GO18037:Development of Next-Generation Parabolic Trough Collectors and Components for CSP Applications

Concentrating Solar Power (CSP)

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Overview

Timeline

- Phase 1: Mar ’08 - June ‘10
- Phase 2: July ’10 - July ‘11
- Continuation granted: Nov ’09, 20% Phase 2 work complete on ASI “at-risk” funding

Budget

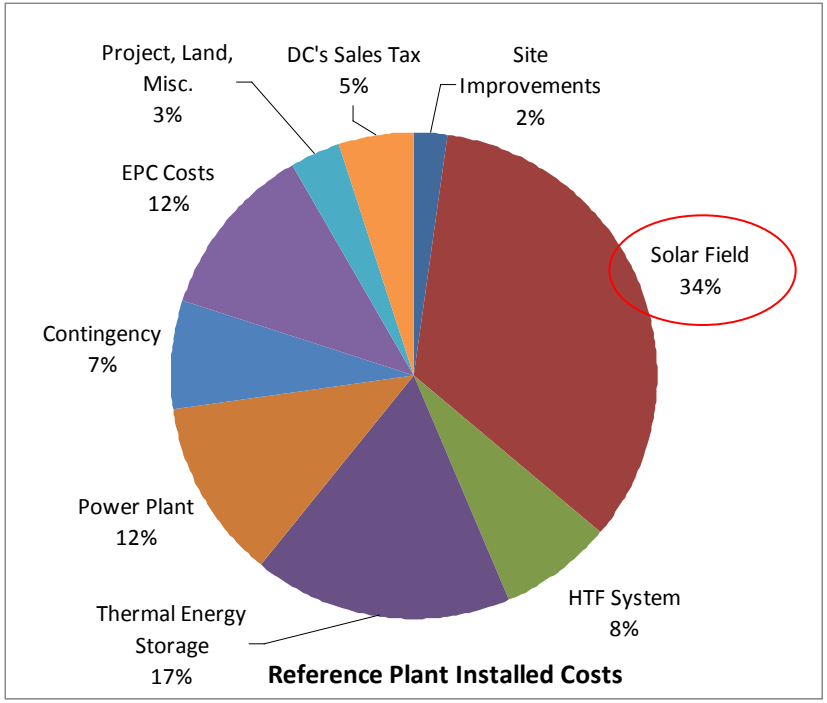
- Total: $4.05M (Phases 1 & 2)
  - DOE share : $3.25M (80%)
- DOE Funding FY09: $700k
- DOE Funding FY10: $1.73M

Barriers

- CSP trough power is ~19¢/kWh (real, 10% ITC), must be reduced ~50% to compete in US intermediate power market (source: NREL/DOE)
- Solar field represents largest single contributor to both capital cost & performance
- Development of robust US-based CSP trough industry

Challenges, Barriers or Problems

- Solar field constitutes majority share of baseline CSP trough plant *(source: NREL/Worley-Parsons 2009 study of CSP Trough Costs)*
- Major role in driving performance of BOP



Challenges

- **Cost must be reduced**
  - concentrator, key components, labor, O&M
- **Efficiency can be increased**
- **Must optimize SCA for next-generation plant technologies**

Project Objectives

- **Short-term:** to reduce the cost of collector technologies that could be deployed in the first US CSP plants in the 2010 – 2013 time frames.
- **Medium-term:** to employ innovative approaches to developing the next generation of lower-cost parabolic trough technologies that can compete on an equal footing with conventional power generation.

Key Efforts

- Analysis of **sys. requirements & metrics**, testing to **validate assumptions**
- **Developing innovative aluminum space-frame collector** (near-term)
- Developing **alternative collector structures & components** (medium-term)

Summary of Approach

- Quantitative assessment of system requirements & cost opportunities
  - Rigorous analysis and prototyping to validate assumptions
- Near-term: assess existing state-of-the-art designs and improve
- Mid-term: re-optimize system and enhance/innovate in key areas

Technical Approach

- Benchmarking
  - Define / redefine system requirements, metrics & test methodology
  - Assess near-term designs and opportunities
- Systems Analysis & Testing
  - Optical, FEA, and thermal modeling of collector
  - Prototype testing (collector, full-loop) to validate assumptions & analysis
- New Concept Development
  - System re-optimization
  - New designs & techniques for key components

Accomplishments / Progress / Results

- Assessed LCOE impact for 3 state-of-the-art collector candidates, identifying best design elements and improvement opportunities (Phase 1 outcome)

