Effektiv Dish-Stirlingbaserad Solel med Termisk Lagring

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Overview

- Introduction to CSP Stirling Technology
- Project Objectives
  - Efficient Solar Recivers
  - Thermal Storage for CSP
- Results: status
- Next Steps

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Concentrating Solar Power (CSP) Working Principle

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- Mirror directed normal to solar irradiation
- Light is reflected (concentrated) to a focal spot
- Light in focal spot is captured in receiver
- Light is absorbet in medium and transformed into heat
- Heat is used to drive heat to power conversion process
- Conversion process is Stirling cycle

Receiver – Stirling Engine

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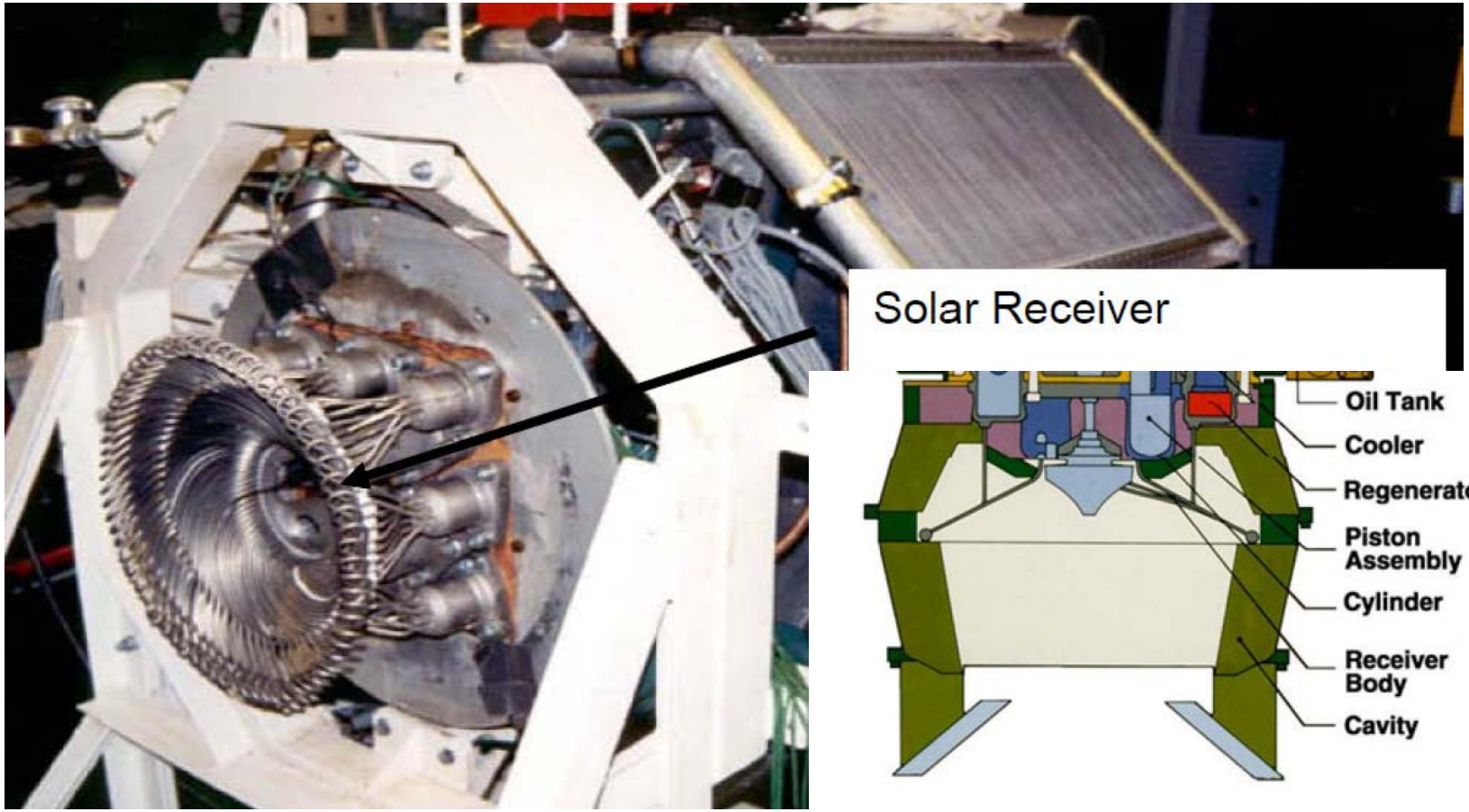

