Thermochemical Energy Storage for Stirling Concentrating Solar Power Systems

CSP Program Team

PNNL-SA-72607

Robert S Wegeng

Pacific Northwest National Laboratory

robert.wegeng@pnl.gov

May 25, 2010

Overview

Timeline

- Project Start: Jan 20, 2010
- Project End: Dec 31, 2012
- Percent Complete: 10.6% (as of May 1, 2010)

Barriers

- Capacity factors and Levelized Cost of Electricity (LCOE) for CSP systems

Budget

- Total Project Funding:
  - DOE Share: $747,974
  - Contractor Share: $49,912
- Funding received in FY09: 0
- Funding for FY10: $747,974

Partners

- Project Lead: PNNL
- Interactions/Collaborations: Infinia Corporation

Challenges, Barriers or Problems

- Market Challenges, Barriers or Problems to be Addressed
  - Improving capacity factors for dish-Stirling power generators from <20% to greater than 40% in the near-term, and greater than 90% in the longer-term
  - Reducing the Levelized Cost of Electricity (LCOE) of dish-Stirling power generators to 7¢/kWh
- Relevance: Successful demonstration of Thermochemical Energy Storage (TcES) for dish-Stirling units:
  - Enables power generation during periods when sunlight is unavailable
  - Increases dish-Stirling capacity factors and reductions in LCOE
  - Enables dish-Stirling units to function as intermediate, load-following power generation systems

Relevance

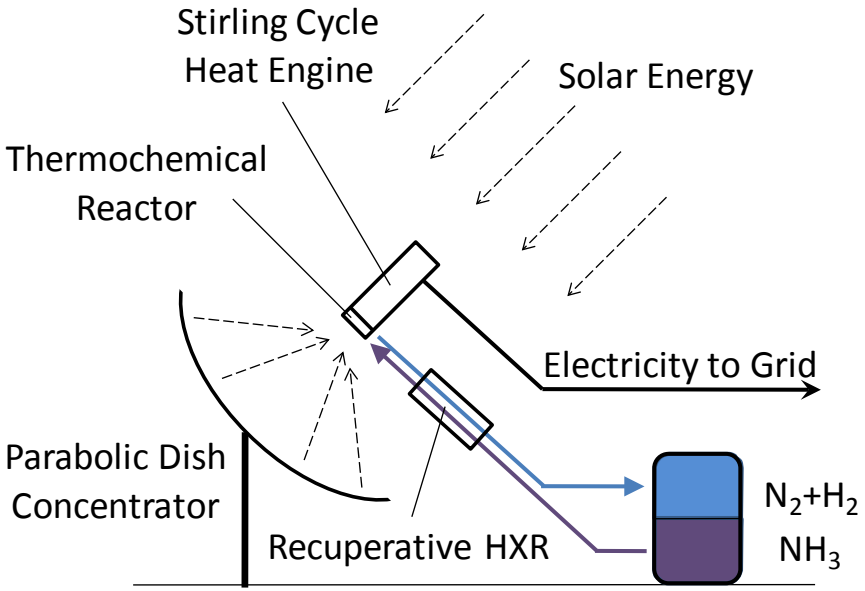
- Project Objective
  - Perform preliminary development activities including an on-sun, proof-of-concept demonstration of a high efficiency, solar TcES system based on the integration of compact, process-intensive microchannel reactors and heat exchangers
- Support to DOE Goals
  - This objective supports DOE goals to increase the use of CSP in the USA, making CSP competitive in the intermediate power market by 2015 and in the baseload power market by 2020

