A Techno-Economic Analysis of Parabolic Trough CSP Plants for Profitability Enhancement

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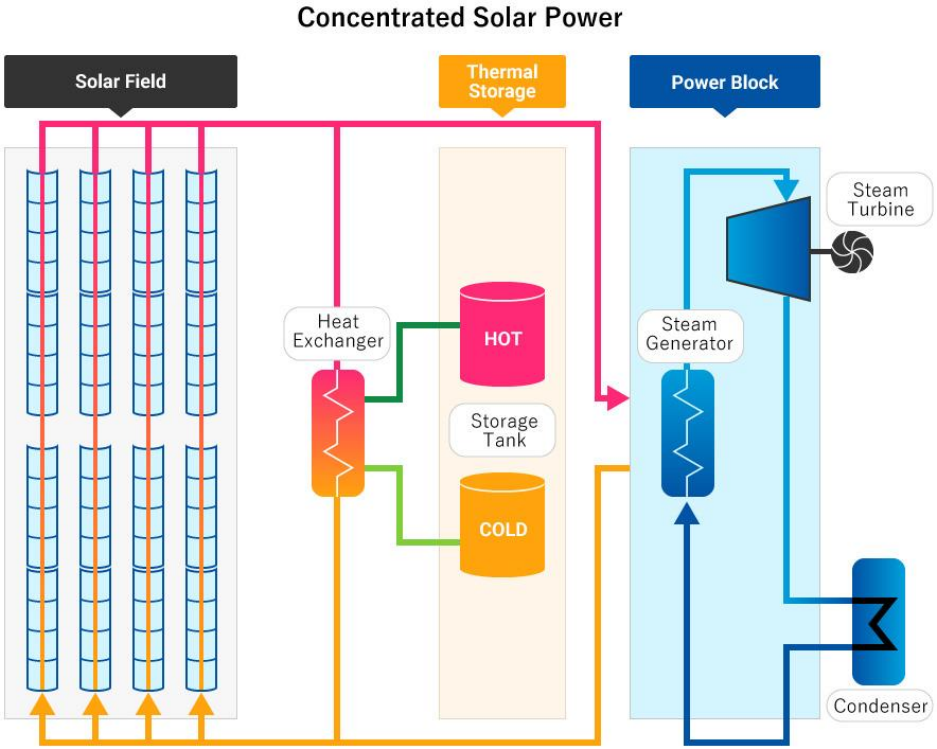
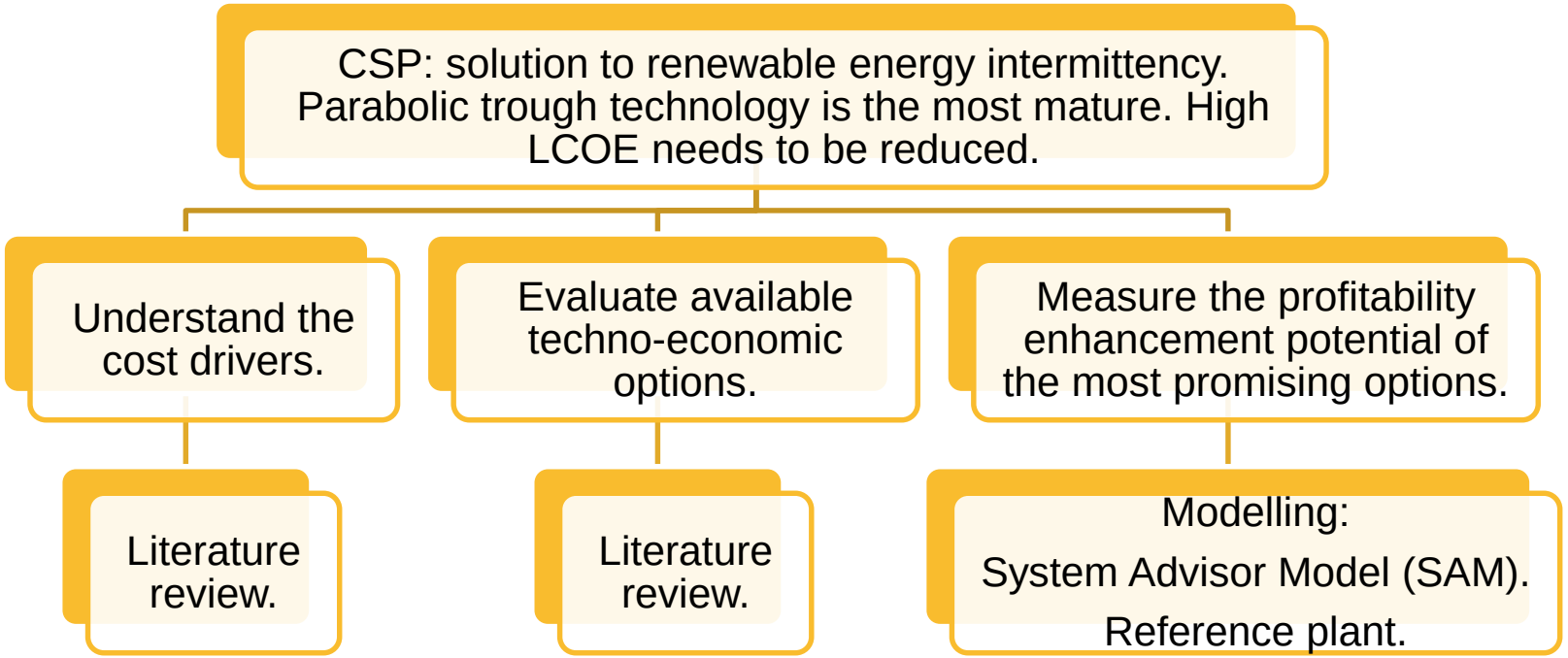
Technology Description