Project Goals

- Simulate and verify a parabolic concentrator in full-scale with state-of-the-art mirrors with optical efficiency of 94%
- Develop and verify a solar receiver with thermal efficiency of 5% higher than today's receiver at an operating temperature of 850 degrees C
- Verify a thermomechanical life of the receiver of 15000 hours with the help of simulations and validating measurements
- For the high efficient solar collector concept, verify a total conversion efficiency of 80%
- For the cost optimized solar collector concept, verify a product cost of 7500 kr/kW for the concentrator and 390 kr/kW for the solar receiver

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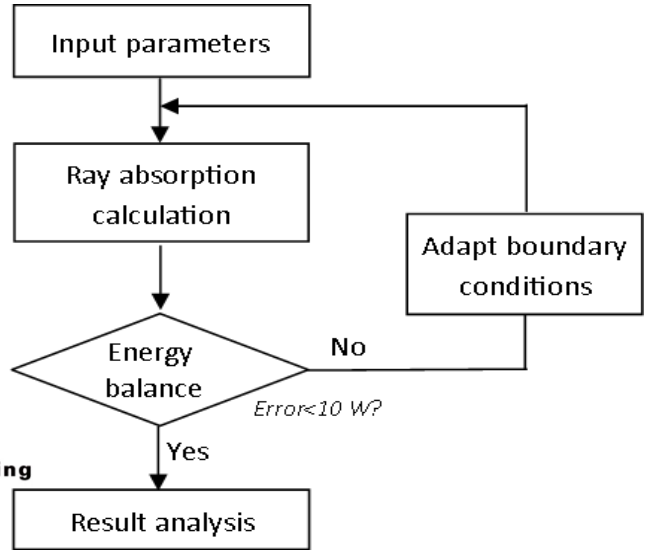
Results: Design and Analysis of New Receiver



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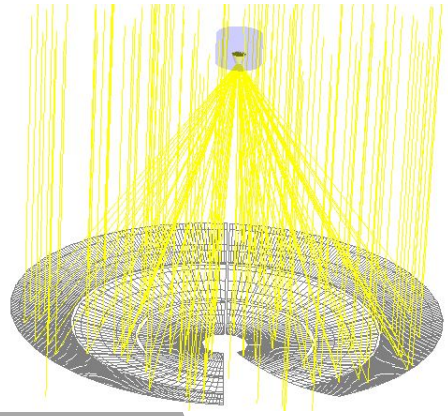
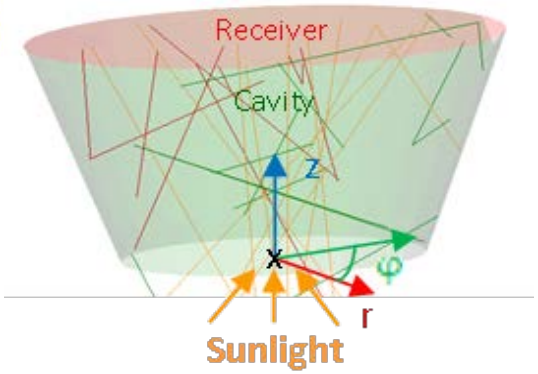
Design method:

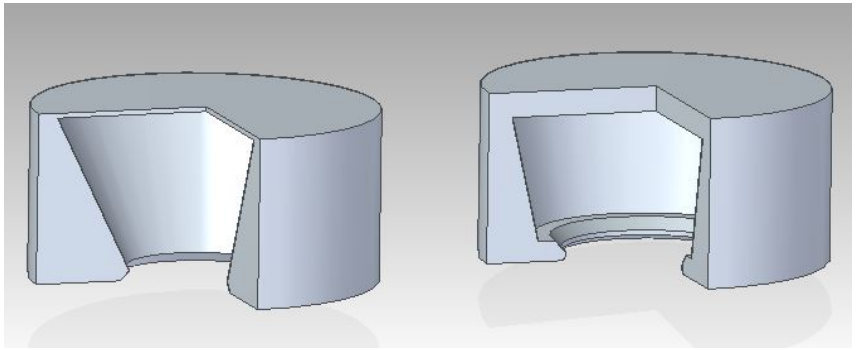
- Constrains and restrictions of the system become the boundary conditions
- Detailed radiation studies
- Sesitivity analyses of all the most relevant parameters to further improve it

Analysis results show

- Maximum theoretical efficiency of 93.5% for new design
- Average expected theoretical efficiency 91% for new design
- Theoretical efficiency increase of 4% from previous model







Results: verification in solar lab

- Preparation of solar laboratory to match dish boundary conditions
- Manufacturing of new receiver
- Testing of new receiver in solar laboratory to very efficiency improvement
- Testing of new receiver in actual power plant

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Results: verification in solar lab

- Instrumented optimized solar receiver with different cavities to verify efficiency and mechanical behavior

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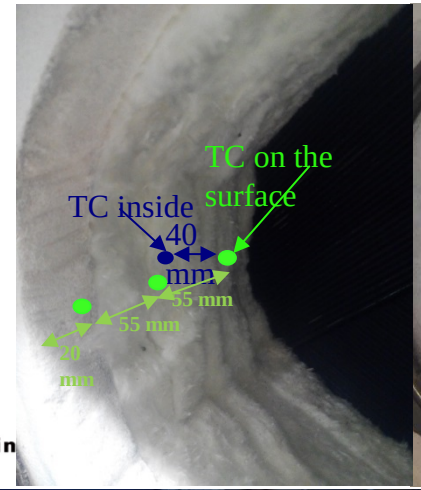

