# 2008 Solar Annual Review Meeting

**Session: Thermal Storage**
**Company: Hamilton Sundstrand - Rocketdyne**
**Funding Opportunity: Concentrating Solar Power**
**Molten Salt Pump – Thermal Storage**
**Central Receiver Panel - Advanced CSP Concepts**

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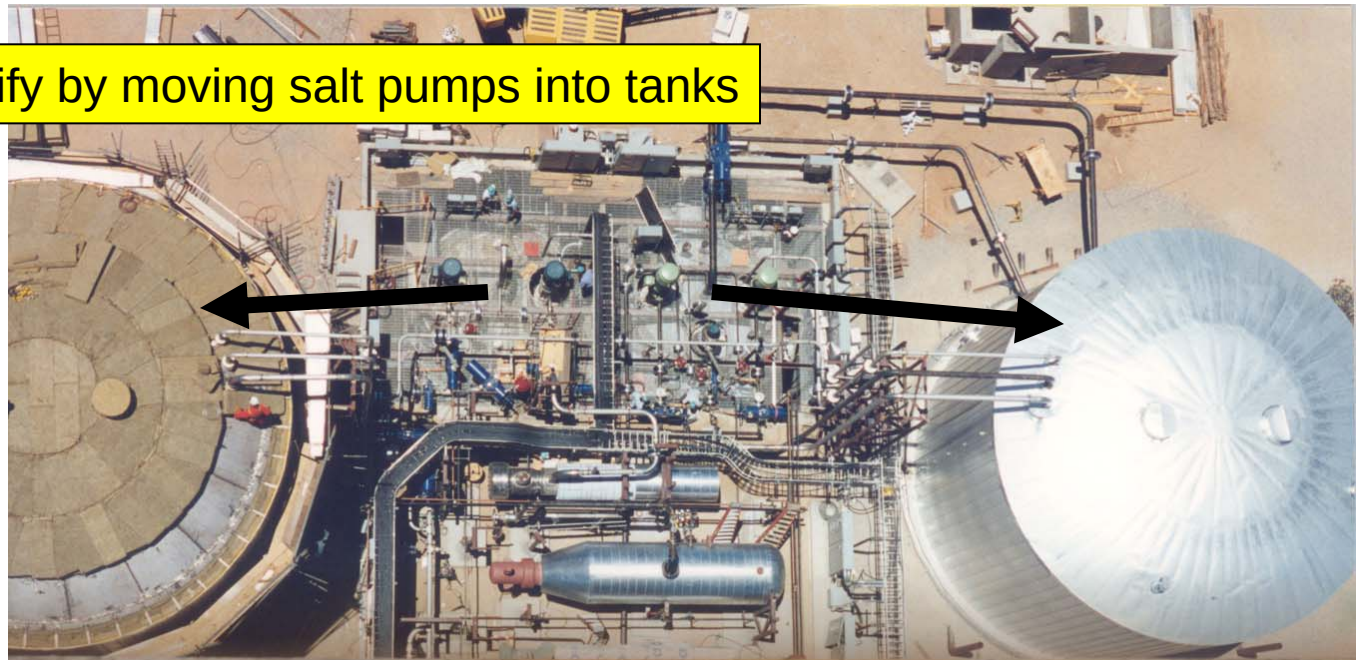
Hamilton Sundstrand
A United Technologies Company
Space, Land & Sea - Rocketdyne

# Molten Salt Pump
# - Relationship to Solar Program Goals

**"...to make CSP thermal storage cost competitive by a reduction of at least $0.0035 (0.35 cents) per kilowatt-hour. This figure is the combination of savings in capital and O&M costs.**