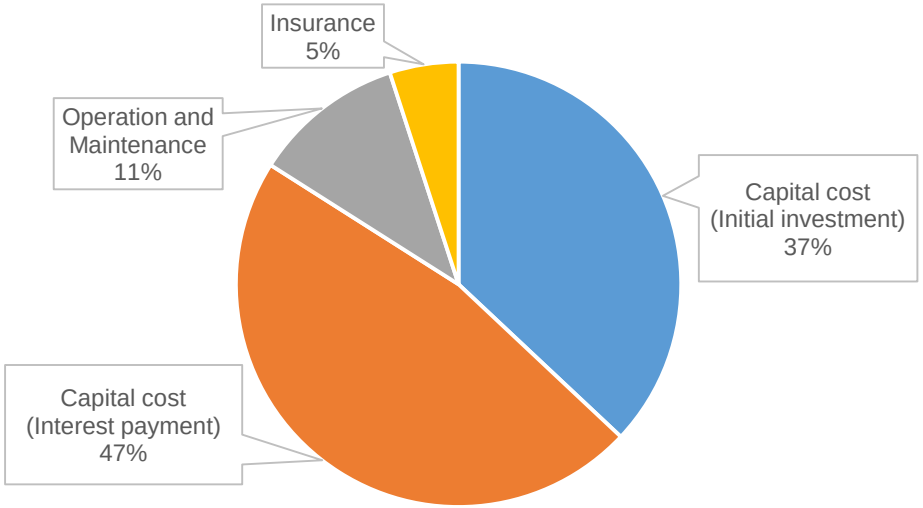
Source: CH4 Energy Group (2019)

Motivation, Objectives, Methodology



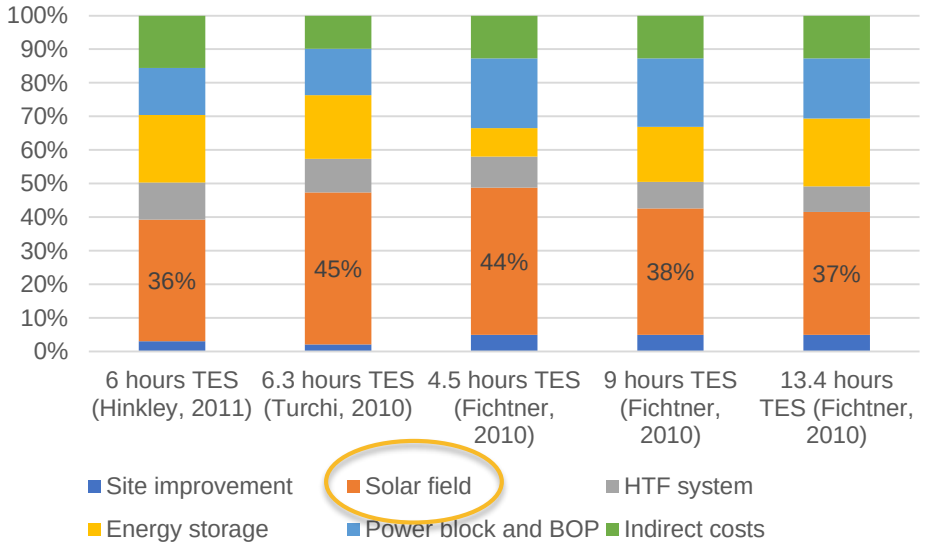
Cost Drivers

Breakdown of the LCOE



Source: IRENA (2016) in New Energy Update: CSP (2019)

