Assessment of solar tower driven ultra supercritical steam cycles applying tubular central receivers with varied heat transfer media

C. Singer, R. Buck, R. Pitz-Paal, H. Müller-Steinhagen

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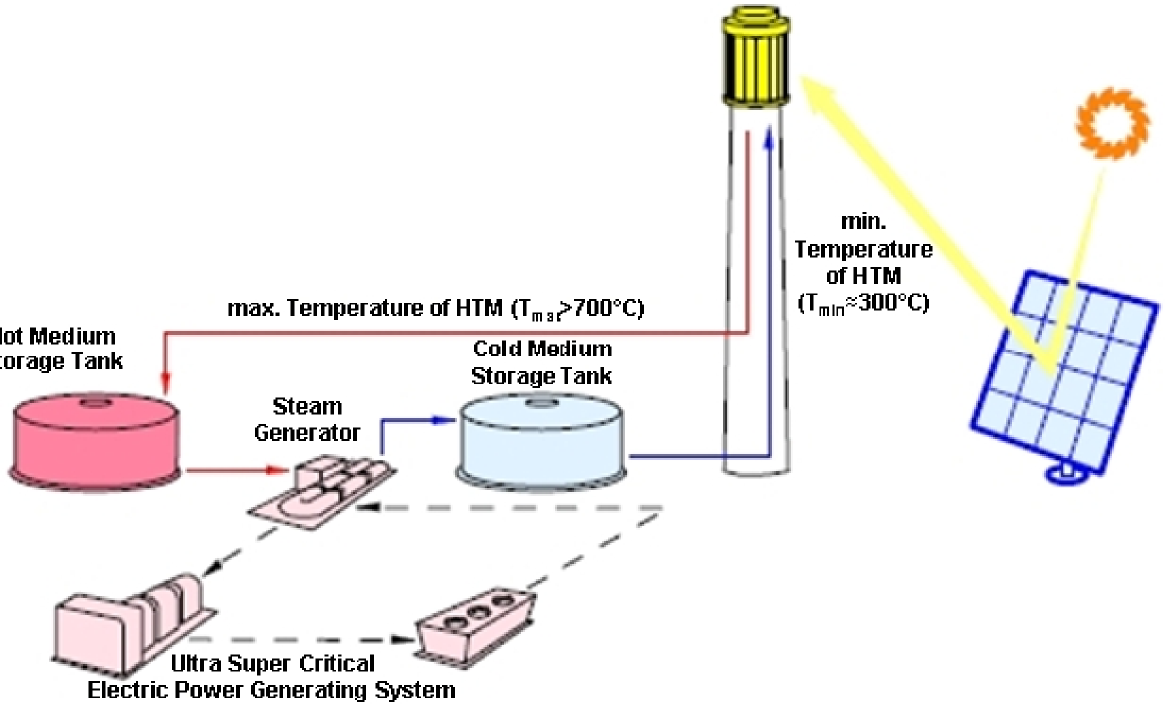
Overview

- Motivation and Objective
- State of the Art
- Numerical Model
- Results
- Conclusions
- Future Work
- Time Schedule