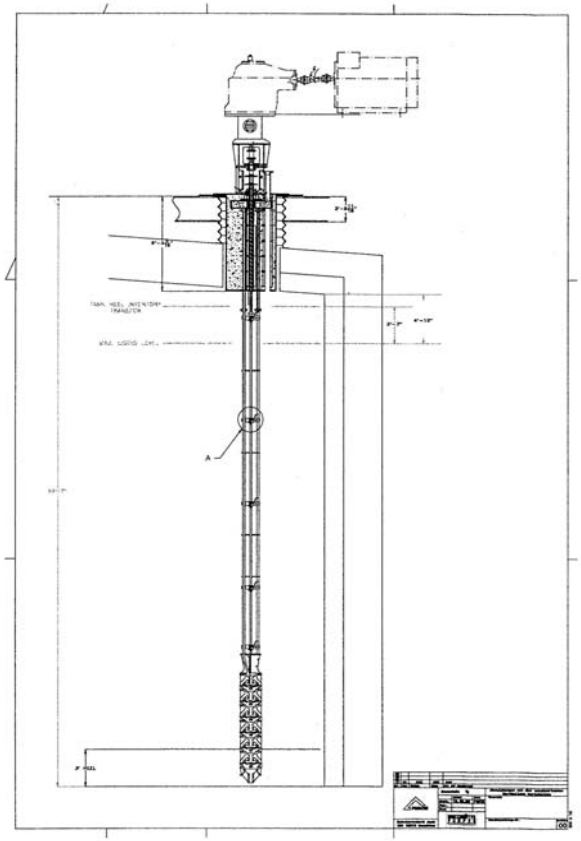
# Molten Salt Pump

## Project overview

### a) Project description:

- **Design, build and test a molten salt pump**
  - **long-shafted ~50 feet**
  - **operate at 1,050 F**
  - **head of 267 feet (200 psid)**
  - **flow of 6,000 GPM**

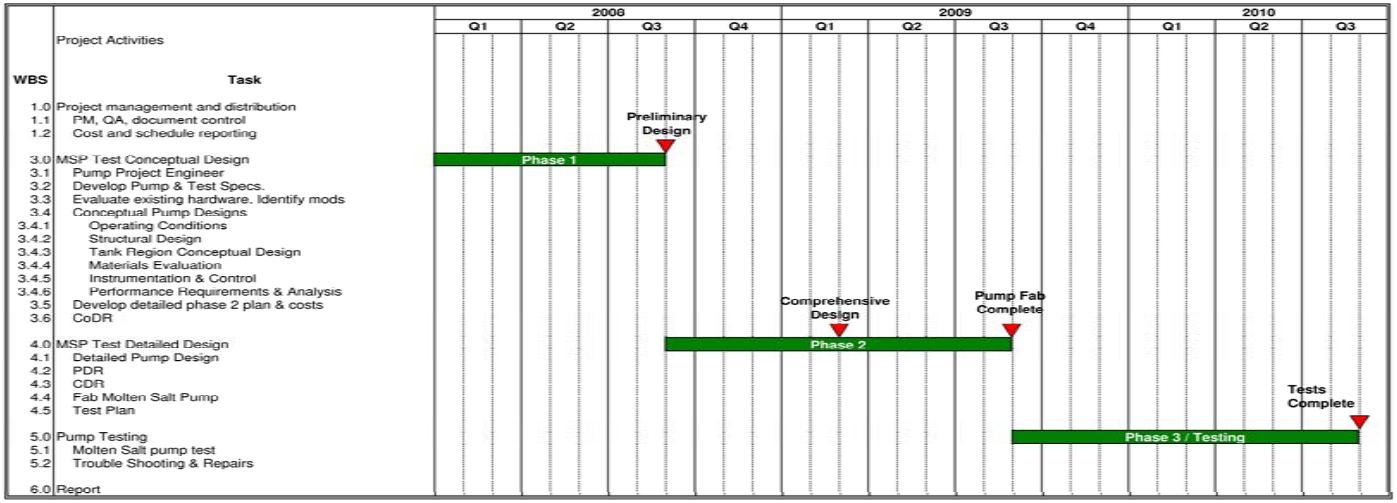
- **Application: thermal storage system of solar trough plant - 100MWe capacity**
  - **1,050°F for using salt in the field**
  - **Extensible to power tower by adding stages to reach 800 feet (600 psid)**