Breakdown of the initial investment for 100 MW

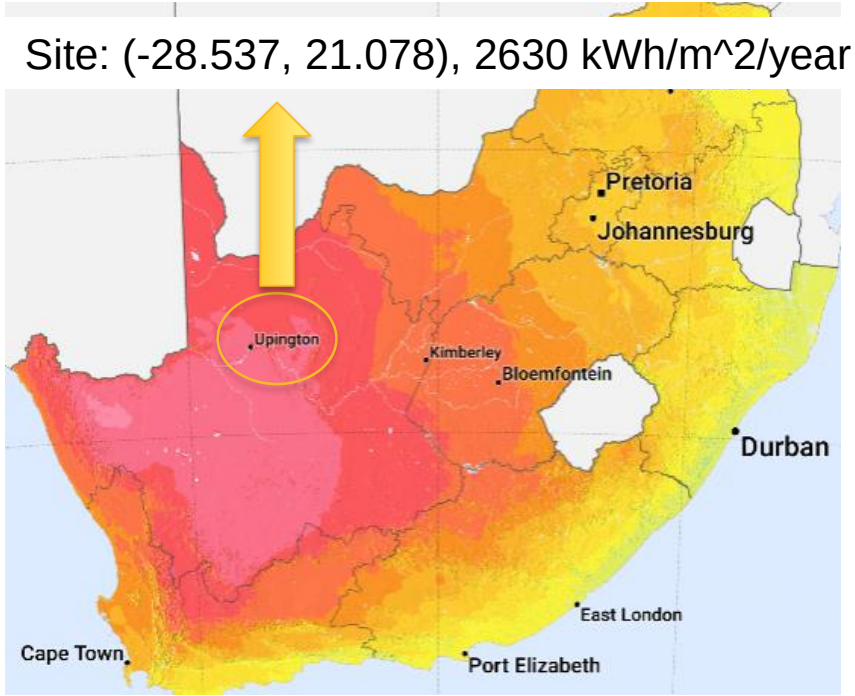


Review of Techno-Economic Options

Solar field	HTF	TES	Scale-up	Project Financing
✓ Reduce CAPEX: larger collectors: Ultimate Trough • Performance: selective coating; Mirror reflectivity	✓ Molten salt • Direct steam generation • Air	✓ Direct 2-tank • Thermo-cline • Latent heat • Thermo-chemical	• Economies of scale	✓ Lower debt interest rate ✓ Tax incentives ✓ Public finance

Reference Plant

Site: (-28.537, 21.078), 2630 kWh/m^2/year

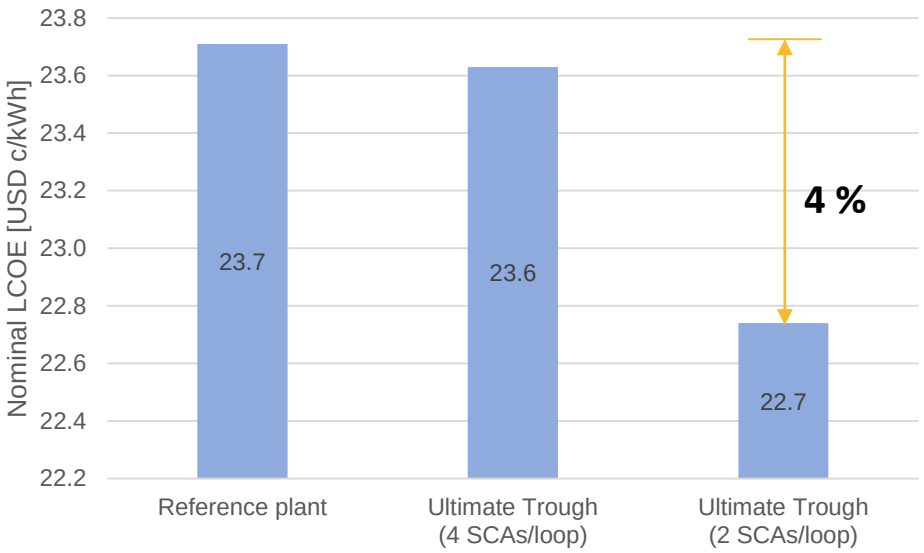


Source of TMY weather data: European Commission (2019)