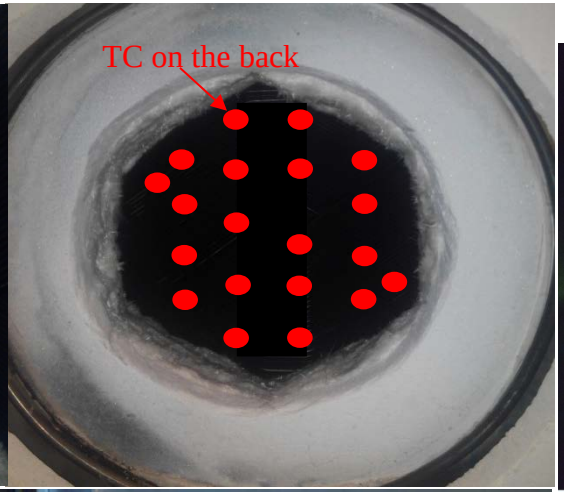

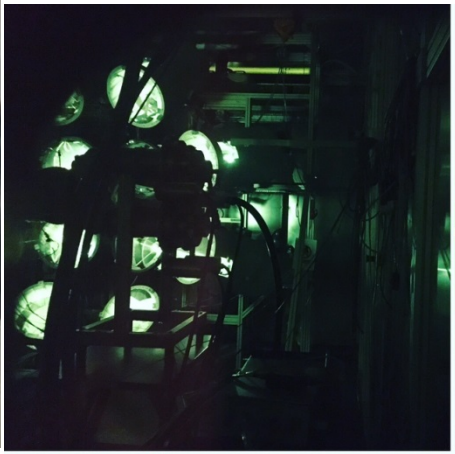

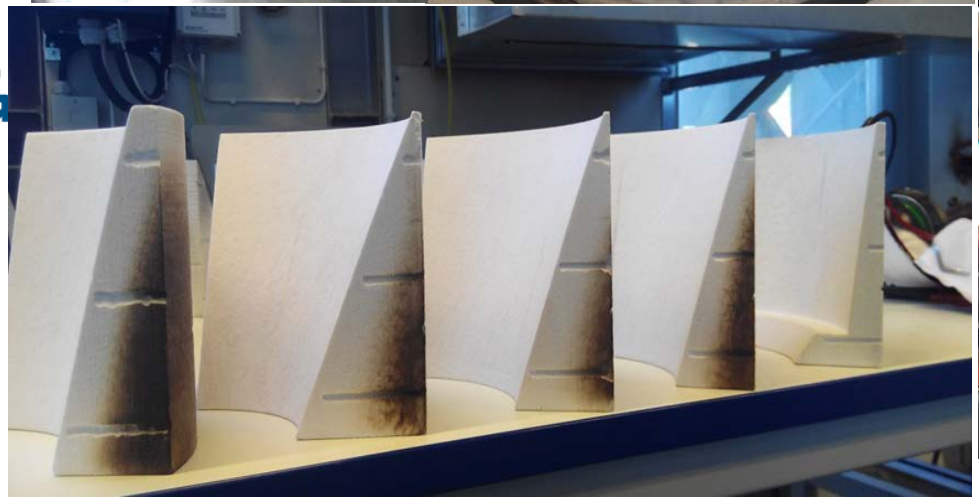

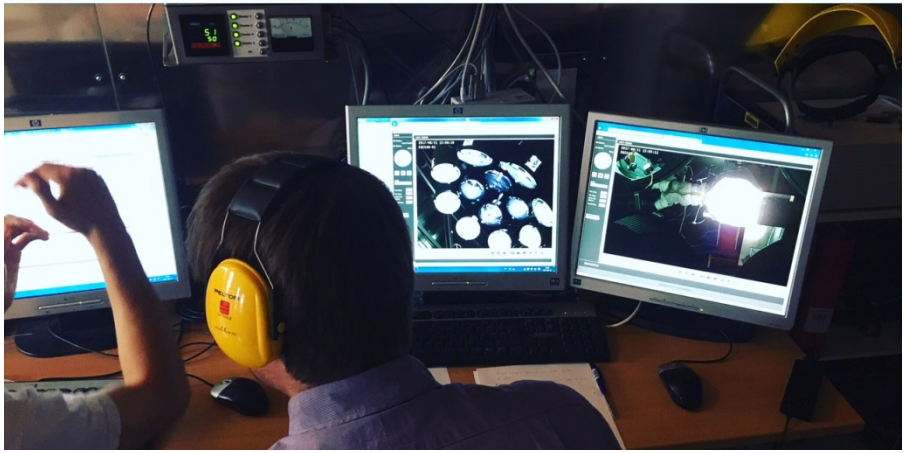

Results: verification in solar lab

- Optical solar collector efficiency is over 95%. The best cavity showed 10% better thermal effect than the original cavity. Extrapolated on a day's operation, this represents an improvement over 5%.
- Lifetime analyzes have been conducted based on FEM calculations that have been validated using measurements in the lab. The conclusion is that a life of over 15000h can be reached with the new cavity
- With an optical efficiency of 95% and thermal efficiency In the solar receiver up to 92%, the solar efficiency is 87% and therefore exceeds the target significantly.
- The total system will be 15-30% more efficient depending on the operating point.
- The cost of the cavity has fallen significantly with the new manufacturing method (mold and ceramics) and reaches the cost target

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Is this enough?