## b) Major FY08 Activities, Planned Milestones & Budget

**Schedule shifting out 4 months**
**Due to later start than planned**

| *Hamilton Sundstrand Rocketdyne* | | | |
|---|---|---|---|
| **Project Beginning Date** | **FY08 Budget** | **FY09 Budget** | **Total Budget** |
| 1/1/2008 | $ 0.8 millions | $ 2.8 millions | $4.4 millions |




- **Key Subcontractor: Friatec-Rheinhütte Pumps and Valves LLC (Friatec) of Odessa, Florida**
  - **Pump manufacturer with experience in molten salt pumps**.

## 2. Link project to Program Plans & Goals

**Improves cost effectiveness of thermal storage pump**

- **One step in achievement of utility CSP cost targets**
  - **2010 10-12 ¢/kWh, 2020 5-7 ¢/kWh**

**Addresses thermal storage for 100 MWe trough plant**

- **Reduces thermal storage cost**
- **Improves thermal storage efficiency**

**Project addresses parabolic trough barriers:**

- **Large-size**
- **Capital cost**
- **Reliability**
- **Performance**
- **O&M Cost**
- **Technology risk**

# FY08 Progress Report

1. What has been accomplished thus far?
    - In DOE fact-finding process, project not started
2. What will be accomplished in the 3rd and 4th Quarters? (May start)
    - Project start delayed ~4 months
    - Start phase 1 work
        - Develop pump & test specifications
        - Evaluate existing designs & hardware for use
        - Initiate preliminary design of pump

# Future Activities (Can this be accelerated?)

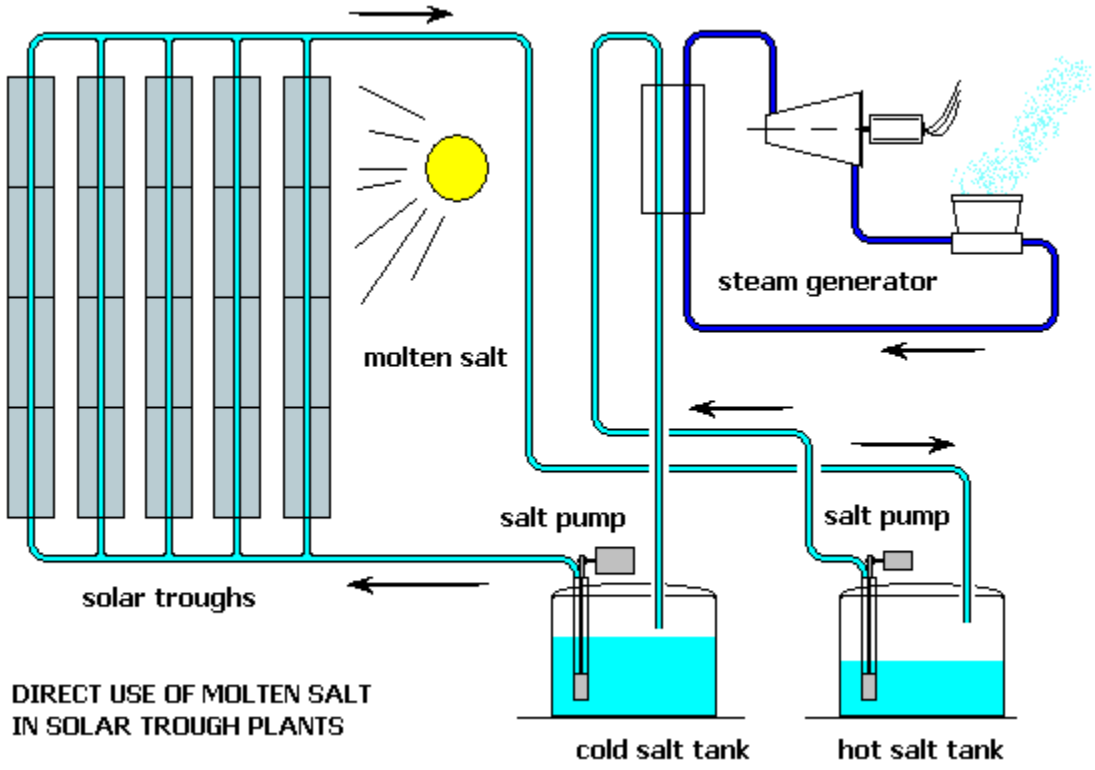
1. FY09 Planned Activities
   - Complete phase 1 work
     - Complete preliminary design of pump
     - Includes preliminary rotordynamic and thermal analyses