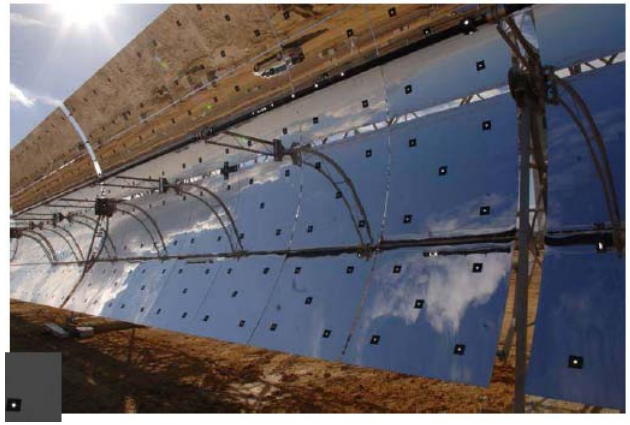
Near-term opportunities identified

- Design simplification
- Competition on key parts
- Construction best-practices
- Novel design elements

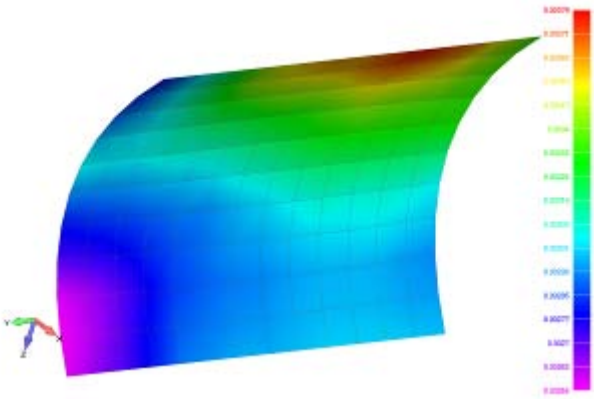
Mid-term opportunities identified

- Collector geometry, concentration
- Non-glass mirrors
- New structures / structural reflectors
- Design & operating strategies
- Industrialize assy & construction

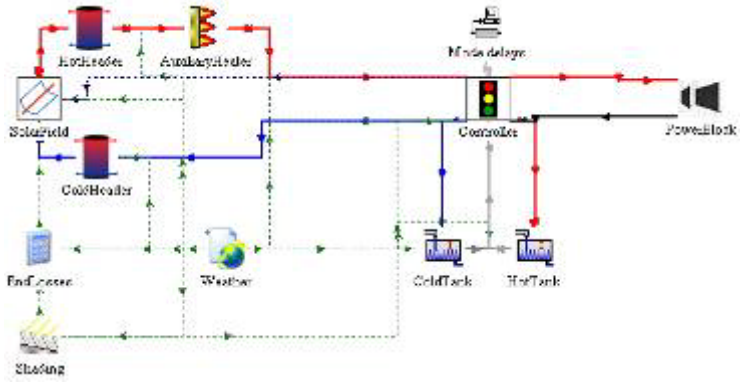
Tools



Optics – VSHOT, photogrammetry, laser radar CMM, thermal testing



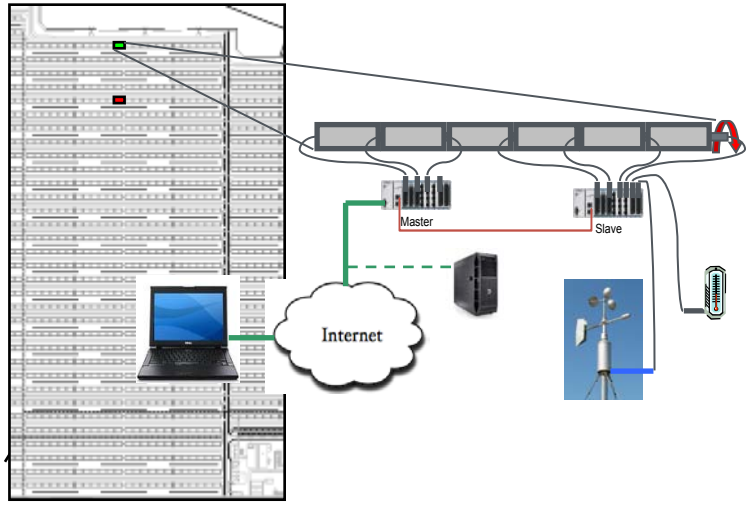
Structural – NASTRAN FEA, wind simulation, static load testing



Performance / LCOE– ray-tracing, transient performance simulation, parametric optimization, detailed cost modeling

Testing

Lakewood Test Site – 2 mini-collectors (phase 1 now complete)



