SkyFuel™

The Sunrise Of Solar Power™

# DOE CSP Program Award Review

## DEVELOPMENT OF A HIGH-CONCENTRATION LOW-COST PARABOLIC TROUGH SYSTEM FOR BASELOAD CSP GENERATION

May 2011

# Presentation Outline

- Contract Requirements
- Development, Scope, and Objectives
- Reduced Cost
- Improved Performance
- Higher Temperature
- Path Forward
- Conclusions

# Requirements

- AB Trough funded by DOE Solar Energy Technologies Program (SETP) grant
  - Grant Requirements:
    - A CSP Plant in 2020 must:
      - **Generate power with Levelized Cost of Electricity (LCOE) ≤ $.09/kWh-e**
      - **Plant Capacity Factor ≥ 75%**
        - The capacity factor is the ratio of the system's predicted electrical output in the first year of operation to the output had the system operated at its nameplate capacity continuously for that year

# Development

- Project is divided into 3 phases
  - Phase I. Subsystem Designs based on cost and performance optimization.
    - Start date: November, 2010
      - » Performance and cost modeling
      - » Component development
      - » Manufacturing and Assembly, conceptual
  - Phase II. Detailed design and component testing.
  - Phase III. Manufacturing, Deployment, and Testing of a full scale Solar Collector Assembly

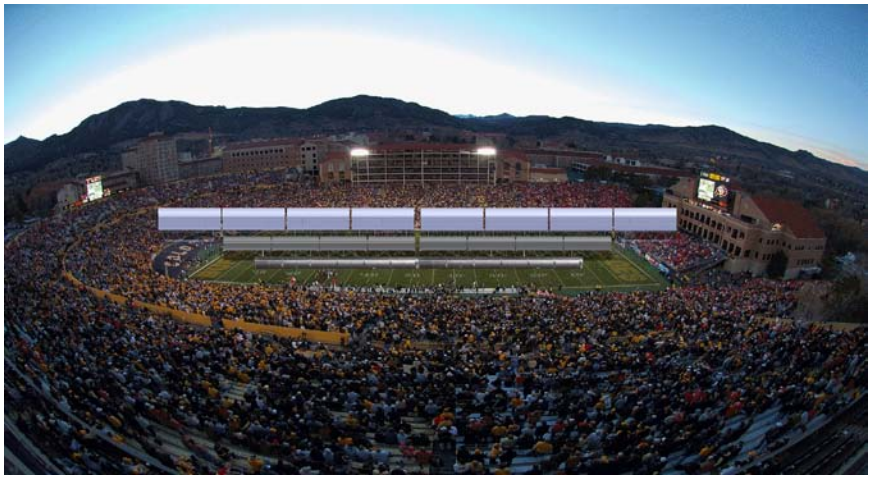
# Scope

- Focus on the parabolic trough concentrator (highest cost component)
  - Reduced cost
  - Improved performance
  - High temperature operation – 500 C or above
- Complement on-going DOE research by others
  - Thermal Energy Storage
  - High Temperature Heat Transfer Fluids

# Reduced cost

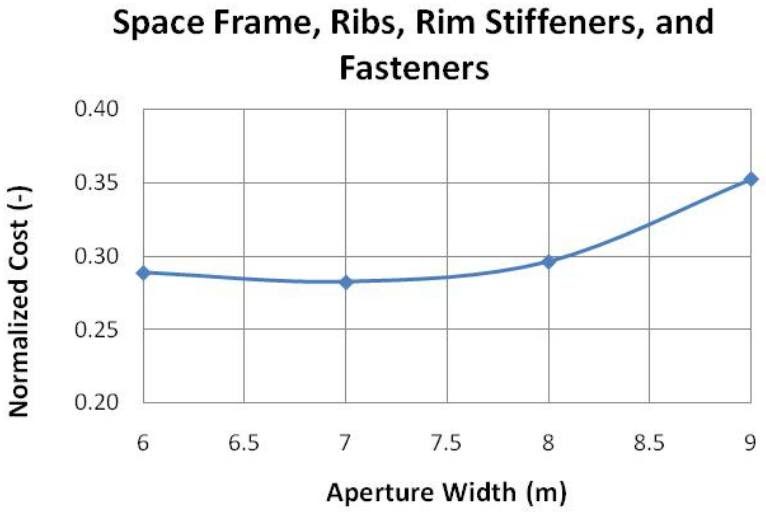
- Increase aperture
  - Proposed by others (Kolb, Diver[1])
  - Industry trend
- Reduced cost - Conceptual
  - Decrease component count
  - Increase component size
  - Lower specific cost ($/m$^2$)