     - Initiate phase 2 work
     - Complete comprehensive design
     - – component / assembly drawings
     - Cost estimates for varying annual production quantities
     - Start pump fabrication

2. FY10 and Beyond Ideas
   - Complete phase 2 work
   - Pump fabricated, ready for shipment to Sandia

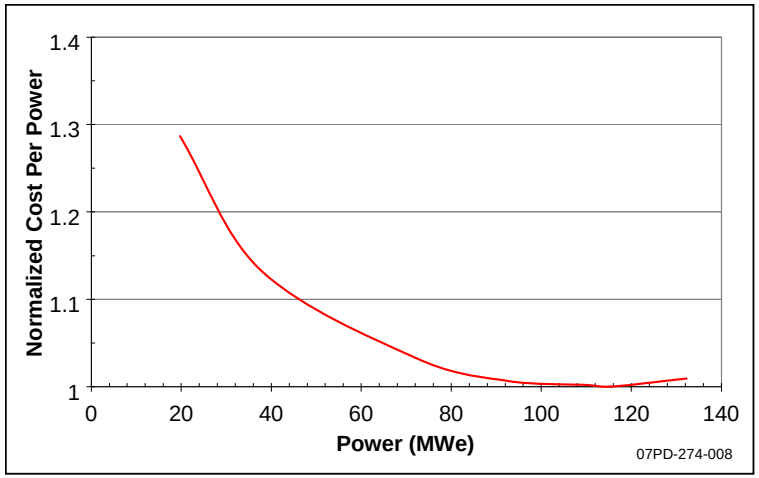
   - Initiate phase 3 work
   - Pump installed in test facility (is test facility

# This molten salt pump development is one step toward direct use of molten salt in troughs



# Central Receiver Panel - Relationship to Solar Program Goals

**"...to make CSP cost competitive by demonstrating larger receiver design, enabling economy of plant scale to reduce LCOE. A power tower of 100 MWe or more can achieve under 7 cents/kWh with storage (12-17 hours) by 2020."**