Full-Scale Field Wind Testing (planning stage)

SolarTAC – 2-SCA Loop (phase 1 construction Q2-Q3 2010)

Other significant planned testing

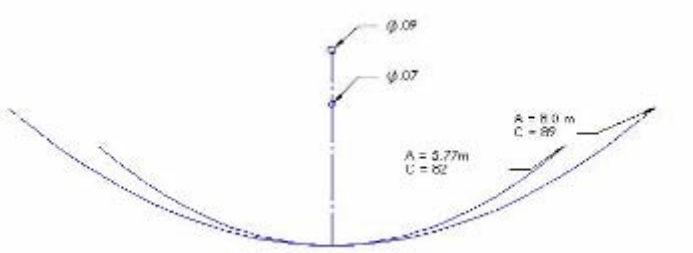
- NREL 2-axis tracker
- Laser radar dimensional characterization
- Structural testing & characterization
- Cameo demonstration project

Advanced Aluminum Space Frame Collector

- R&D prototypes (2nd Gen) demonstrating strong potential, now developing pre-commercial (3rd Gen) design
- 10-20% reduction of module cost (vs competitive 12m advanced designs - steel & alum) based on mechanical simplification, reduced assembly labor
- Increased torsional stiffness, reducing tracking losses (now quantifying)

Advanced Concepts

- New collector geometries, structures
- Integration of non-glass reflectors
- New construction & operating strategies
- Optimize for advanced plant technologies (HTF, TES, hybridization)



Example of aperture scale-up from 5.77m to 8m, 80° rim angle

Early prototype of non-glass mirror facet

- Phase I: Identified design opportunities to reduce SCA cost 20-30%, increase thermal performance
- Phase 2: Metrics-based analysis and down-selection of concepts, prototype & test advanced concentrator module Q1-Q2 2011

Collaborations

Subcontracts

- Labor review by Arizona State University School of Construction Management (Phase 1)
- Martin/Martin Consulting Engineers (Lakewood, CO) for foundation assessment and optimization (Phase 1)

Internal collaborations

- Molten Salt / TES awards – leveraging performance modeling tools
- Reflective film award – collaborating on advanced reflector integration
- Spanish projects (~200MW troughs) – leveraging cost & operating data
- Internal project engineering team (Solana, Mojave) – leveraging US cost and construction planning data

NREL: FOA support, technical oversight

SANDIA: FOA support (limited to-date), technical oversight

Timeline, Milestones, and Next Steps

Decisionmaking Strategy

- ASI New Technologies implementing Stage-Gate system to guide R&D decision-making
- Phase 1 metrics will form basis for decision criteria

PHASE 1: Mar 2008 – Jun 2010
Evaluate existing designs, identify improvements

8/08 Metric definition & near-term collector assessment

7/09 Testing of Gen 1 adv. aluminum frame

11/09 Phase 2 continuation approved

1/10 Testing of Gen 2 adv. aluminum frame

PHASE 2: Jul 2010 – Jun 2011
Develop and test improved collectors

9/10 Testing of Gen 3 adv. aluminum frame

Q4/2010 Complete test sites and begin thermal efficiency, field wind load testing

3/11 – 6/11 Build & test mid-term module prototype

PHASE 3: Jul 2011 – Dec 2012
Scale-up, demonstrate new technology

Budget Status and Potential for Expansion

- Phase 1 budget $696k – SOPO work completed within budget
  - $211k extension funding (transferred from Phase 2) during negotiation

- Phase 2 expansion approved based on increase in anticipated engineering & construction costs

Budget	DOE Share	Cost Share	Total	Cost Share
Original	$2,668,770	$667,193	$3,335,963	20%
Updated	~~$3,562,975~~	$890,744	$4,453,719	20%
Increase in Budget	$894,205	$223,614	$1,117,755	

- Phase 3 (18mos) total budget anticipated $8.9M (at 50% cost share)

- <u>Expansion efforts, if funding was added</u>
  - Increase depth of advanced collector exploration
  - Further study of field wind loads, construction industrialization
  - Expand SolarTAC to full loop (4 collectors)

Mandatory Summary Slide

Key Points

- Cost reduction approach must be methodical, quantitative, and based on real cost & performance benchmarks
- Current industry designs do not necessarily represent optimum points
- Better definition of system requirements, combined with radical design approaches and rigorous evaluation measures is required
- Integrated with advanced CSP systems (HTF, TES, power cycle) is critical to mid-term cost reduction
- ASI is developing near-term advancement on state-of-the-art and is pursuing several promising mid-term opportunities