In order of increasing size: LS2, SkyTrough, AB Trough as proposed



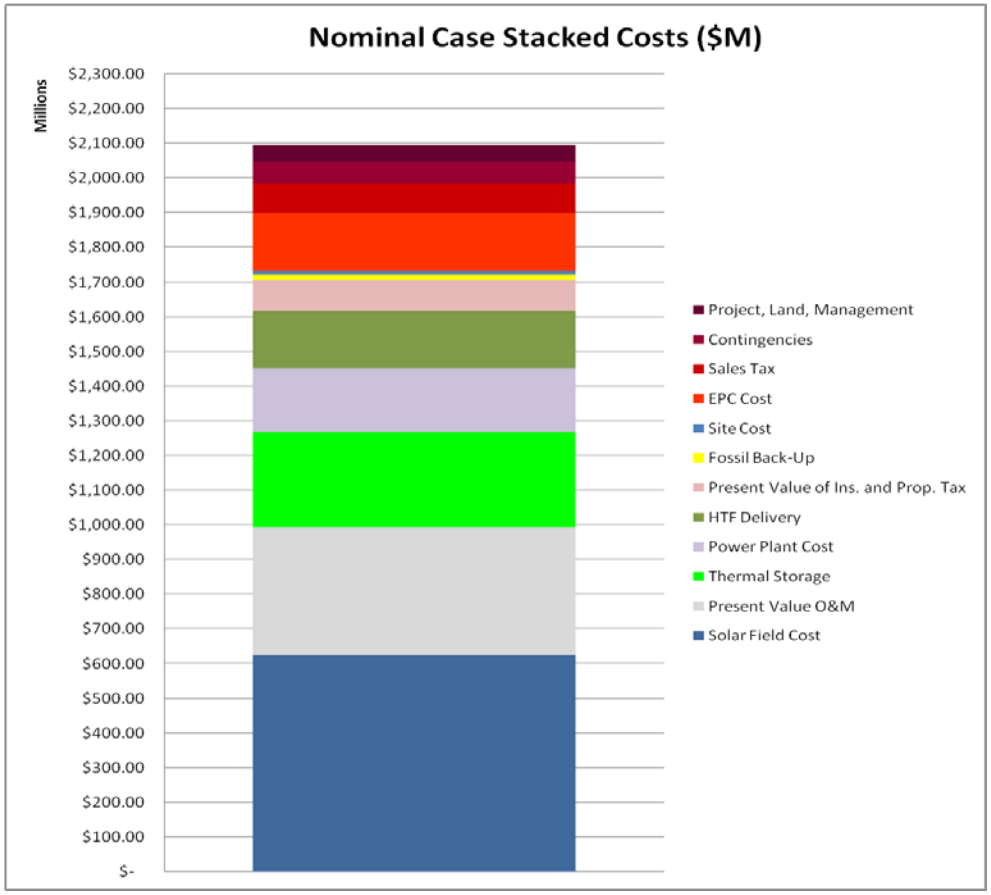
[1] Conceptual Design of an Advanced Trough Utilizing a Molten Salt Working Fluid, Greg Kolb and Richard Diver, Sandia National Laboratories.

- At large aperture widths (>7.5m)
  - Component specific costs increase faster than aperture width
- Pitching moment proportional to (aperture width)$^2$
  - Design loads are pitching moments



# Reduced Cost

- Design to Cost Basis
  - LCOE<$90/MWhr$_e$ , 75% capacity
  - SAM[1] for annual performance
  - DOE template for components outside of our scope, except
    - EPC profit / wrap reduced
    - AZ v. CA field labor rates
- $190/m$^2$ allowable installed cost




[1] "SAM DOE 2010 Parabolic Trough Cost Model" Retrieved from https://www.nrel.gov/analysis/sam/templates.html.

