



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

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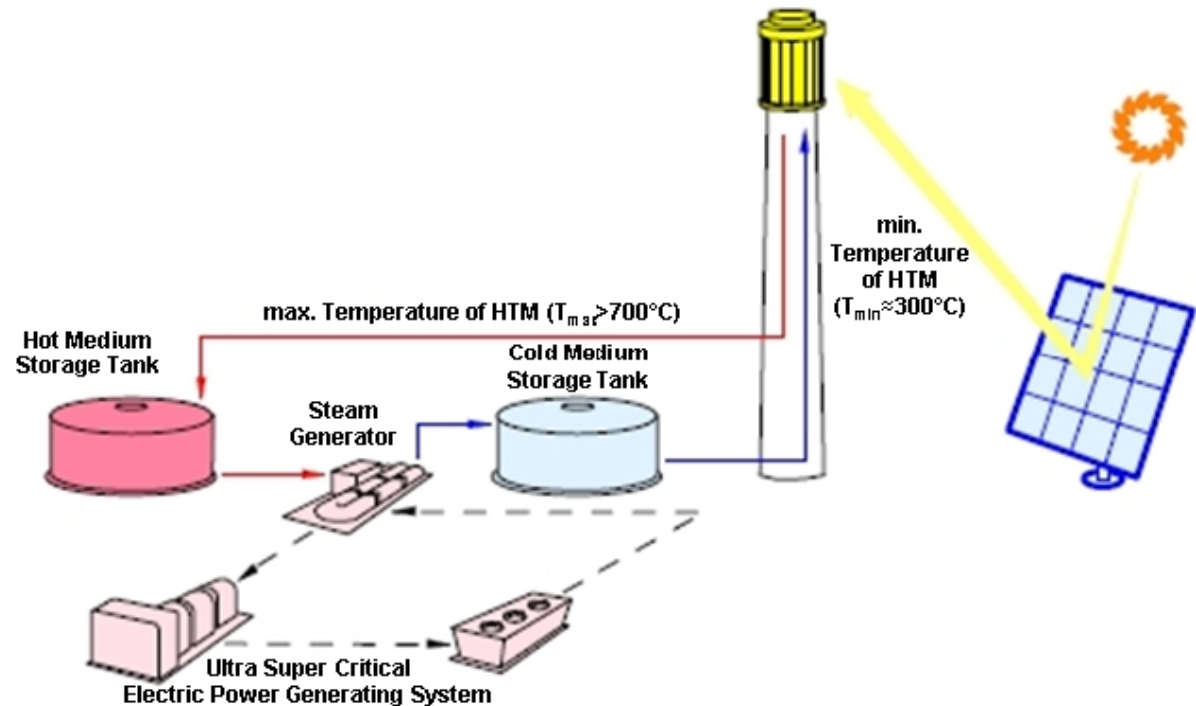
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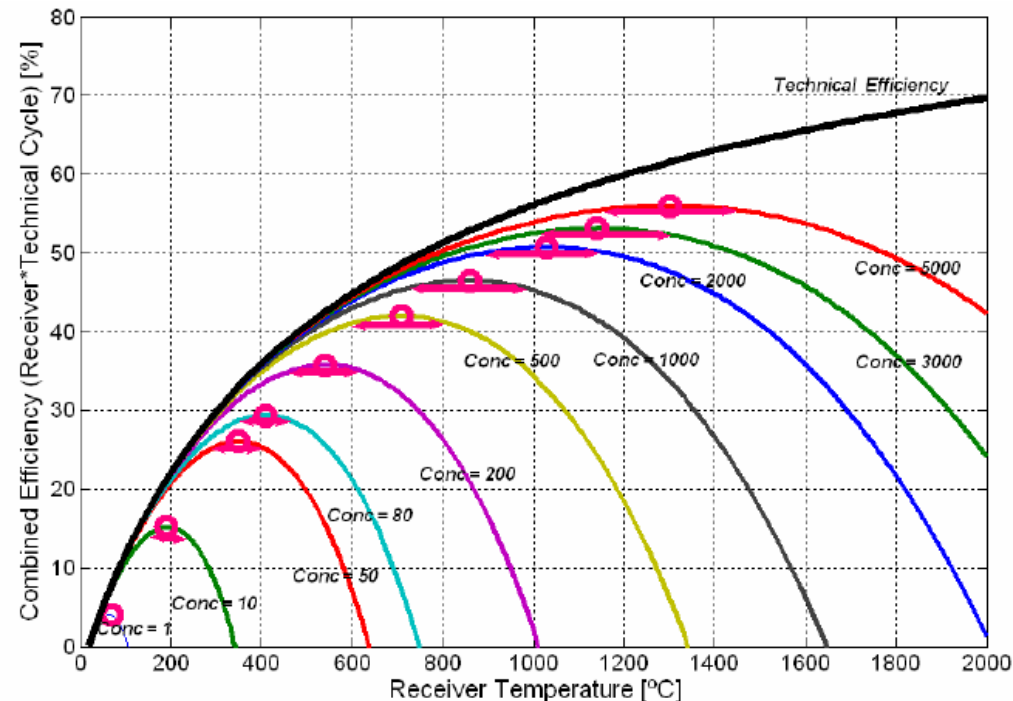
Overview