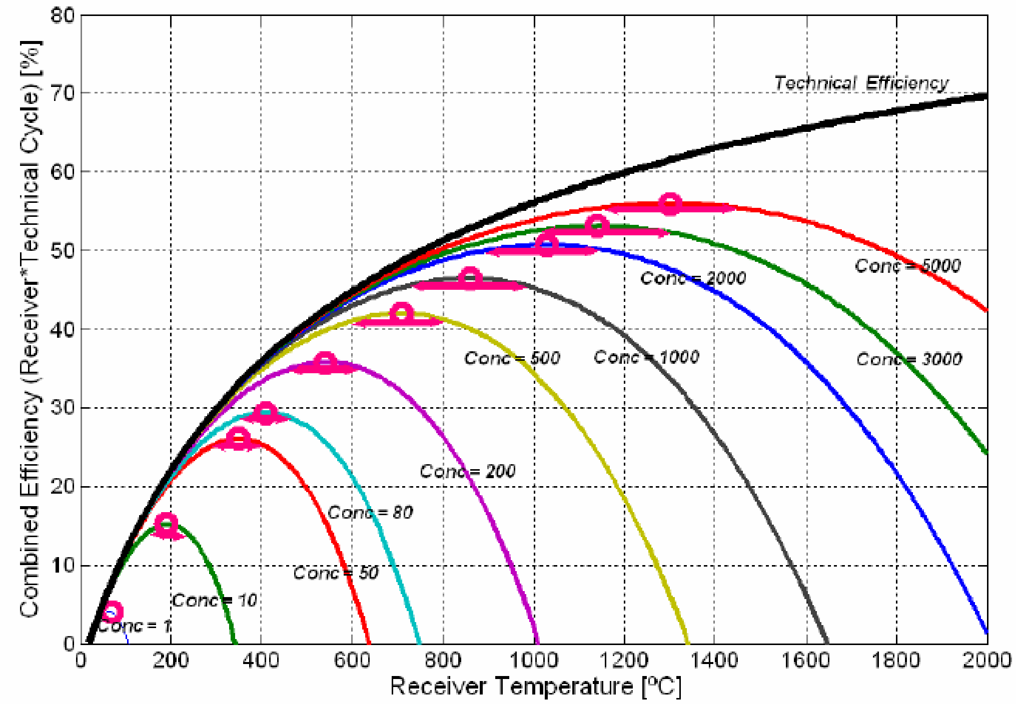


Source: Sandia National Laboratories (modified)

Motivation and Objective

- USC parameters around 350bar and 720°C is the next development step
- A 55% thermal efficiency is within the potential of USC steam cycles
- CSP has the potential to clean and sustainable energy supply
  - relatively conventional technology
  - ease of scale-up
- Assessment of potential for solar tower driven USC cycles (50-1000MW$_{el}$)
- Solar system options:

  - tube receiver
  - Beam-Down
  - Direct Absorption
  - Multi Tower Solar Arrays
  - and combinations