- Technology needs to be competitive on market
- CSP will not beat PV on cost for installed power
- CSP has an important market niche for dispatchable power as long as system with thermal storage is cheaper than PV with chemical batteries

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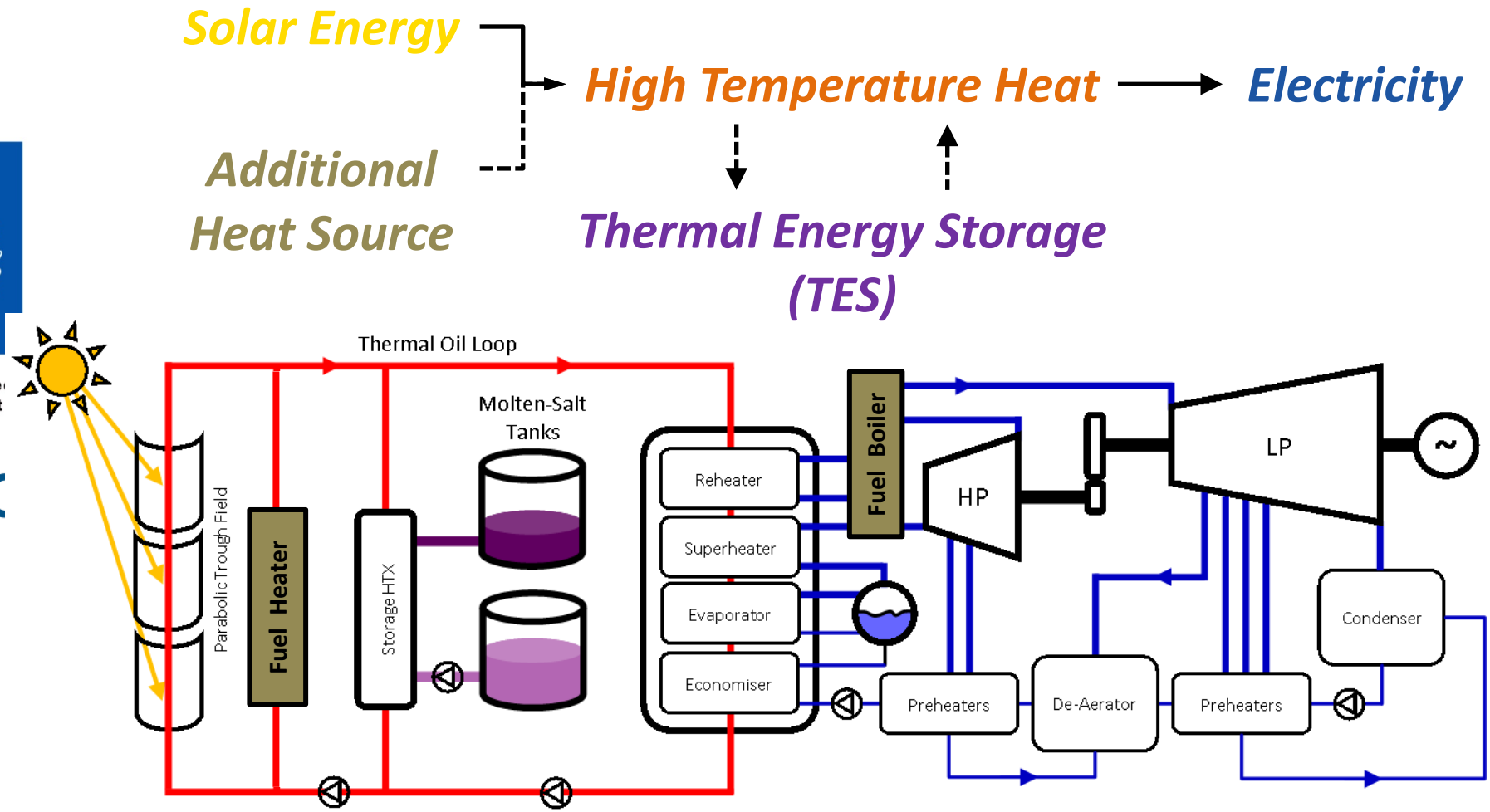
Cost for utility scale storage

- Heat in the order of 15-25 dollar/kWh
- Batteries in order of 200-400 dollar/kWh (falling to 100 in 2030?)