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



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

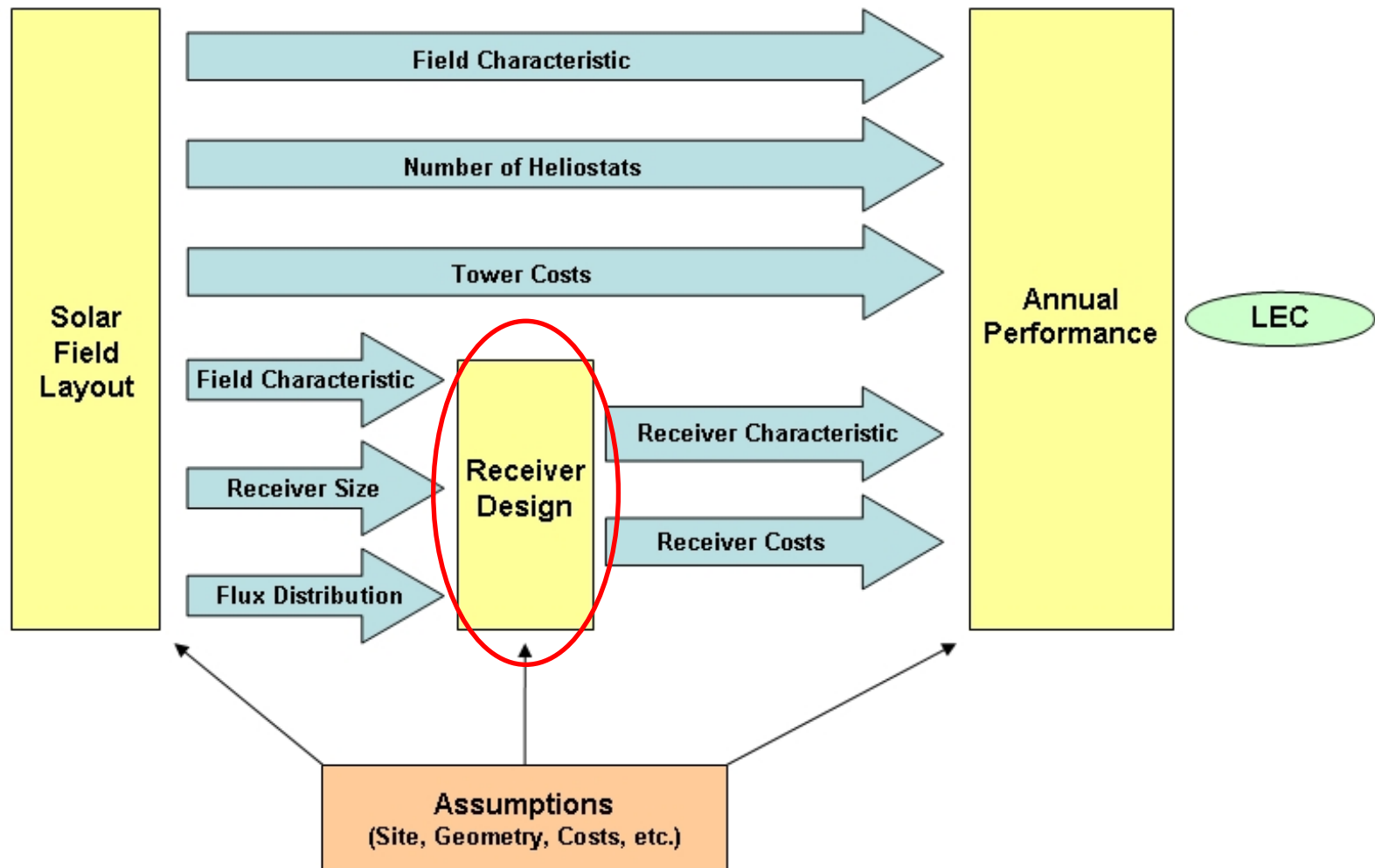
State of the Art

- 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)

