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Identification of optimum molten salts for use as heat transfer fluids in parabolic trough plants. A techno-economic comparative optimization

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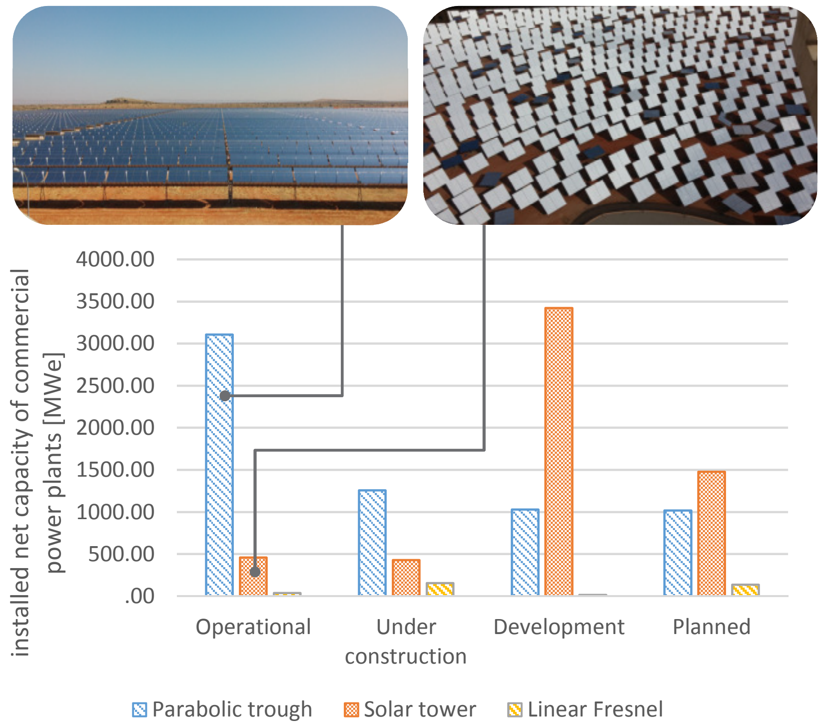
Contents

Introduction

- PT most mature and bankable CSP technology
- Towers are catching up
- Increase competitiveness of PT by reducing LCOE
- Higher cycle efficiency through larger cycle temperature difference needed
- Molten salt linked to challenges
- New opportunities for CSP in Southern Africa



Source: CSP World, 2017

Background

- LCOE reduction by switching from thermal oil to molten salt
  - 12.1 % (Dersch *et al.*, 2014)
  - 16.4 % (Boukelia *et al.*, 2015)
  - 20 % (Ruegamer *et al.*, 2014)

  large variations caused by different assumptions and locations (Abu Dhabi, Béchar, Daggett)

- LCOE reduction by using different molten salts
  - 3 to 5 % (Ruegamer *et al.*, 2014)