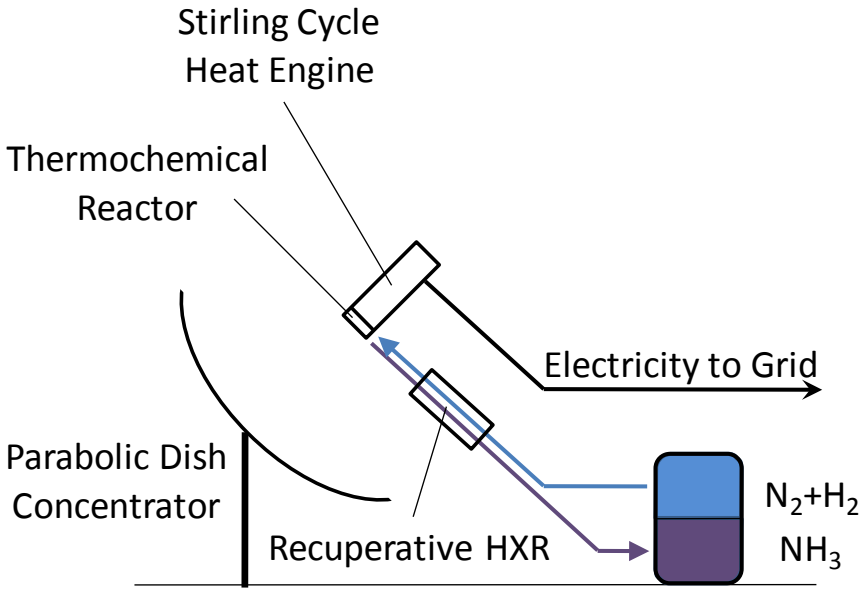
Approach

- Evaluate multiple TcES chemistries and cycles
- Examples include:
  - Ammonia Decomposition and Resynthesis

    $2NH_3 \leftrightarrow N_2 + 3H_2$
  - Hydrocarbon Conversion

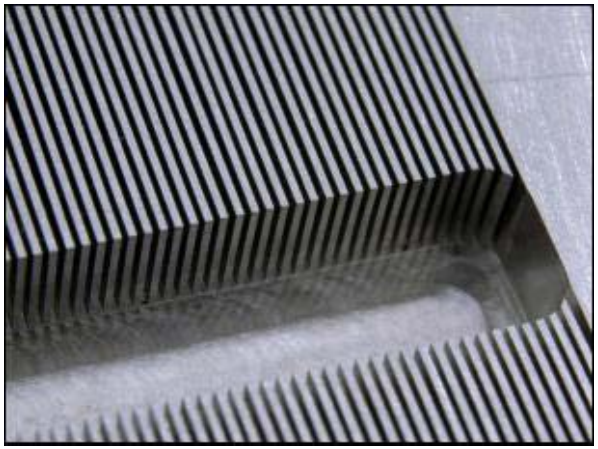
    $CH_4 + H_2O \leftrightarrow CO + 3H_2$

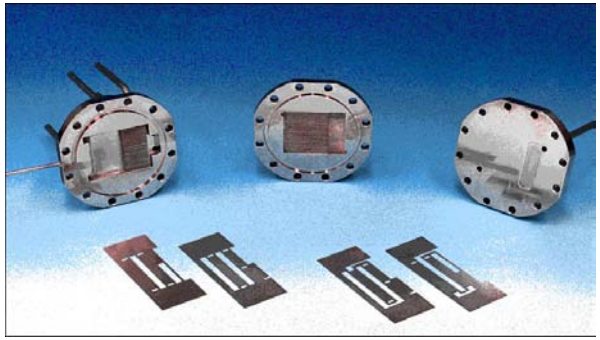


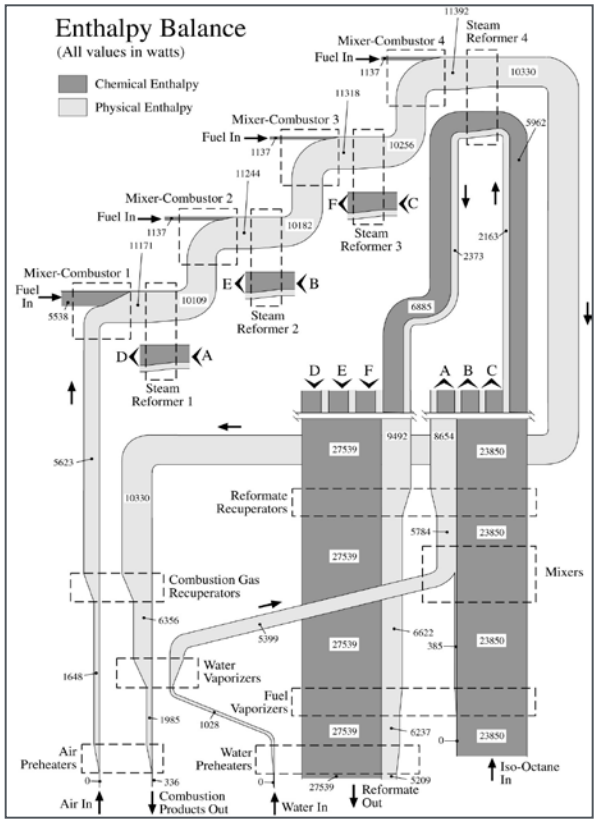


Approach

- Provide TcES conversions using highly efficient, microchannel reactors and heat exchangers