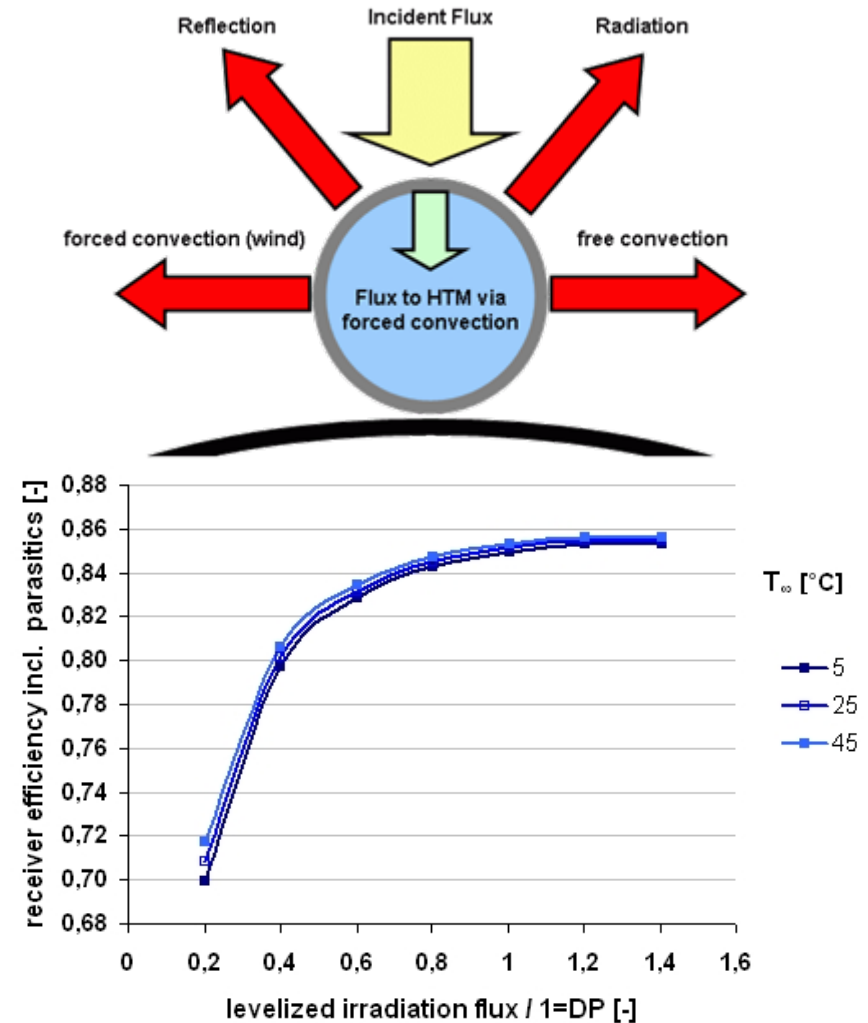
