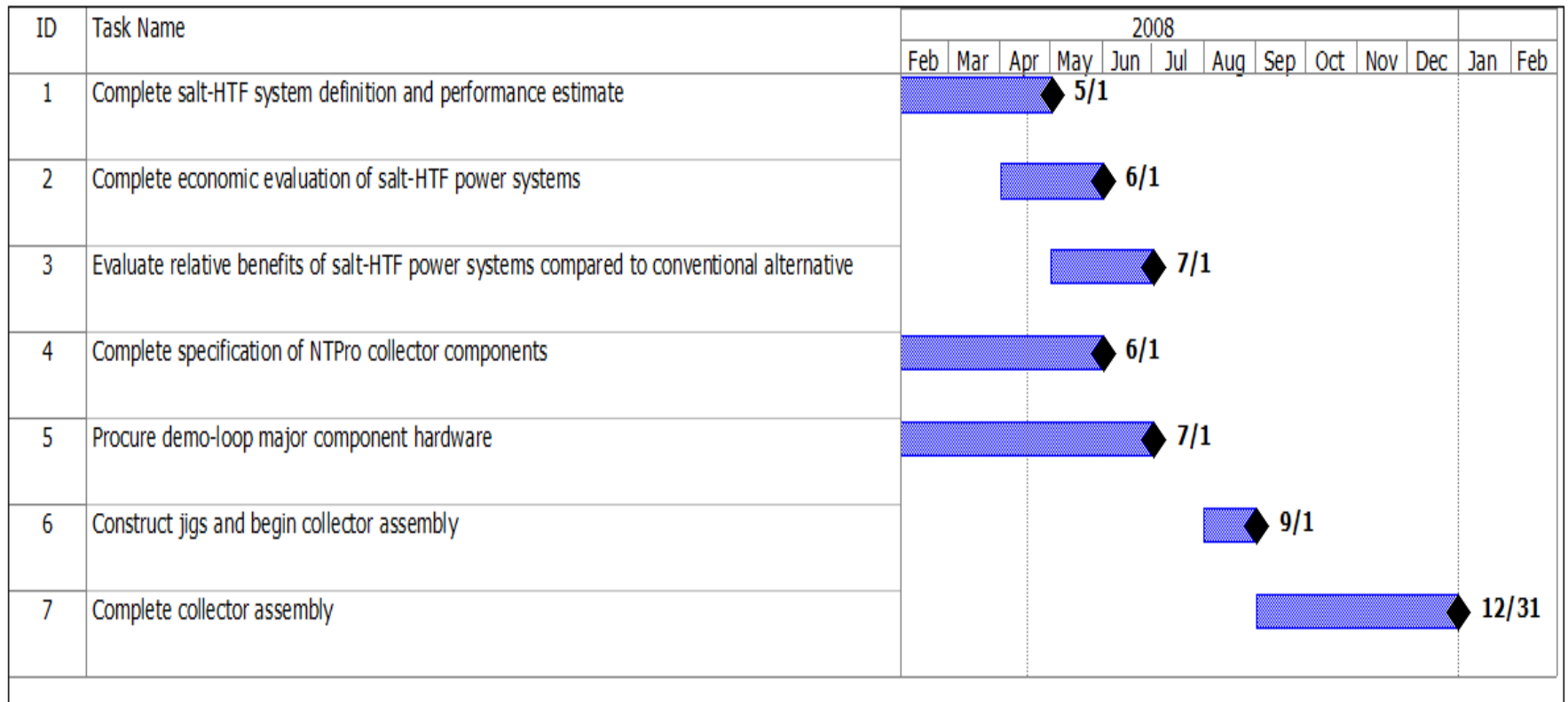
SkaIET Demo Loop – Kramer Junction 2003

*Specify and procure components*

*In collaboration with FPLE,  
construct the demonstration loop  
within the SEGS V solar field, with  
complete thermal integration.*

# Advanced High Temperature Trough Collector

## Development: Schedule/Milestones - 2008



# Advanced High Temperature Trough Collector Development



## Project Budget - 2008

	Total Cost	Solar Millennium Cost Share
Phase 1 Salt Systems Analysis	\$437,500	\$87,500
Phase 2 Design, Procurement and Construction – Kramer Demo Loop	\$2,000,000	1,258,000
Total Project Costs (Through 2011)	\$5,920,000	\$2,608,000

# Advanced High Temperature Trough Collector Development



## Key Project Personnel - 2008

Ray Dracker	Project Director
Klaus-Jürgen Riffelmann	Project Engineer
Andras Nady	Sr. Process Engineer
Nils Gathmann	Sr. Engineer – Salt Technology
Jake McKee	Construction Engineer
Jens Kötter	Engineering and Procurement
Shujia Ma	Financial Analyst
Paul Nava	Engineering and Construction Supervision
Bruce Kelly (Nexant)	Salt Systems and Components
Babul Patel (Nexant)	Systems Engineering

# FY08 Progress Report



## Accomplishments to-date

- a) NT Pro Collector Design Completed
- b) Advanced Nitrate Salt HTF Patent Pending
- c) Long Lead Time Components for Kramer Junction Demonstration Loop Specified and Ordered
- d) Advanced geometry HCE for both VP1 and Salt has been defined in conjunction with Schott



# Advanced High Temperature Trough Collector Development



## Anticipated accomplished in the 3rd and 4th Quarters

- Completion of the Advanced Salt HTF Solar Field Cost and Performance Assessment
- Complete NTPro VP1 collector procurement and assembly in collaboration with FPLE at Kramer Junction Power Plant



# Future Activities

## 1. FY09 Planned Activities

- a) Complete checkout and commissioning of the VP1 NTPro Demonstration Loop at Kramer Junction
- b) Conduct detailed performance tests on the VP1 NTPro Demonstration Loop
- c) Prepare detailed designs for the modifications required to operate the demo loop with salt HTF
- d) Specify and order long lead time salt components (Heat collection elements, heat exchangers)

**Milestone:** *Verify optical and thermodynamic performance projections of the advanced geometry collector*

# Future Activities



## FY '10

- Commissioning of the Salt HTF loop
- Test of operating strategy, filling, evacuation
- Optimization of heat tracing system

## and Beyond

- DSG and Salt HTF Subfields at AndaSol 3