Source: F. Téllez, CIEMAT

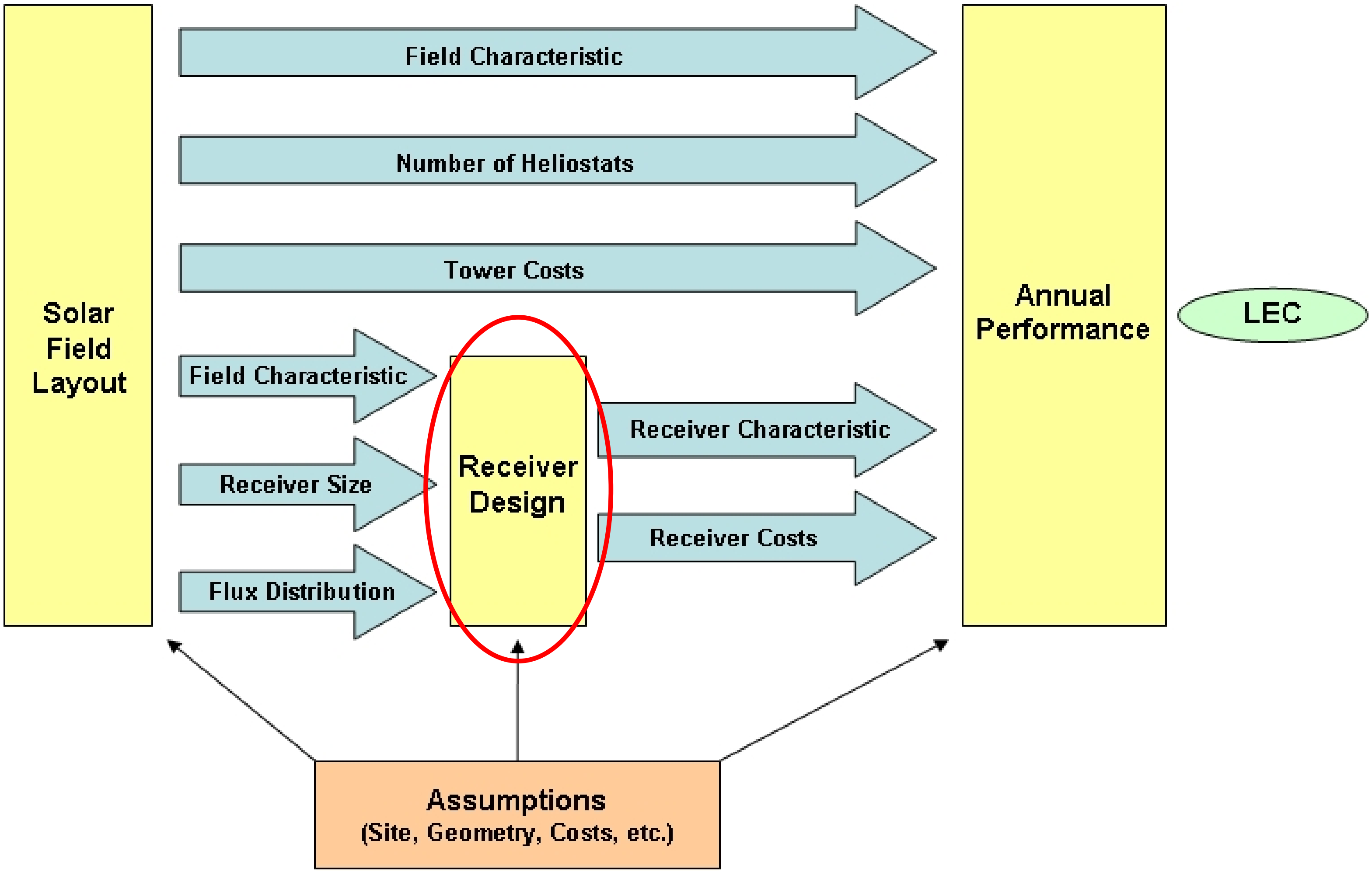
State of the Art

- 360° cylindrical receiver, Solar Salt (290°C-565°C)
- Solar Tres (Basis for the assessment)
  - 17MW_{el} / 15h storage capacity / Fuentes de Andalucia (Sevilla, Spain)
  - steam power cycle (38% thermal efficiency)
- Solar 50 (Reference of the economical assessment)
  - 50MW_{el} / 8h storage capacity / Fuentes de Andalucia (Sevilla, Spain)
  - steam power cycle (44% thermal efficiency)