  small variations but still significant

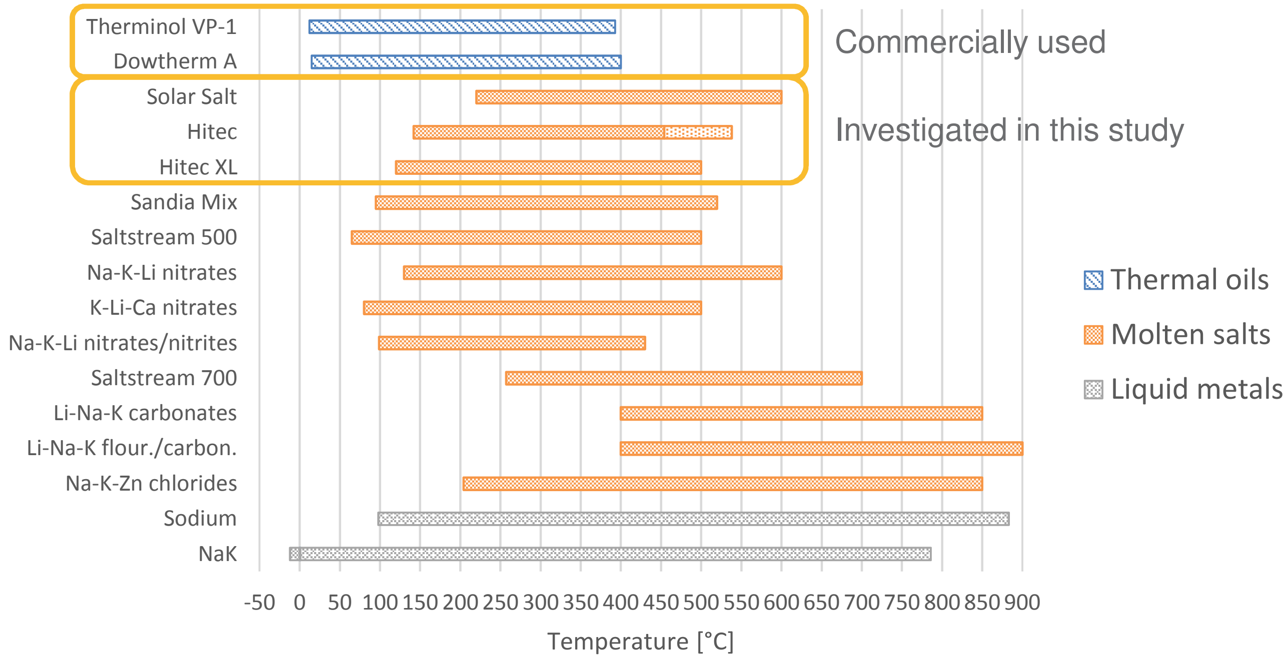
- LCOE variations in literature
  - 7.59 to 23.6 $cent/kWh$_e$

- Studies only look at one power plant configuration and compare it with other fluids, but what about different configurations?

Research question

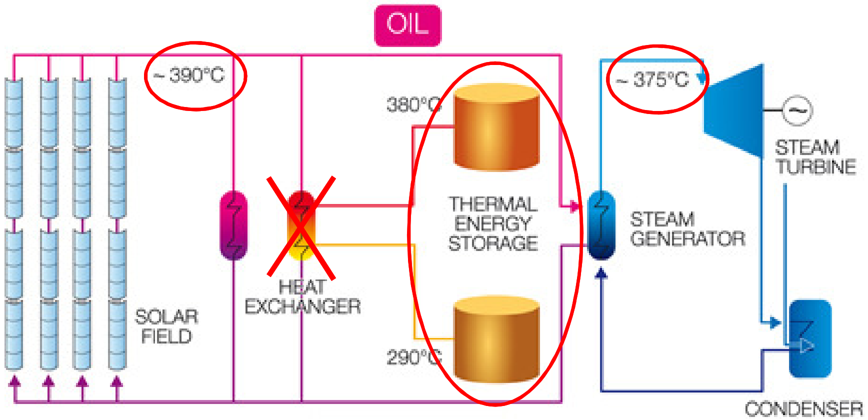
- Which molten salt as heat transfer fluid (HTF) is most suitable to improve the performance of a parabolic trough power plant from a techno-economic standpoint for a variety of configurations and locations?