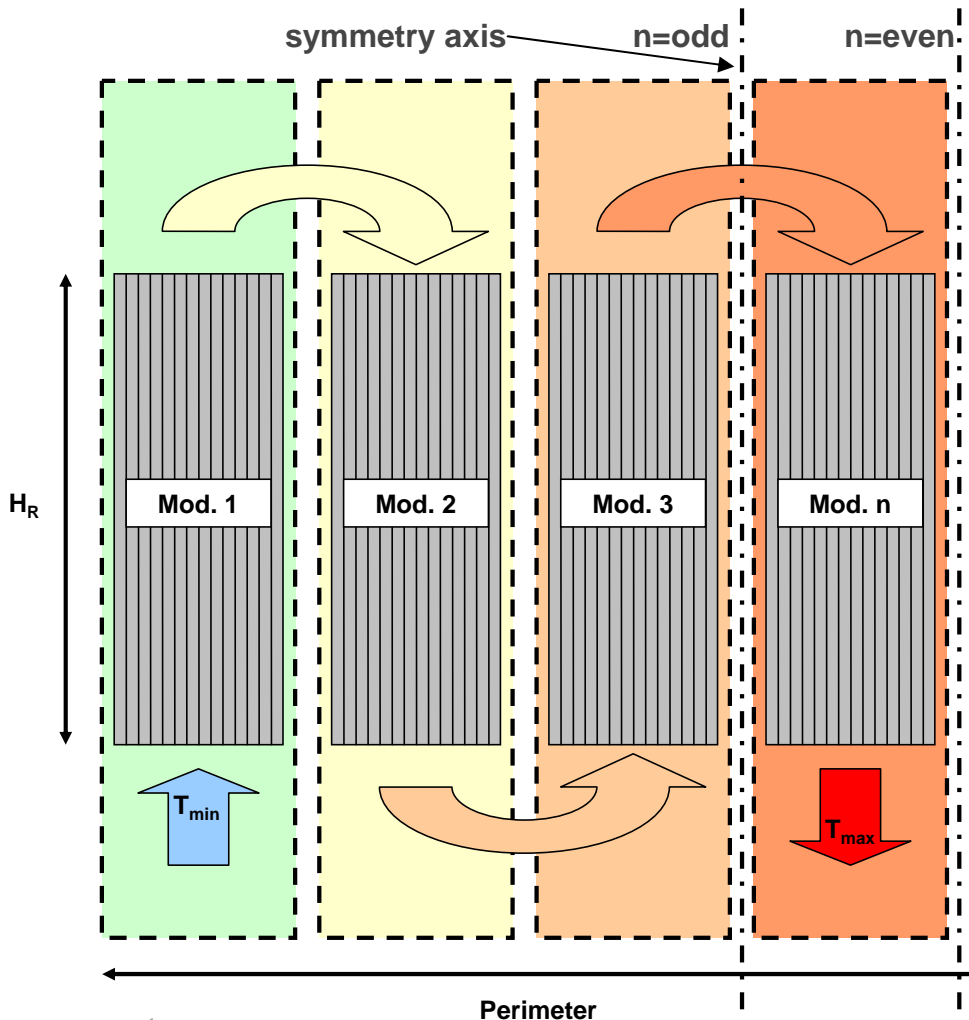
Innovations