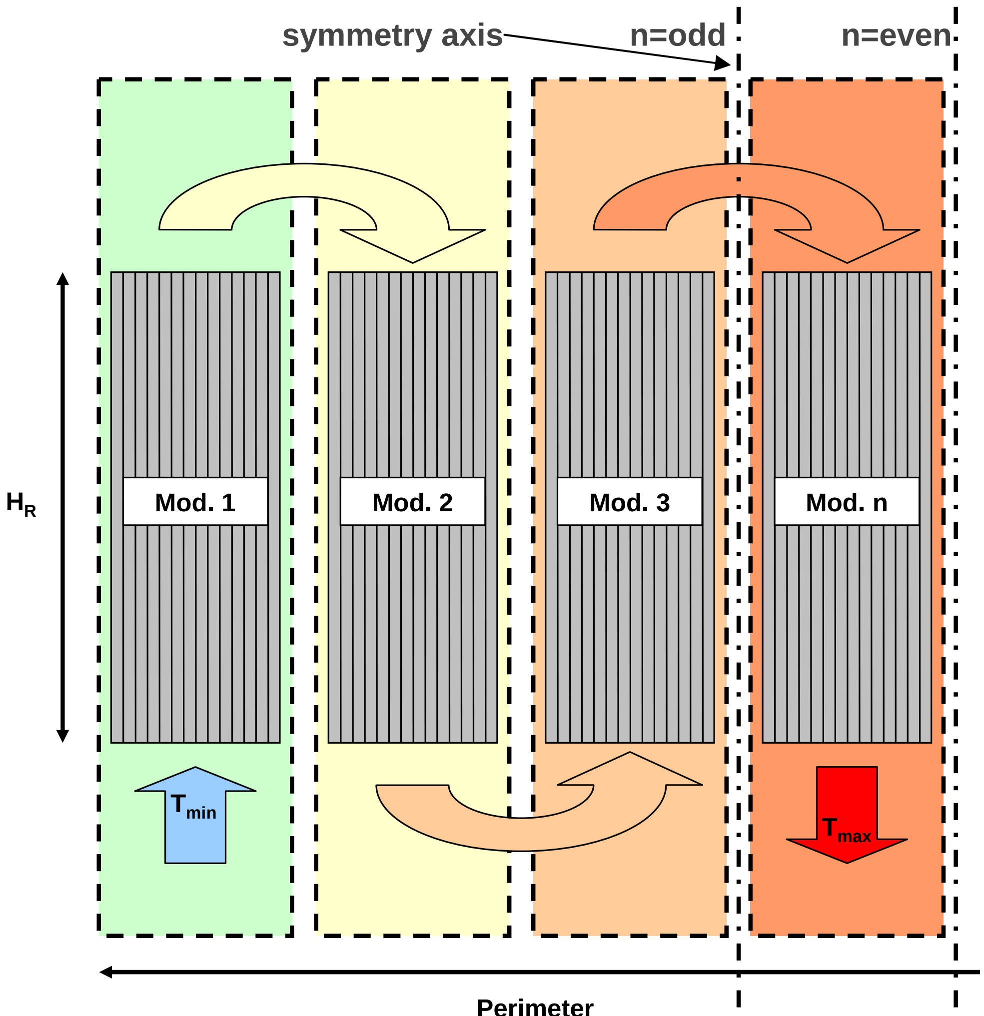
Innovations

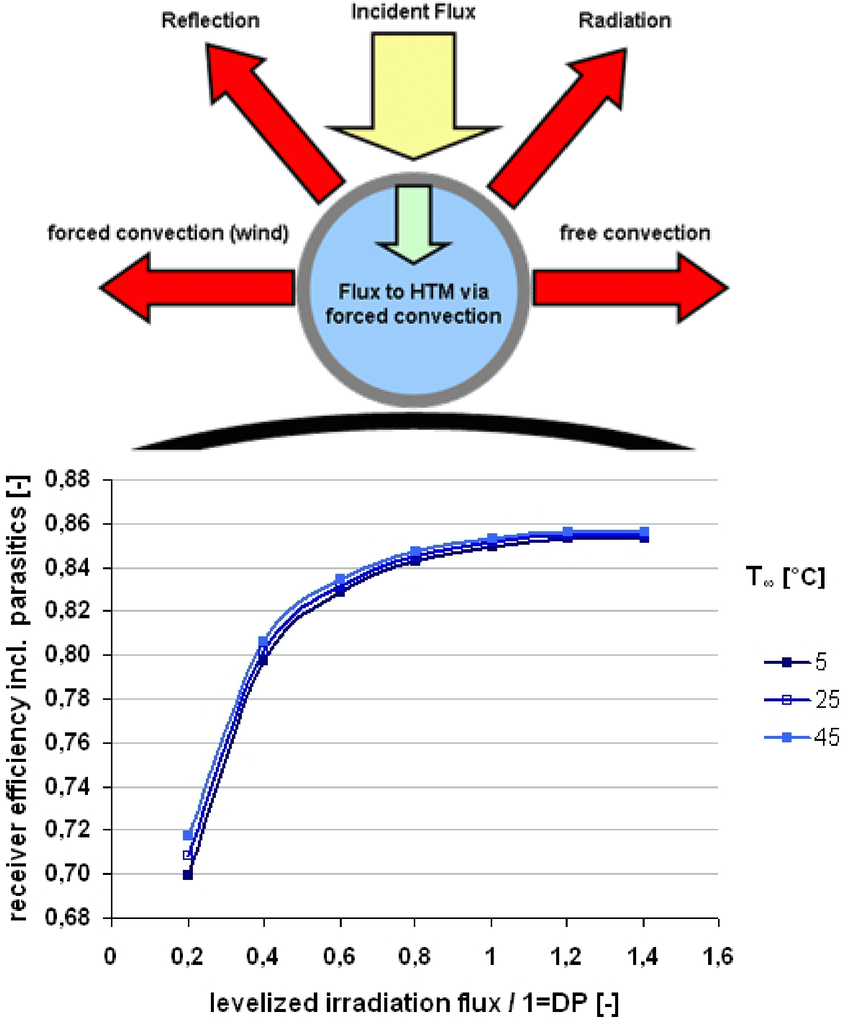
- Solar USC
  - supercritical power cycle (350bar / 720°C / 53% thermal efficiency)
- HTM
  - tin, sodium, bismuth-lead or. bismuth-tin and LiCl-KCl eutectic