Input/Assumptions

- **Solar field:** EuroTrough collector (150 m long, 5.75 m wide); Schott PTR70 2008 receiver.
- **HTF:** Therminol VP-1 (293-393 °C)
- **Thermal Energy Storage:** 5 hours; Hitec XL molten salt; 2-tank indirect.
- **Power block:** 100 MW net; Dry cooling; Cycle efficiency = 36.4 %.
- **Capacity factor:** 45 %.
- **Financing:** 25 years PPA; 10 % interest rate; 16 % target IRR; DSCR = 1.35; 10 % discount rate.

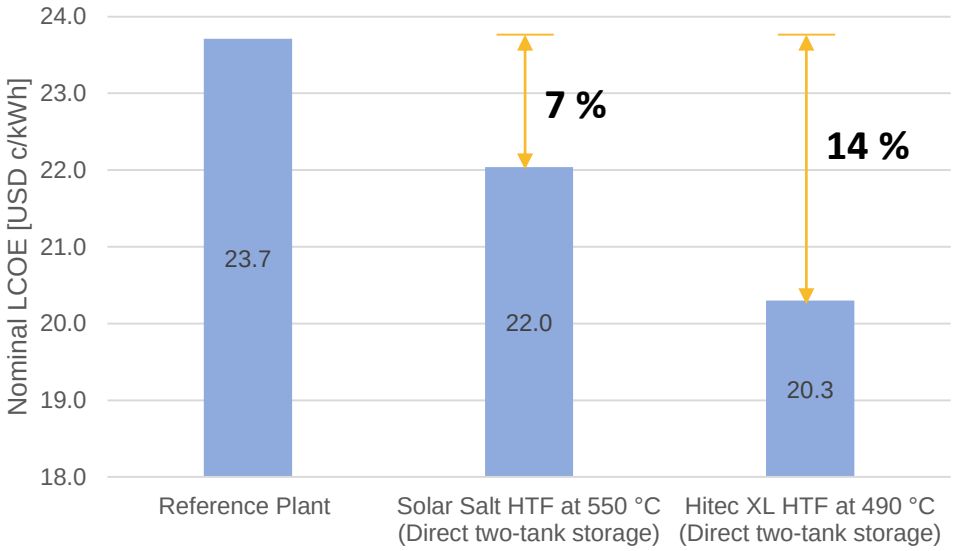
Results: Solar Field



Input/Assumptions: Adapted from Ruegamer et al. (2013)

- Ultimate Trough: 247 m long; 7.5 m aperture.
- Schott PTR80 receiver: 80 mm OD.
- Solar field specific cost ($/m^2): -13 % for 4 SCAs/loop; -6.5% for 2 SCAs/loop.

Results: HTF and TES

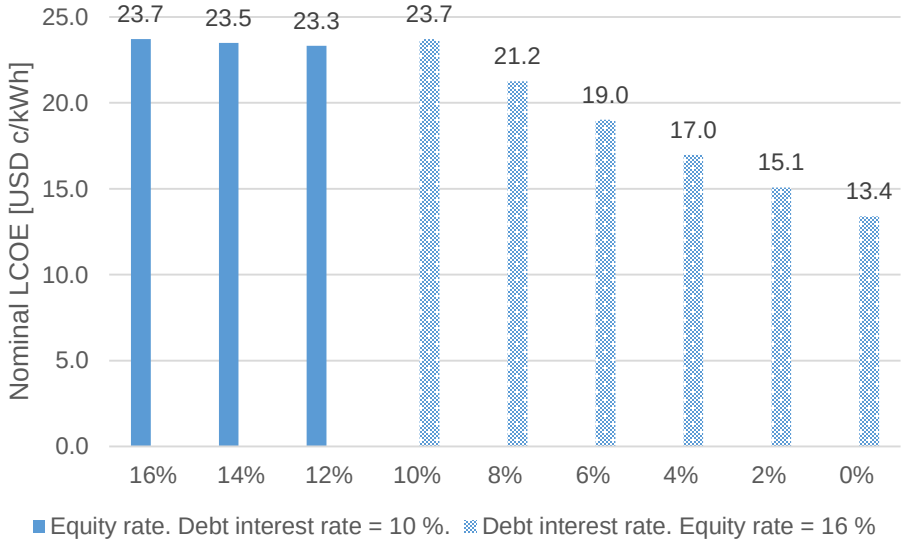


Input/Assumptions: Adapted from Ruegamer et al. (2013)