- 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

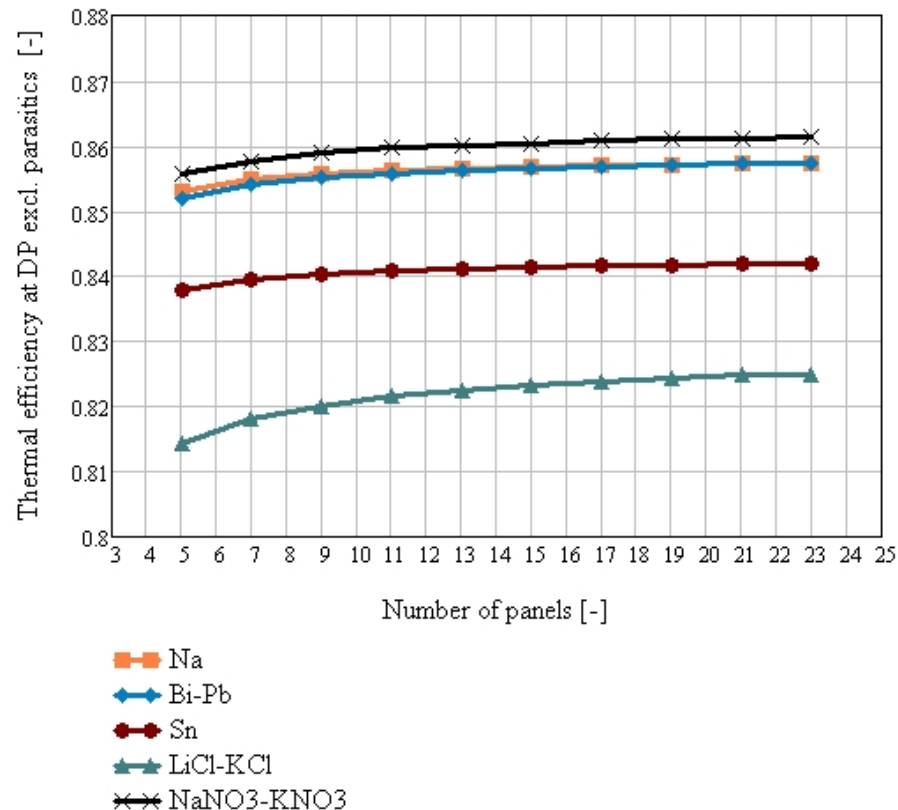


Numerical Model - number of serial panels

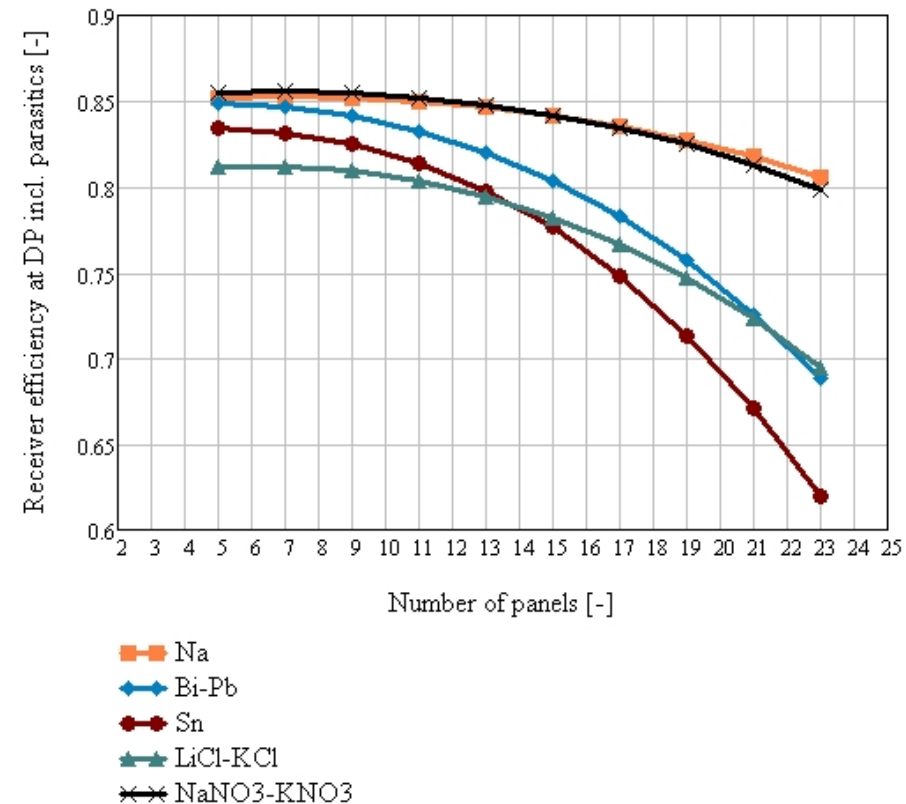