Assessment Workflow



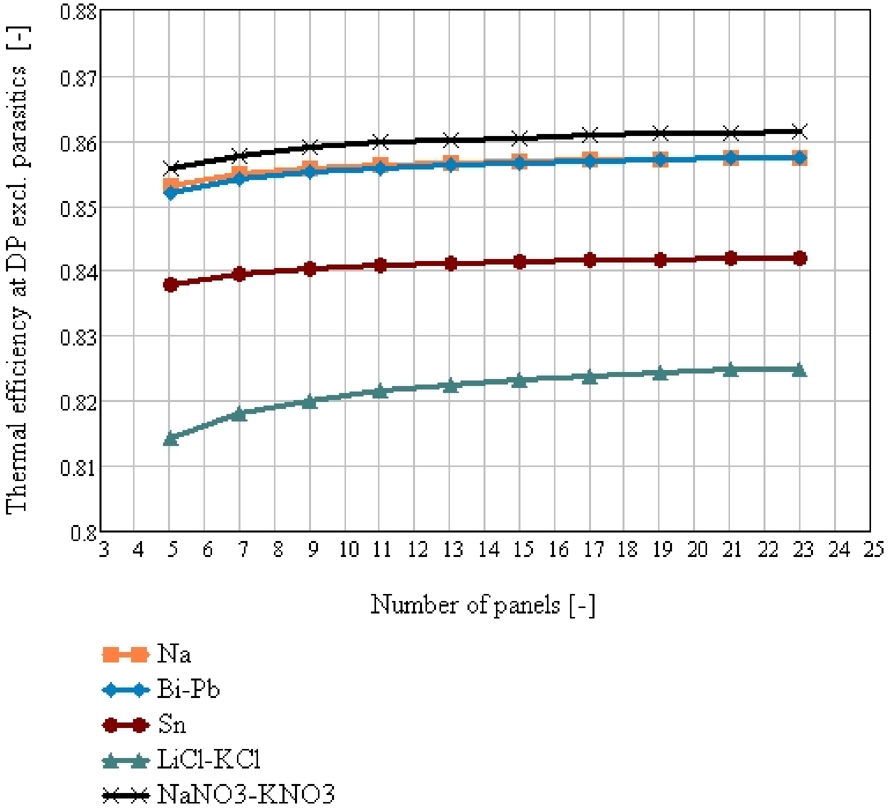
Numerical Model - number of serial panels