# Improved Performance Goals

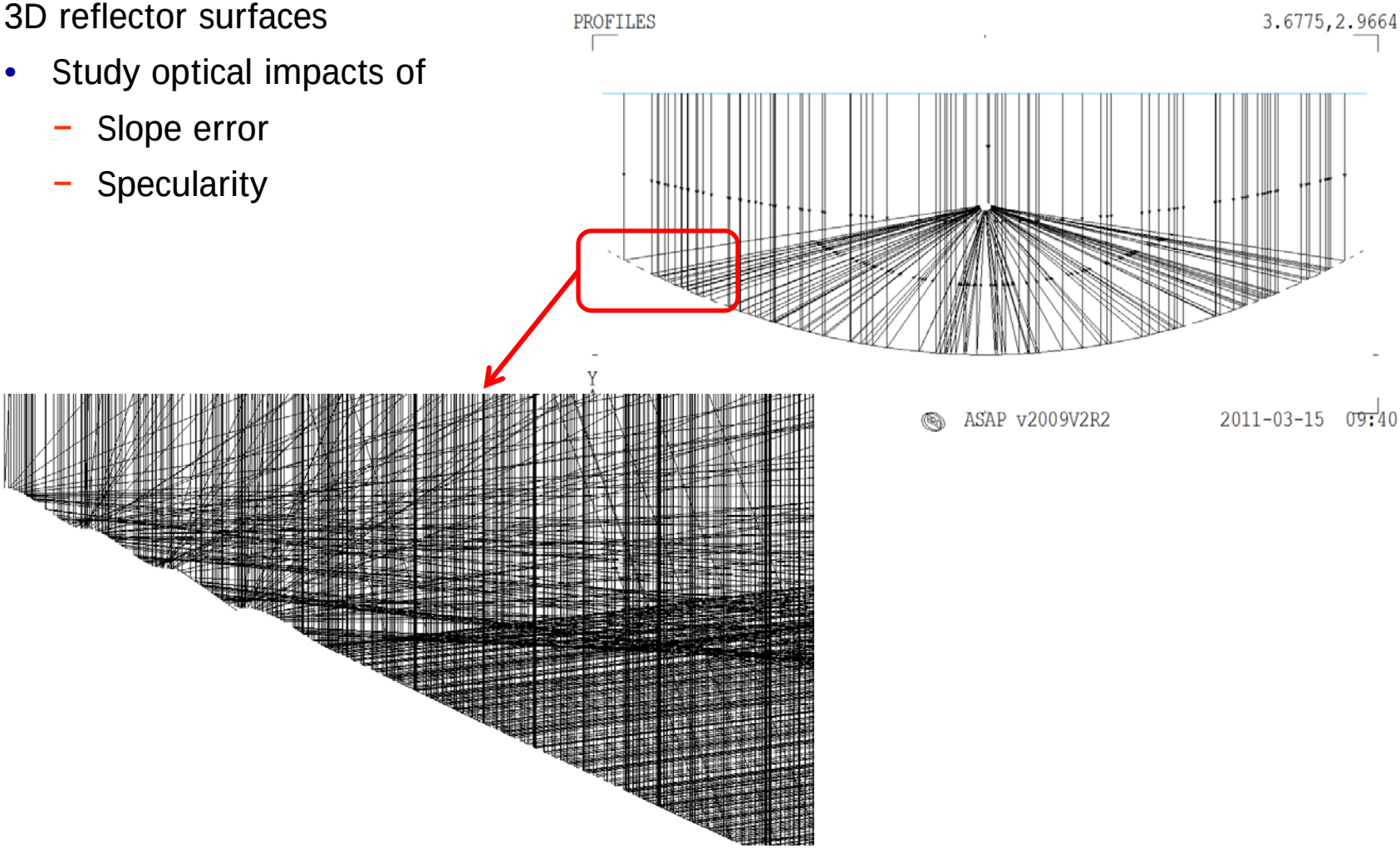
- Higher Concentration Ratio (CR)
  - Reduce receiver thermal losses
  - Secondary: lower specific cost, receiver
- Mechanical precision
  - Slope error (contour accuracy)
  - Load induced twist (frame stiffness)
  - Receiver location error (frame stiffness)
  - Secondary: higher specific cost