Heat transfer fluids

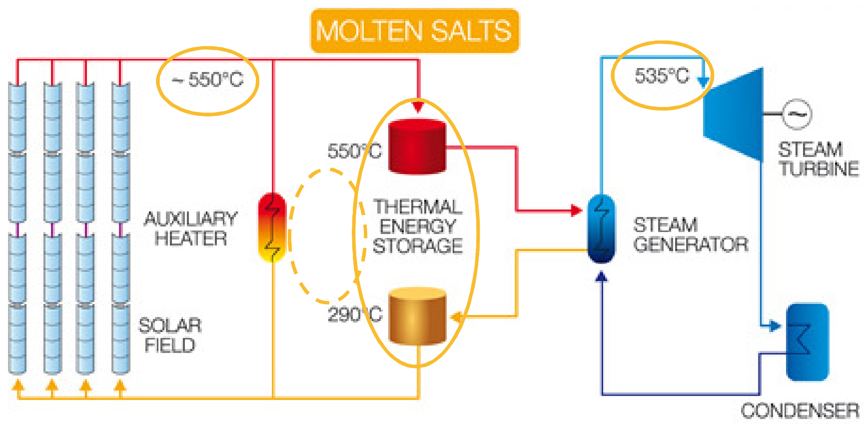


Sources: Dow Chemical Company, 2001; Bradshaw & Siegel, 2008; Vignarooban et al., 2015