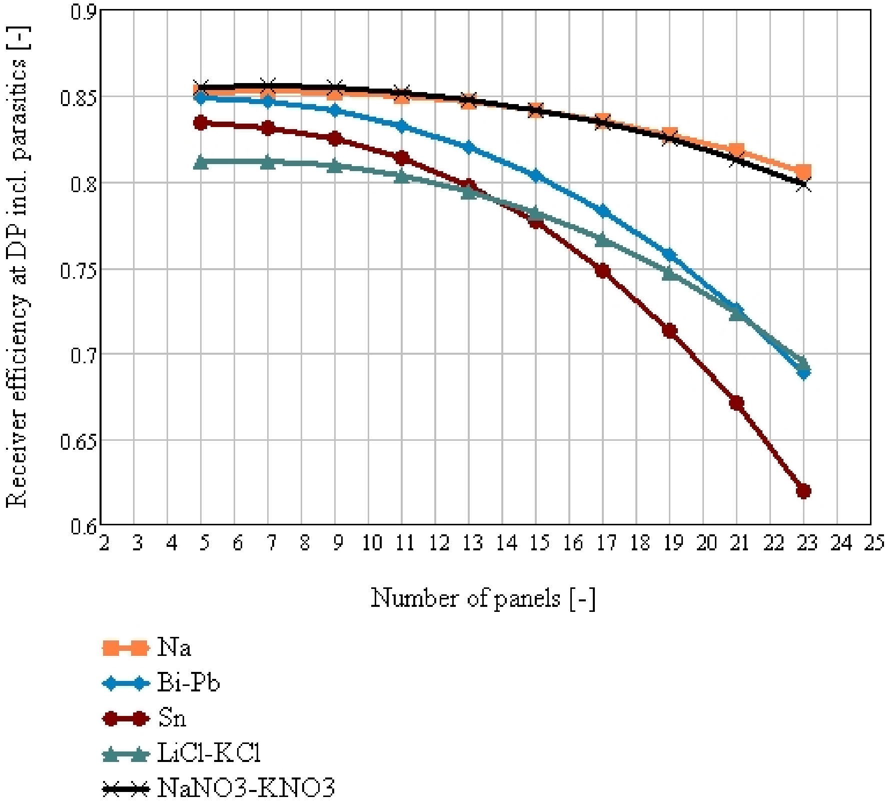


Results - performance due to number of serial panels

Without HTM pumping parasitic losses

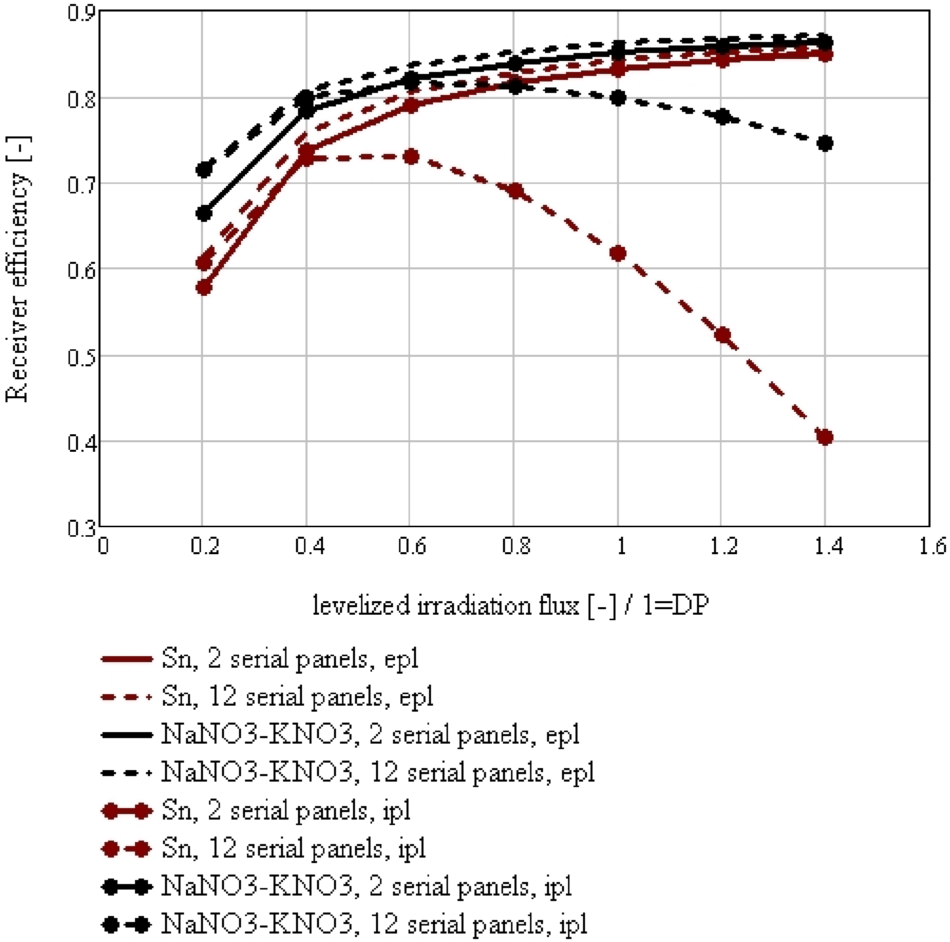


With HTM pumping parasitic losses