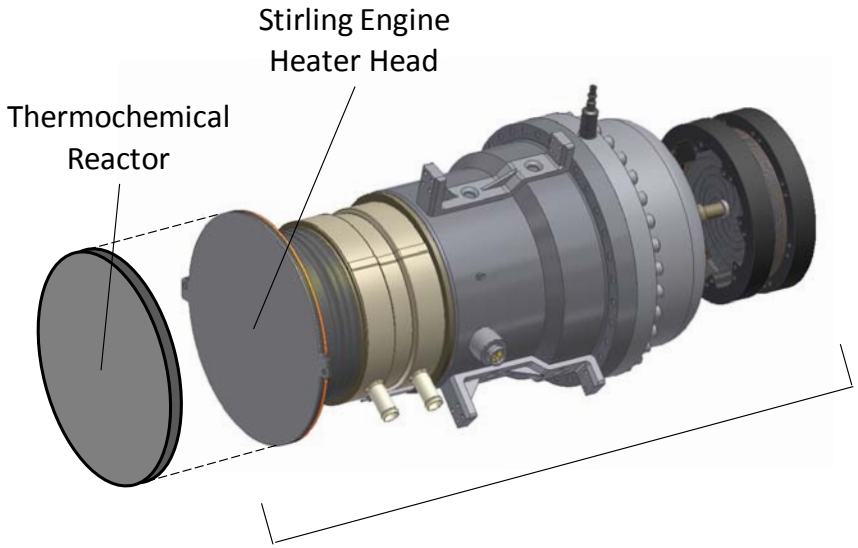






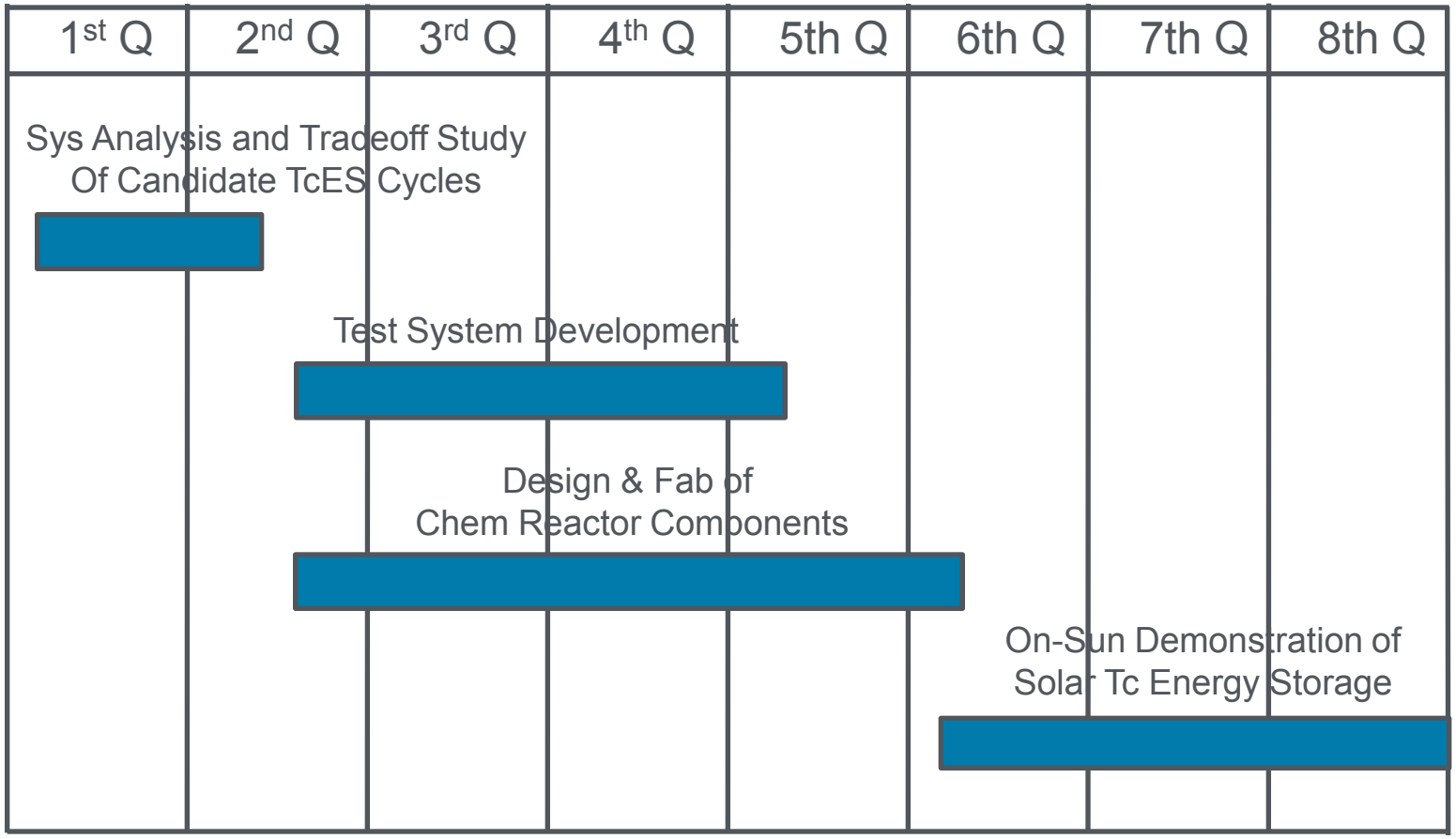
Approach

- Initial Concept: Integrated TcES with dish-Stirling power generator



Approach

- Project Timeline



Collaborations

- PNNL – Lead Role
- Infinia Corporation – Subcontractor to PNNL
- Tasks
  - Task 1 – System Analysis and Tradeoff Study – PNNL Lead
  - Task 2 – Test System Development – Infinia Lead
  - Task 3 – Design and Fabrication of Chemical Reactor Components – PNNL Lead
  - Task 4 – Demonstration of Solar TcES Operations – PNNL and Infinia

Accomplishments / Progress / Results

- System Analysis and Tradeoff Study Completed (ahead of schedule)
  - Various chemistries/cycles evaluated
  - Hydrocarbon conversion cycle selected for demonstration
  - Go / No-Go Review completed
- Reactor Design Work Underway (ahead of schedule)
- Proof-of-Concept Demonstrations to be performed in 2011 at Infinia

Budget Status and Potential for Expansion

- Project Start: January 20, 2010
- DOE Share ($747,974):
  - Spending to Date on DOE Share (as of End of April):
    - $79.4K (10.6% of total): Variance of -$5.8K (-6.83% of planned)
- Infinia Cost Share ($49,912)
  - Infinia subcontract being established
- If additional funding were provided:
  - Accelerate project: Complete on- and off-sun TcES demonstrations in CY 2010
  - Accelerate hardware development – perform extensive/intensive reactor testing and development
  - Establish beta-testing program

Future Plans (FY 2011 and beyond)

- FY2011: On- and off-sun proof of principle testing for one TcES cycle
  - May 2011

- Additional reactor testing and development – if additional funds are provided

Summary Slide

- Microchannel reactors and heat exchangers enable efficient Thermochemical Energy Storage (TcES) for CSP power generation systems
- TcES based on hydrocarbon cycles (closed- and open-cycles) provide reasonable efficiencies
- TcES based on hydrocarbon cycles (closed- and open-cycles) can improve capacity factors and LCOE
  - Eliminates need for alternative, standby fossil fuel facilities for periods when sunlight is unavailable
  - Enables transition to intermediate/loading following applications by 2015
  - Enabling transition to baseload power generation by 2020
  - Provide a possible route to the production of solar-based transportation fuels (not part of this project)
- Initial on-sun demonstration planned in 2011
- Path to commercialization is clear