7m, 8m, and 9m mirror panels – contour measurements

- Optical power and precision (ReflecTech)
  - Increased reflectance
  - Improved specularity
  - Secondary: lower specific cost, mirror

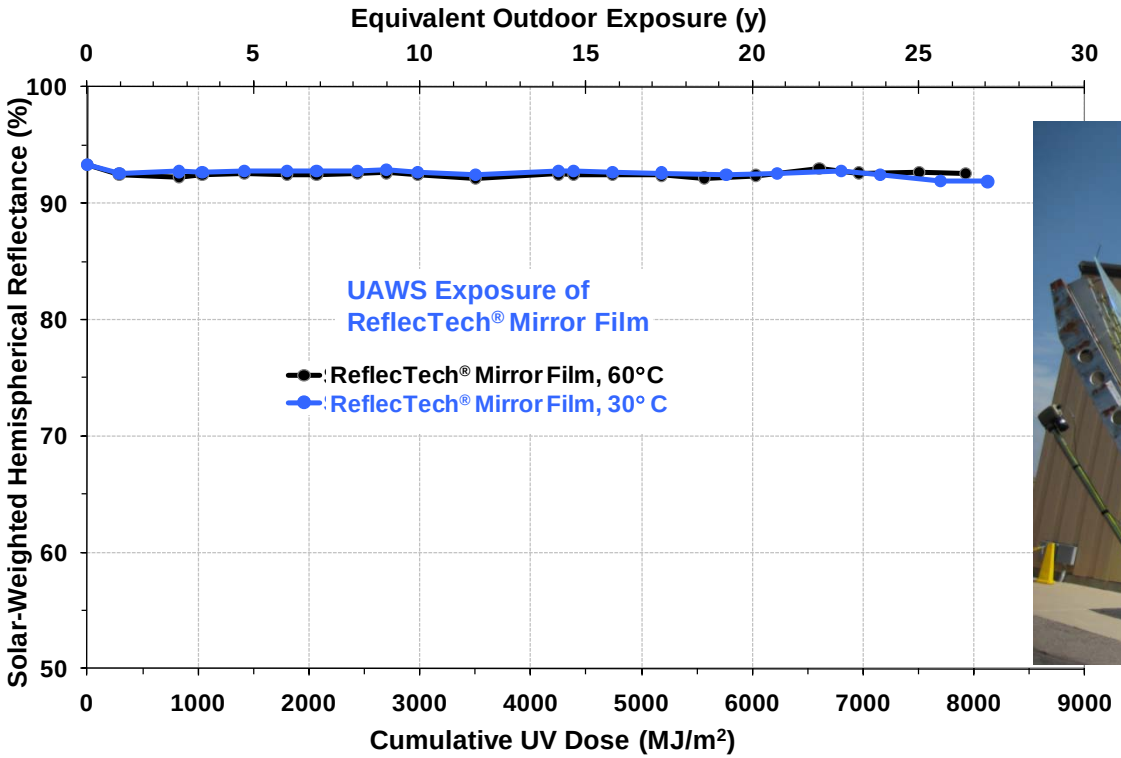
# Improved Performance Evaluation

- Using ASAP (Advanced Systems Analysis Program) to model optical system
- Developed ASAP code that uses empirical slope error data to make 2D and 3D reflector surfaces
  - Study optical impacts of
    - Slope error
    - Specularity