Results - performance due to number of serial panels

Without HTM pumping parasitic losses

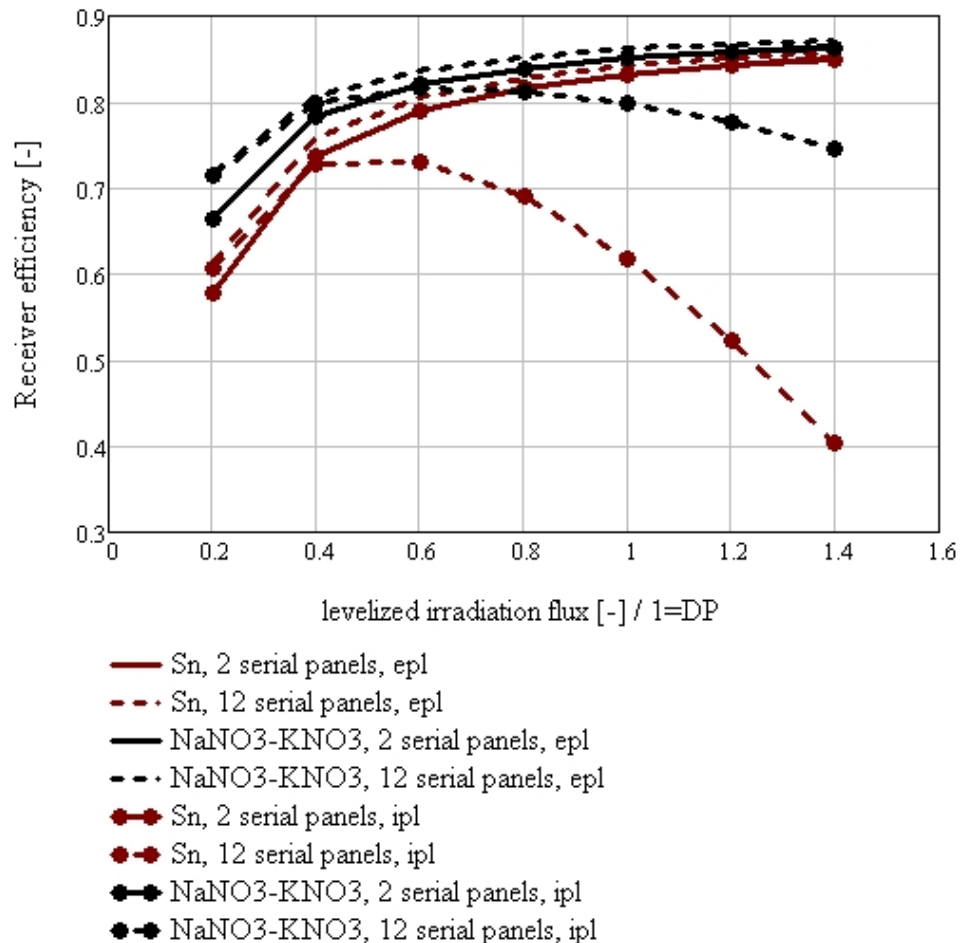


With HTM pumping parasitic losses