Advantages of molten salts



Cycle efficiency up to 38 %



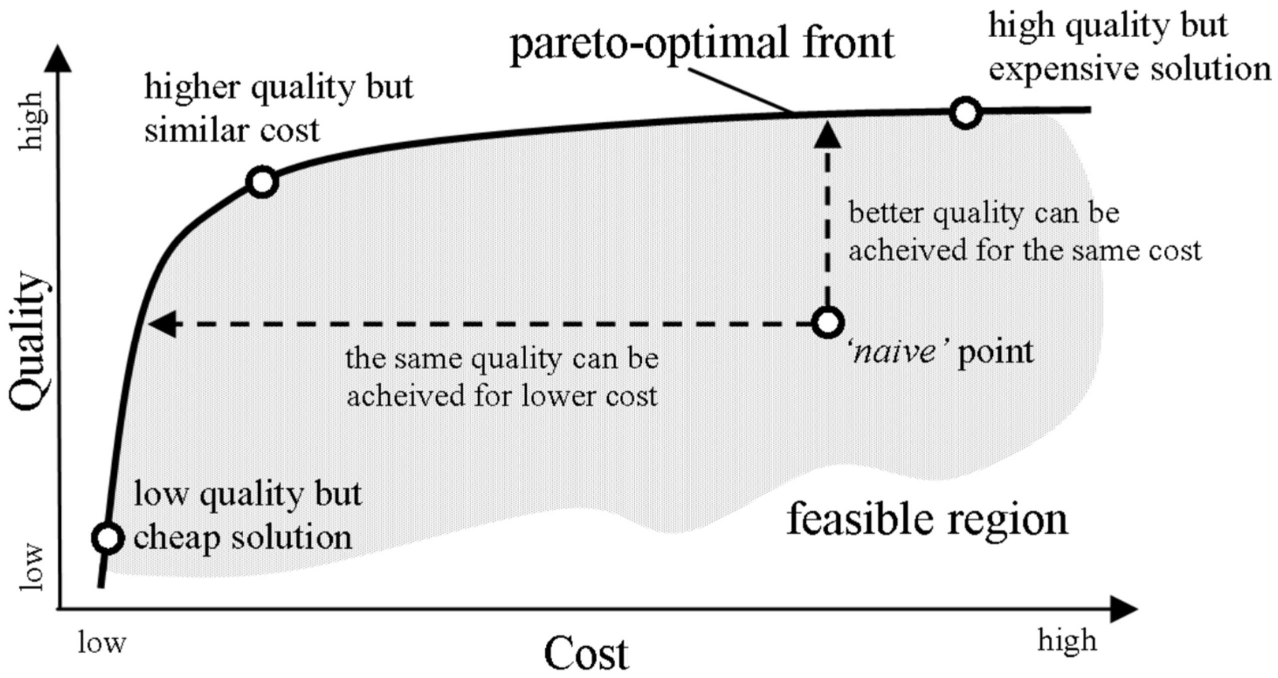
Cycle efficiency over 40 %

Adapted from: Archimede Solar Energy, 2016

Techno-economic optimization

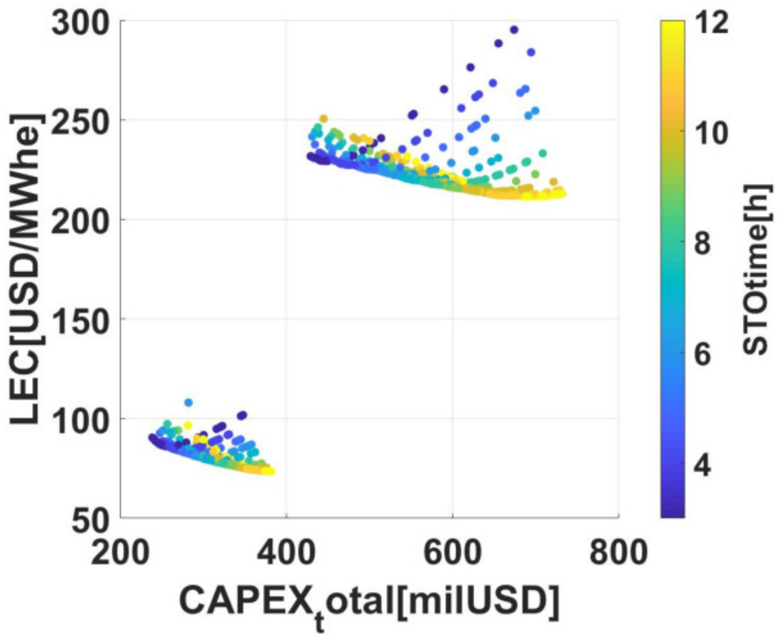
- Optimization of technical and financial indicators
  - LCOE
  - CAPEX
  - IRR
- Identification of optimal HTF for
  - various component sizes (TES, solar field, turbine capacity, etc.)
  - various operating strategies (base load or peaking)
  - various location-based framework conditions (solar resource, feed in tariff, financial parameters)
- Population based evolutionary algorithm
- Range of solutions that are optimal
- Compromise between cost and quality

Techno-economic optimization

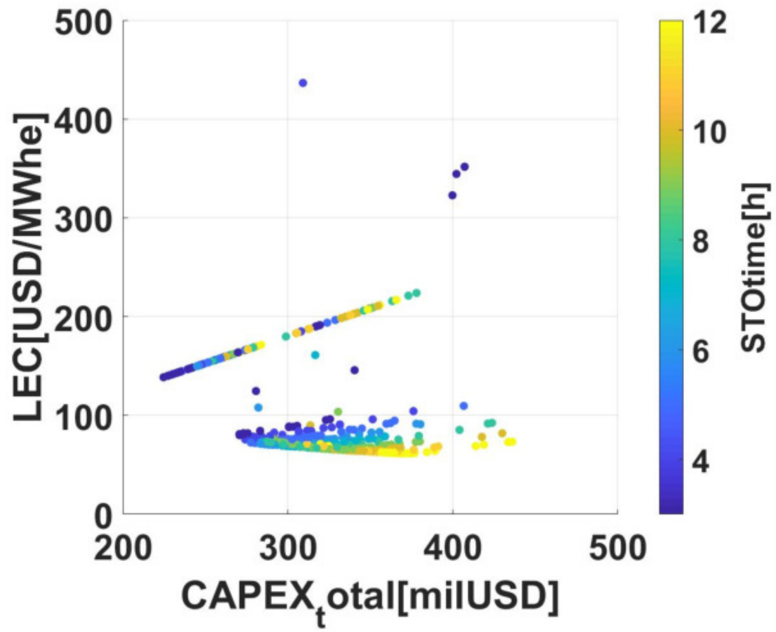


Source: Spelling, 2013

Results – TES (Upington)