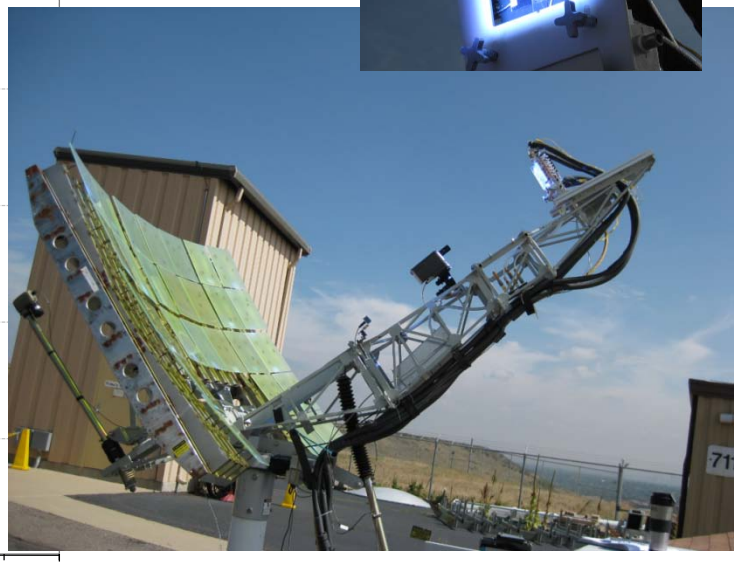


# ReflecTech® Mirror Film

- ReflecTech® Mirror Film recently surpassed the 25 year mark demonstrating durability against ultraviolet (UV) radiation using the Ultra-Accelerated Weathering System (UAWS) at NREL.

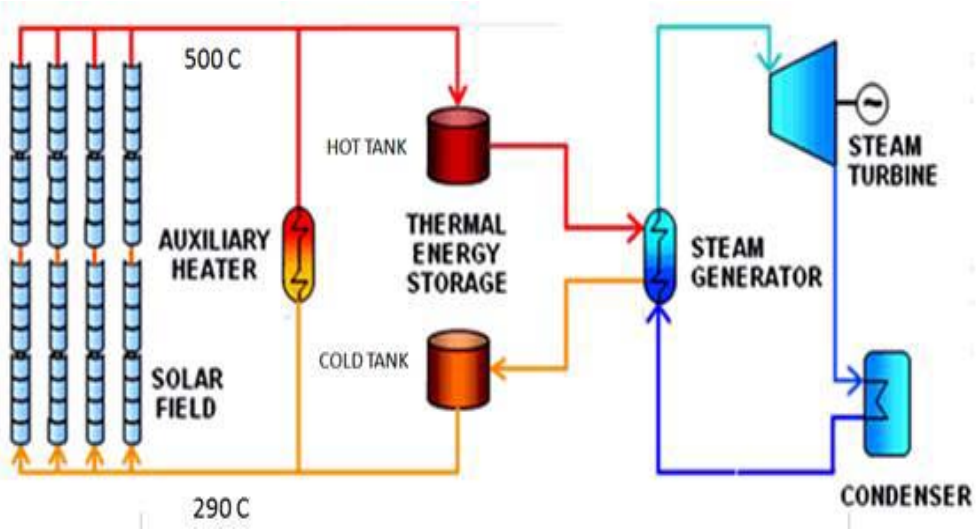



ReflecTech®
samples on sun @
30° & 60°C



100 X Concentration
50-60 X UV Exposure Dose

# Increased Temperature




- Objective of increased temperature: reduce thermal storage cost
  - High capacity factor demands storage
  - Storage mass, cost inversely proportional to collector field temperature difference
  - Aside: Collector field performance degrades with higher temperature
  - Aside: HTF delivery system costs increase with higher temperature

# Preliminary Conclusions

- The optimum collector aperture width is 20-35% larger than current state-of-the-art
  - Moment loads increase with aperture width squared
  - Component specific costs are driven by moment load
    - Costs increase faster than aperture

- Concentration Ratios larger than the current state-of-the art anticipated
  - Receiver cost and performance leading to 90mm receiver selection
  - Current estimates for frame stiffness, and contour accuracy support geometric concentrations higher than 85/pi

# Future Work Planned

- Define relationship between collector length and cost
  - Mirror module
  - SCA level
- Receiver diameter / length selection
- Performance enhancements to ReflecTech
- Specifications
- Component designs
- Manufacturing and Assembly, conceptual

- Phase II. Detailed design and component testing.
- Phase III. Manufacturing, Deployment, and Testing of a full scale Solar Collector Assembly