CSP Thermal Storage

A simple schematics with energy conversion in a CSP plant:



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CSP High Temperature Storage

For Stirling Engines Temperature range needs to be at 700-900 degrees

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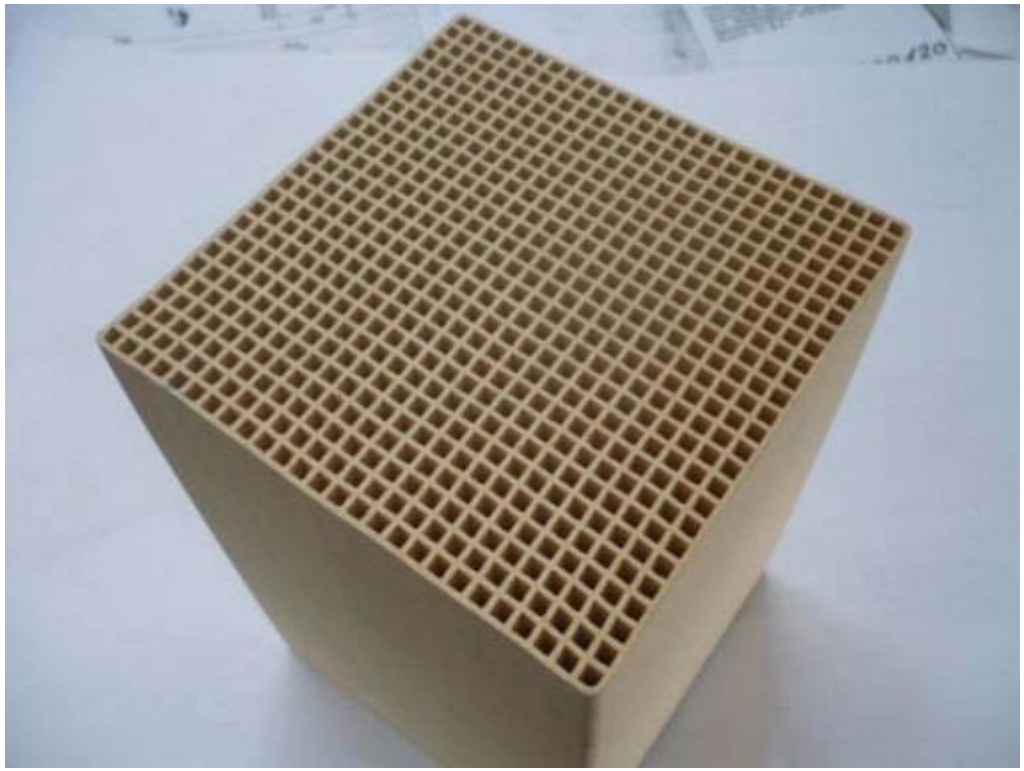

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Project Goals

- utveckla och optimera ett termiskt lagringskoncept baserat på sensibel och/eller latent lagringsmaterial med en gas, t.ex. luft eller koldioxid, som värmeöverföringsmedium och med en arbetstemperatur över 800°C och upp till femton timmars lagringskapacitet.
- dimensionera om en befintlig KTH-konstruerad luftbaserad solmottagare avsedd för gasturbiner till en applikation baserad på Stirling-kraftverk och termiskt lager.
- prova ett termiskt lager i labbskala under väldefinierade förhållanden i KTH:s sollabb och identifiera laddnings- och urladdningsbeteende samt värmeflöde i lagret. Simuleringar av det termiska lagret skall genomföras och verifieras med hjälp av mätningarna.
- verifiera i labbskala i KTH:s sollabb ett integrerat kraftsystem inklusive lager, solmottagare och en realistisk presentation av en Stirlingmotor (då en Stirlingmotor i labbskala inte är tillgänglig) med avseende på laddnings- och urladdningsbeteende. Speciellt skall optimala driftsbetingelser studeras. Både före och efter provningen skall simuleringar utföras för att stötta provningen och för att översätta resultaten till fullskala.

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