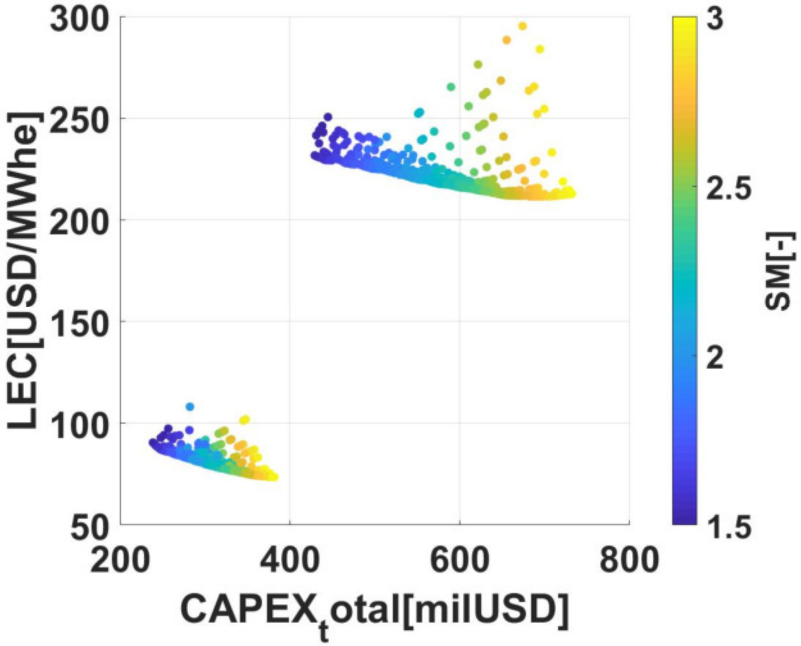


Thermal oil

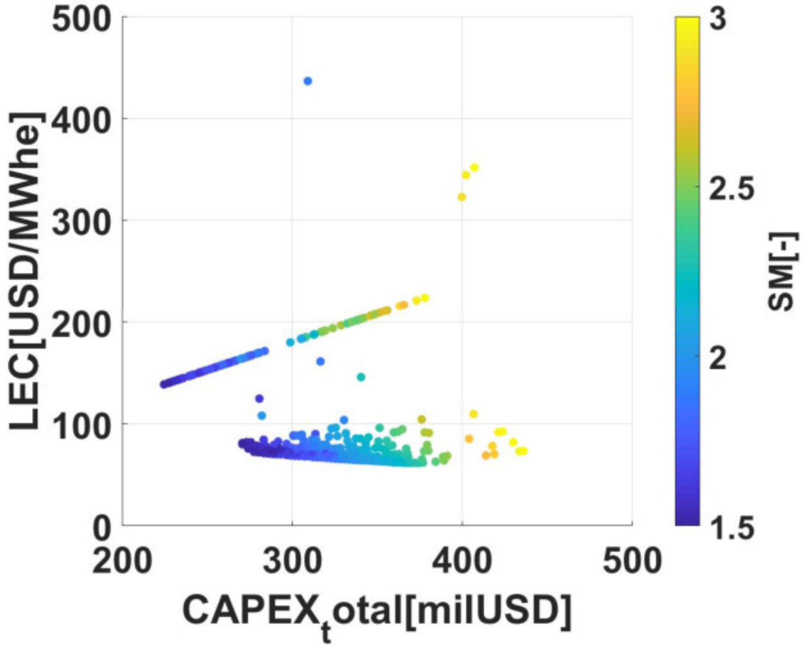


Solar Salt

Results – Solar field (Upington)



Thermal oil



Solar Salt

Next steps

- Vary other parameters (turbine capacity, location)
- Analyze different operating strategies (base load, peaking)
- Analyze different molten salts (Hitec, HitecXL)
- Optimize IRR, capacity factor
- Future applications of optimization
  - TES technology (direct storage, thermocline)
  - Water consumption
  - Steam generator (ramp-up rates, pinch points)

Conclusion

- Optimal HTF for specific framework conditions existent?
- Model can be used to find optimal power plant configuration in terms of
  - location
  - operating strategy
  - feed in tariff
  - costs
- New salt mixtures needed
  - cheaper
  - wider operating temperature range
- Increase competitiveness of parabolic trough
- Support for policy makers, developers and plant operators
- Technology promotion & development opportunities in Southern Africa

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Thank you

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