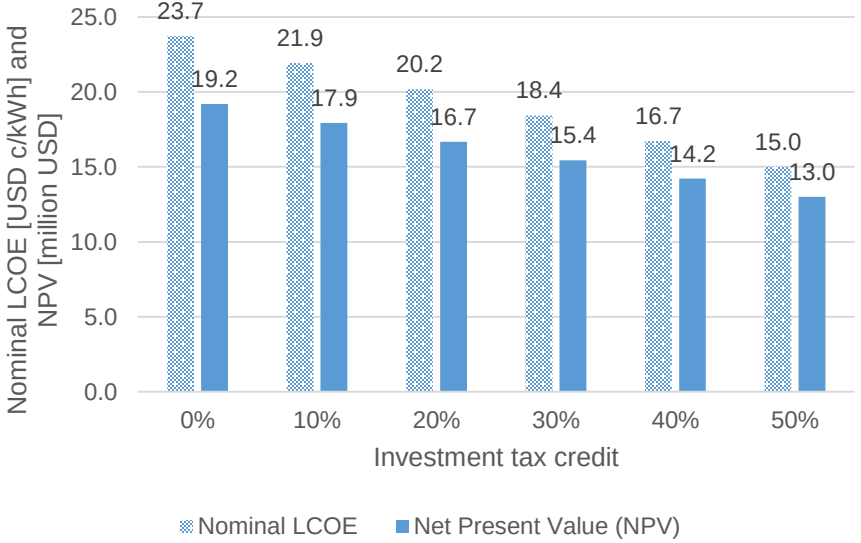
- Cycle efficiency: 41 % for Solar Salt; 39 % for Hitec XL.
- Solar field cost ($/m^2): +6 %
- TES cost ($/kWhth): -50 % for Hitec XL; -60 % for Solar Salt.
- Power block cost ($/kWe): -15 % for Hitec XL; -17 % for Solar Salt.

Results: Financing

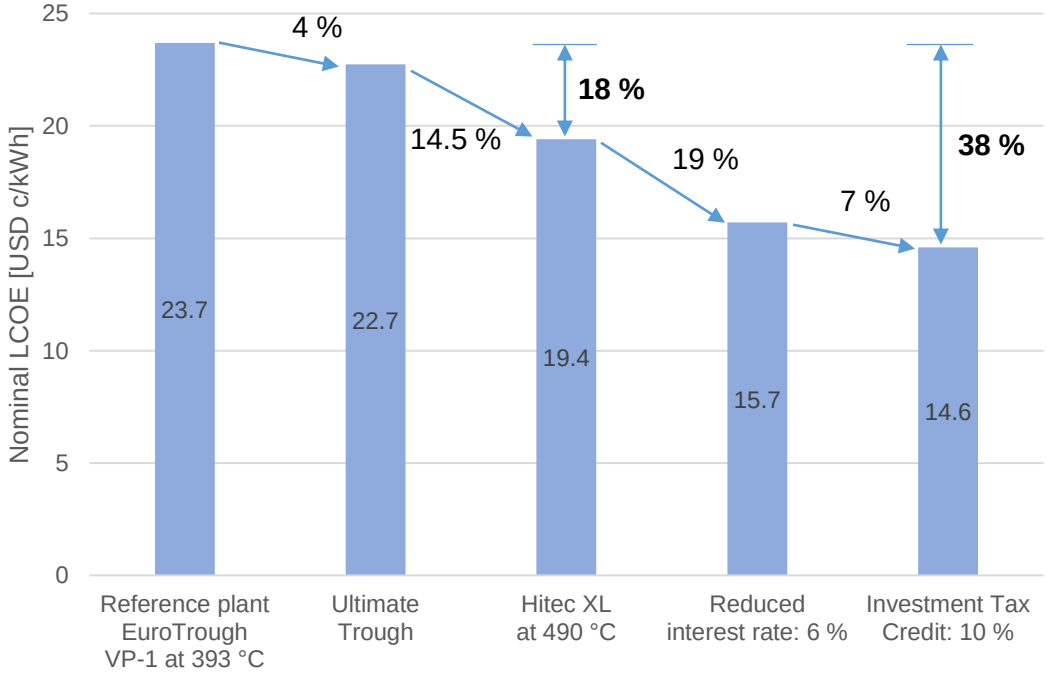
Effect of reducing equity rate and debt interest rate