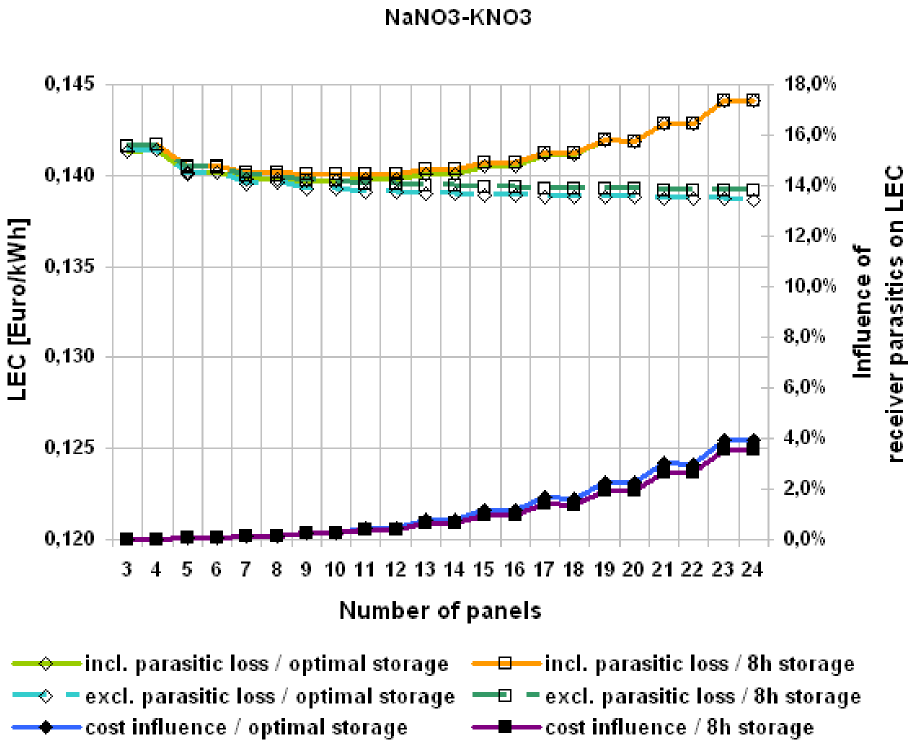


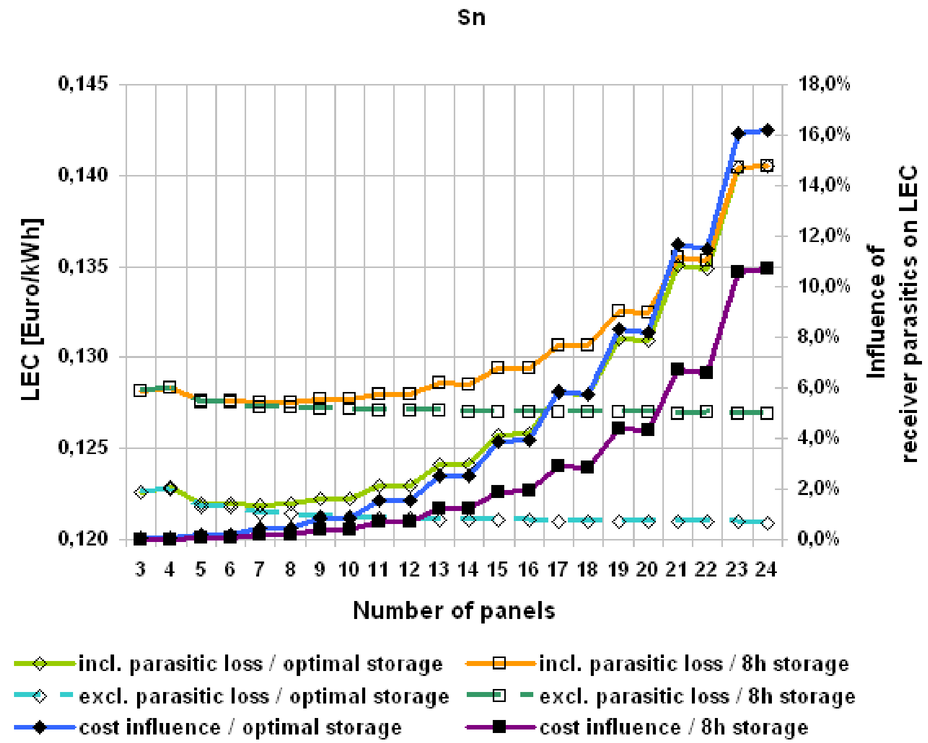
Note: The number of serially flow-through panels has a significant influence on the plant performance