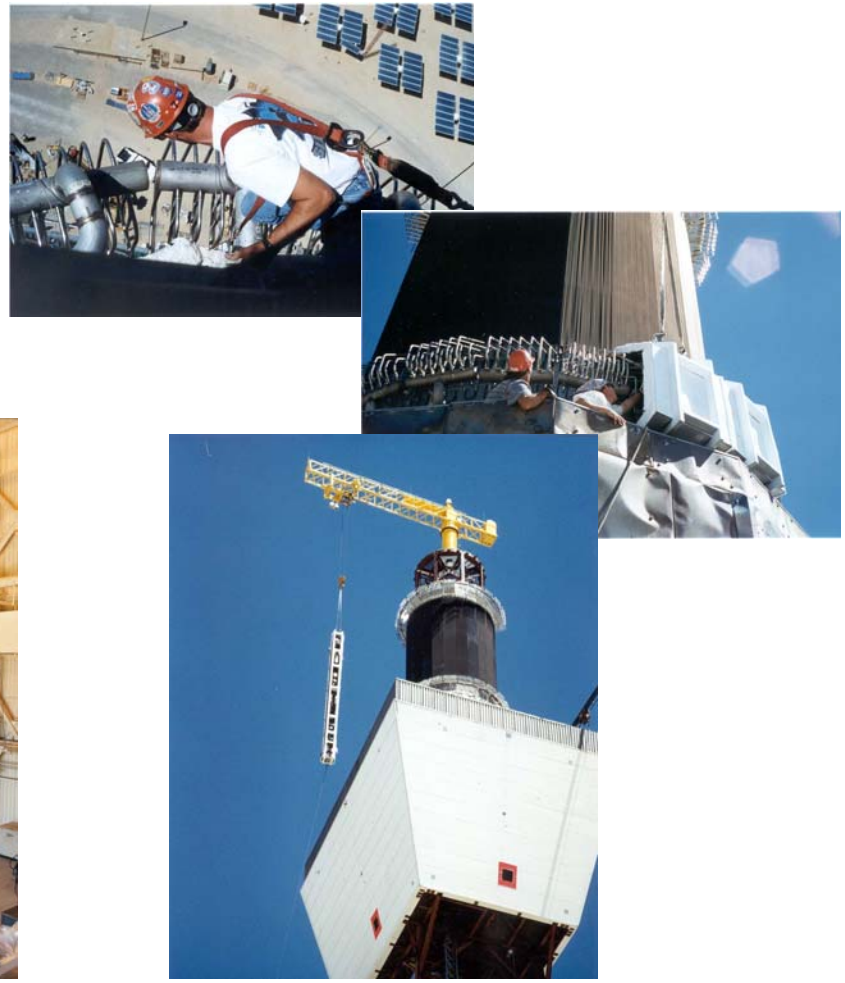

# Project overview

## a) Project description

- **Design, fabrication & test a sub-scale receiver panel**
  - **Prototypic of an advanced large receiver system**
- **Confirm panel size, & perform preliminary design**
  - **Size panel to ~5 MWt & 1,000 kWt/m2 limitations of National Thermal Solar Test Facility (NSTTF) at SNL**
  - **~10 ft. of active length, 25 ft. in overall length, width ~45 inches.**
- **Comprehensive panel design**
  - **Structural, thermal-fluid analyses & materials engineering**
  - **Detailed component specifications**
  - **Manufacturability assessment**
- **Panel fabrication, production run on repetitive components**
- **Panel testing at NSTTF, on-sun with molten salt**
- **Evaluation of future production scenarios & costs**

# Central Panel To Have Larger Tubing & Header Than The Solar Two Receiver Fabricated By Rocketdyne

Fabrication at Rocketdyne



Installation at Barstow CA.