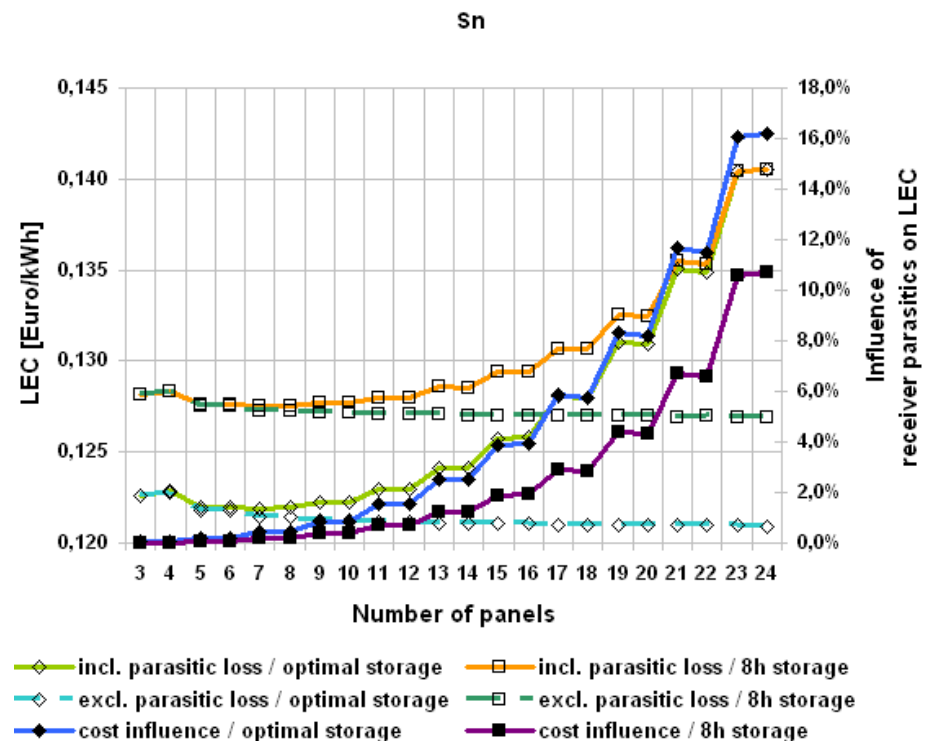
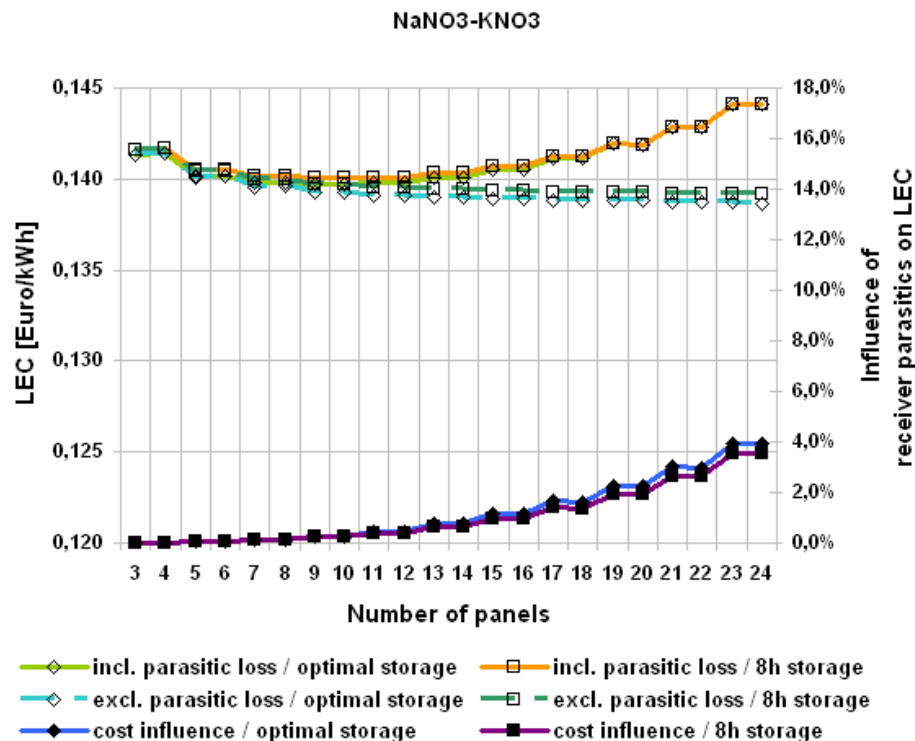


Note: The number of serially flow-through panels has a significant influence on the plant performance