Results - performance due to number of serial panels



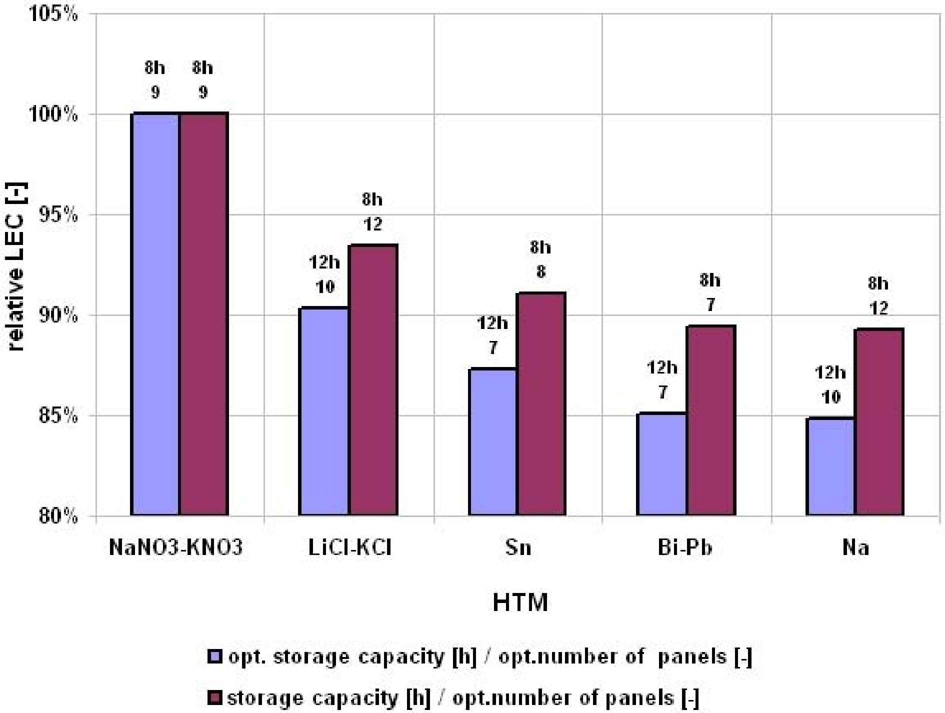
Results - LEC due to number of serial panels

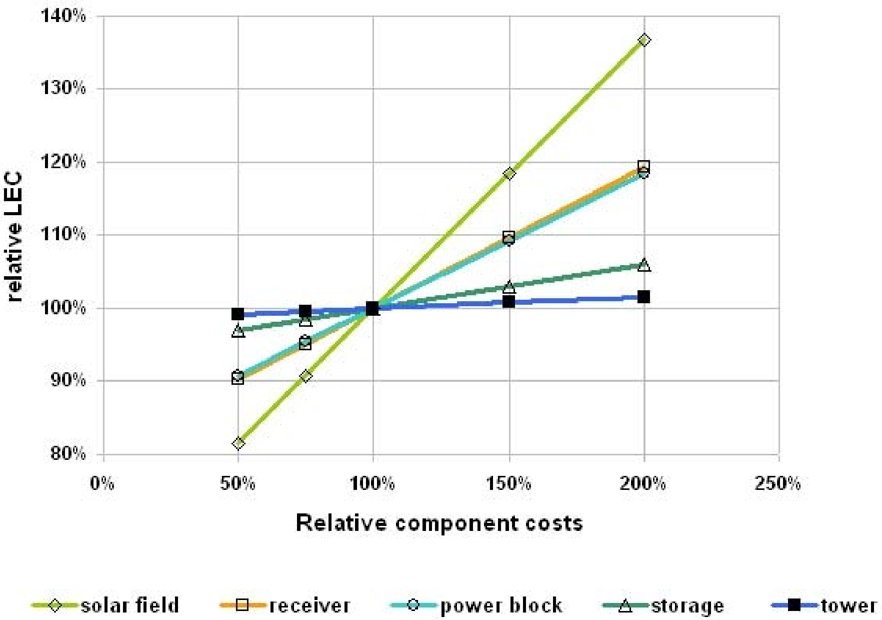




Note: The number of serially flow-through panels has a significant influence on the plant performance, even more if the cooling takes place with liquid heavy metal

Results - annual performance and LEC sensibility





Conclusions

- significant LEC reduction potential of
  - about 15%, if USC, liquid metal, optimum storage size is assumed
  - about 10% if equal storage sizes are compared
- HTM with higher thermal conductivity leads to lower LEC
  - due to the reduction of radiation loss at the central receiver,
  - if the storage cost is independent of the used HTM costs
- The assessed liquid metals provide a significantly better receiver performance
  - however, these HTM are too expensive for the usage as storage medium
- No salt mixture or liquid metal is available in the cost range of solar salt without decomposition in the required temperatures range for USC
- High temperature receiver loop with a separate storage material tends to be more cost effective for future solar applications