# Project overview

## b) **Major FY08 Activities, Planned Milestones & Budget**

**Schedule shifting out 4 months**
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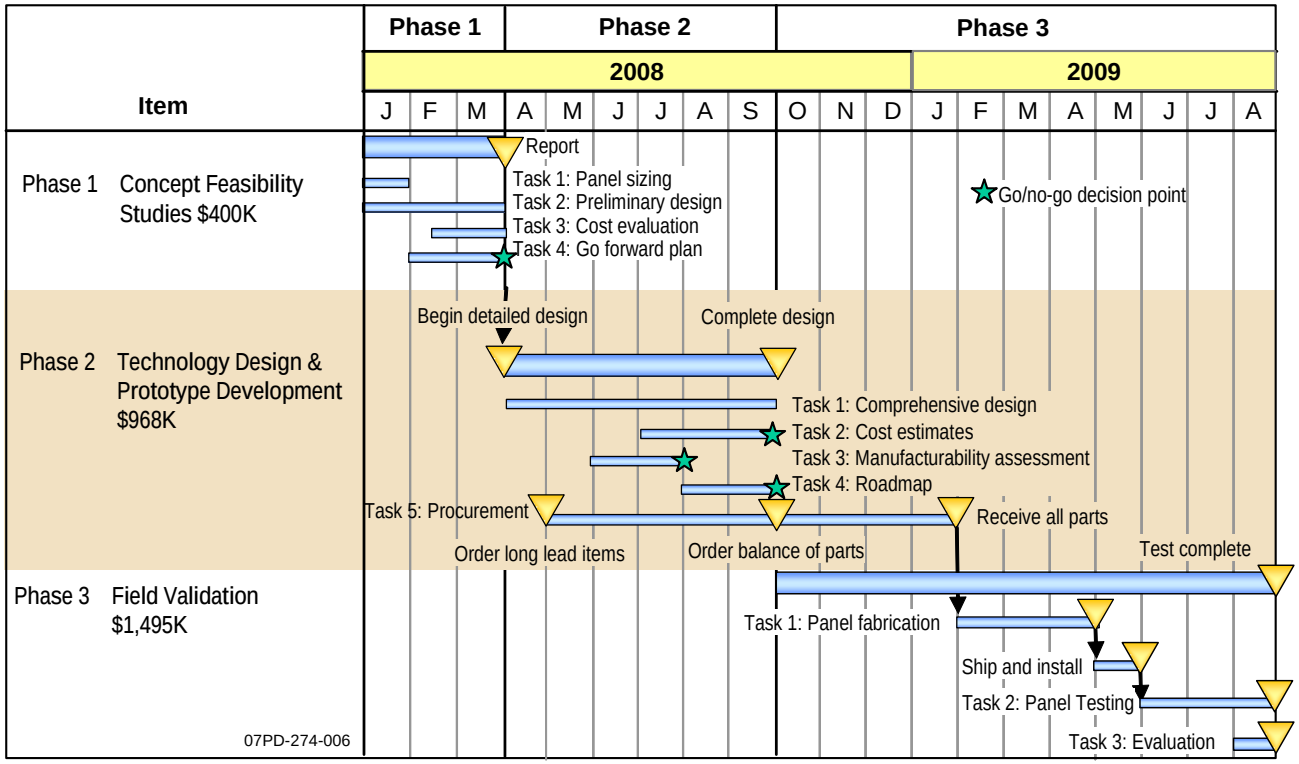


## 2. Link project to Program Plans & Goals

- Forecast achievement of utility CSP cost targets
  - 2010 10-12 ¢/kWh,  2020 5-7 ¢/kWh

- Advanced system - low cost power & storage / up to 24 hr ops.

- Project addresses barriers:
  - Large-size
  - Capital cost
  - Reliability
  - Performance
  - Technology risk

# FY08 Progress Report

1. What has been accomplished thus far?

- Completing DOE fact-finding process, project not started

2. What will be accomplished in the 3rd and 4th Quarters? (May start)

- Project start delayed ~4 months
- Start & complete phase 1
  - Panel sizing
  - Preliminary design
  - Cost evaluation
  - Go forward plan
- Initiate phase 2
  - Start comprehensive design & procurement

# Future Activities

## 1. FY09 Planned Activities

- Complete phase 2 work
  - Comprehensive design & cost estimates
  - Manufacturing assessment
  - Procurement

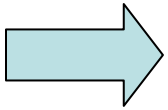
- Initiate phase 3 – field validation
  - Panel fabricated & ready for test

## 1. FY10 and Beyond Ideas

- Complete testing - design validated
- Fabricate & install full scale (~500 MWt) receiver systems

# Molten Salt Power Towers

## *Design Evolution*



- **<u>Solar 2</u>**
- **10 MWe**
- **42 MWt**
- **3 hrs storage**
- **230 ft tower**
- **1926 heliostats**
- **1993-1999**

- **<u>Commercial</u>**
- **~100 MWe**
- **~500 MWt**
- **Storage hrs vary**
- **~500 ft tower**
- **~8000 heliostats**
- **In work**