Results - performance due to number of serial panels

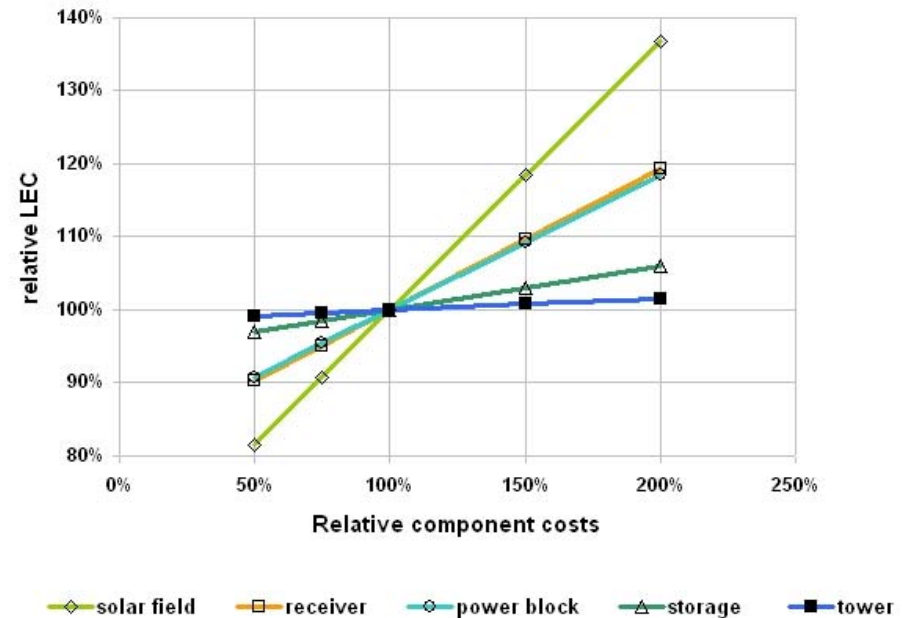
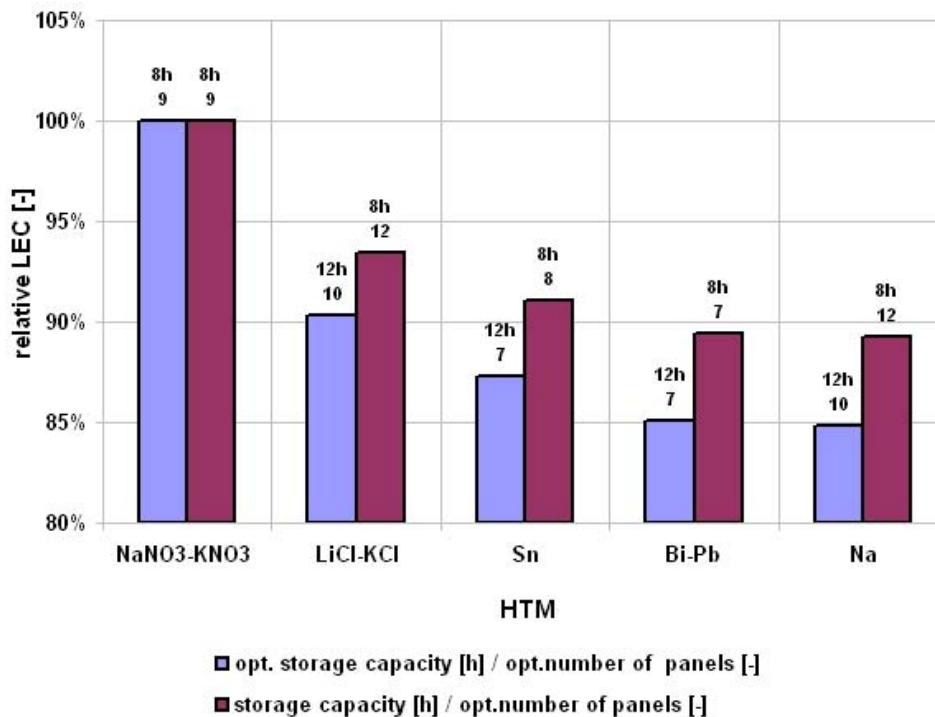


Results - LEC due to number of serial panels



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