2008 Solar Annual Review Meeting

Session: CSP Dish Systems
Company or Organization: Sandia National Laboratories
Funding Opportunity: DOE Laboratory Funding

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Sandia National Laboratories

Relationship to Solar Program Goals

"…The long-term goal of the CSP Subprogram is to develop parabolic trough and dish/Stirling power plant technologies that produce electricity that is competitive with electricity from conventional fossil power technologies in identified markets."

- **From 2006 MYP, Proof edition**
- **Identified markets have evolved**
  - **Large, central plant utility scale installations**
  - **Conventional fossil power prices increasing**

CSP Dish Systems Overview

- Laboratory Dish Development
  - Industry-led support
  - Consultation
  - SES
  - Infinia 3kW system
- SES development contract
- Infinia FOA: 30kW multi-cylinder engine
- Brayton Systems FOA: Dish-Brayton system
- Market model contract: S&L-like report for dishes
  - Will also update S&L for troughs and towers

Laboratory Activities: Infinia Support

Project description

Support Infinia Corp with design, development, installation, and testing of pre-production prototype 3kW dish-Stirling systems.

Major FY08 Activities

Assisted in final design of solar portions of prototype system, including optical design and analysis, model support, and controls algorithms

Support installation and characterization of prototype system at Sandia, including logistics, installation, and characterization

Support installation and characterization of two second-generation prototypes at Sandia, including engine systems and controls

Support 2 Infinia employees as long-term on-site engineering and support

Develop formal working agreements with Infinia

Significant advances in CIRCE2 model to support detailed Infinia design work

Laboratory Activities: Infinia Support

Budget

FY07 funding $200k, $46k spent

Personnel contributing to project

Rich Diver: Project lead

Chuck Andraka: Consultation on optics, thermal performance, and controls

Links to MYPP:

Limited: MYPP concentrates on 25kW dish Stirling

Accomplishments:

Substantial optical, thermal, controls, structural design support provided

3kW dish (no engine) installed and characterized at Sandia

Performance limited by hand-built facets

MOU for working relationship negotiated

Preparations underway for 2 next-generation prototype installations

Laboratory Activities: SES Support

Project description

Support Stirling Energy Systems with design, development, installation, and testing of pre-production prototype 25kW dish-Stirling systems in support of commercialization for large deployments

Major FY08 Activities

Support continued operation of Model Power Plant (MPP) for reliability characterization and improvement, including root cause analysis, prioritization, data reduction, modeling and design support

Participate in the Design for Manufacturing and Design to Cost process, providing solar expertise, optical and thermal modeling, design tool development, and consultation

Characterize and improve system performance in support of cost reduction

Laboratory Activities: SES Support

Budget

FY07 funding $1171k, $483k spent so far

Personnel contributing to project

Chuck Andraka: Project lead

Jimmy Lloyd: Prior project engineer (moved on)

Sandia support: Materials, failure analysis

Sandia technicians

Links to MYPP:

5-year goal:

Achieve a design point solar-to-electric efficiency of 30% and annual solar-to-electric efficiency of 24%. Demonstrated 31.25% net system performance

CSP Approach

Performance improvement

Cost Reduction

Deployment Support

Laboratory Activities: SES Support

Accomplishments

- Substantial systems, optical and thermal modeling supports design approach and systems models to properly size next-generation systems to engine and environmental conditions
- Substantial input to design process with expertise and tool development led to weight reduction of 4000 pounds (out of 17500), with potentially more reduction to come
- Development of two viable options for rapid assembly and field alignment of mirror systems, to be completed this summer
- Demonstrated 31.25% net system efficiency after incorporating Sandia and SES system improvements
- Established and maintained ES&H controls, documentation, and training processes for entire SES team
- VAVE sessions for major systems and subsystems, leading to substantial cost reduction and improvement opportunities
- Consistent involvement in reliability improvement evaluations, root cause analysis, option development, prioritization, and design processes
- Maintained some semblance of sanity

Laboratory Activities: SES Support

FY08 remaining plans

- **Sweatshop 2008**: Hired 6 graduate students for intensive summer program to address time-critical development issues. These candidates are all potential resources for future full-time staff
- **Alignment systems**: Complete hardware and software development and demonstrate leading candidate by end of FY
- **Optical design**: Support SES in optical and thermal design of dish, cavity, receiver, and engine as they move to manufacturable design. Potential significant changes for cost effective system will require substantial modeling. Support SES in development of cost-effective facet technology
- **Controls**: Provide background knowledge, simulations, consultation, and expertise to facilitate the development of next-generation dish and engine controls
- **Production systems**: Provide support to the development of logical, effective test plans, processes, and equipment for qualification of pre-production prototypes from soft or hard tooling, for engine, dish, and controls

Future Activities: Baseline

- Continue industry support: Industry led
  - SES $1.2M
  - Infinia $250k
  - Could use increases to support accelerated deployments
  - Design support, operations support, testing and evaluation
  - Timely, flexible characterization and evaluation
- Enhanced Industry support
  - Improved data analysis leading to AI approaches for O&M
  - Significant enhancement in instrumentation and measurement for detailed system performance
  - Detailed receiver modeling and testing
  - Additional $750k/year
- FOA support level undetermined

Future Activities: Near Term

- Advanced Facet Manufacturing
  - Cross-cutting
  - $500k/year, 1FTE
  - Immediate needs
- Next-generation field tools
  - Alignment
  - Facet characterization
  - System performance tools
  - $150k
- Improved analysis tools
  - CIRCE, AEETES, etc. updated to interface with modern computers and software
  - Improved system models
  - $200k
- Continuous operation engine test facilities
  - Robust and safe gas-fired systems
  - $200k

Future Activities: Next Generation

- Advanced Test Bed Concentrator
  - Flexible data and control systems and test platform
  - Unattended testing
  - Compatible with 25-35kW engine systems
  - $1M
- Kinematic engine seal development
  - Key component
  - Design, analysis, and durability testing
  - $250k
- Advanced Dish Receivers
  - Heat pipe development
  - Interest from industry partners
  - Estimate $500k/year, leverage Ukrainian work
- Multi-cylinder Free-Piston Heat Pipe system
  - Combine multiple 1-3kW FPSE's on a single heat pipe
  - ADDS size or larger
  - Interest from several companies
  - $500k to $750k

Future Activities: Vision for Solar

- Laboratory support of Industry
  - Improved response time through increased staff
  - Significant value added through extensive experience base
  - Tools and facilities significantly beyond industry capabilities
  - Increased industry presence at test facilities
  - Reactive
- Laboratory research
  - Develop the things industry does not even know they need yet
    - Closed-loop tracking algorithms and sensors
    - Structural facets
    - Heat pipe receivers
    - ADDS
    - Systems models/engineering
  - Pipeline to industry, showcase at labs
- Laboratory development
  - Partner with new industries to develop deployable solutions
  - Significant funding to currently non-solar industries to leverage
  - Proactive

Issues

- Industry is outpacing laboratories
  - Funding
  - Schedule
  - Must maintain leading edge
  - We have significant contributions
- Labs/DOE funding is not timely
  - FOA is an example
  - Must find ways to accelerate to remain relevant
- Laboratory equipment is generally old
  - Electrical safety
  - Compatibility