The effect of investment tax credits (ITC)

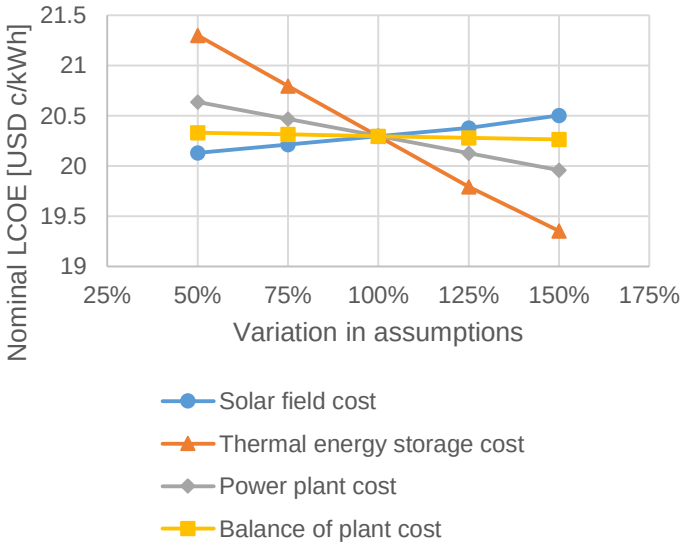


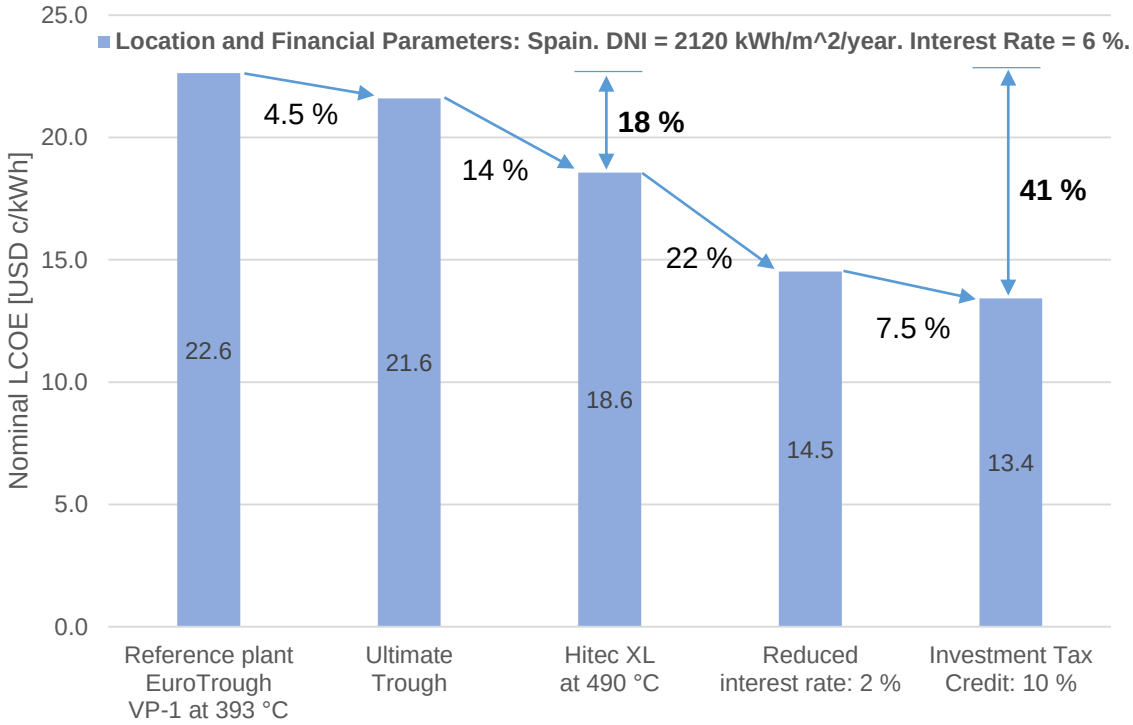
Proposed Cost Reduction Path



Sensitivity Analysis

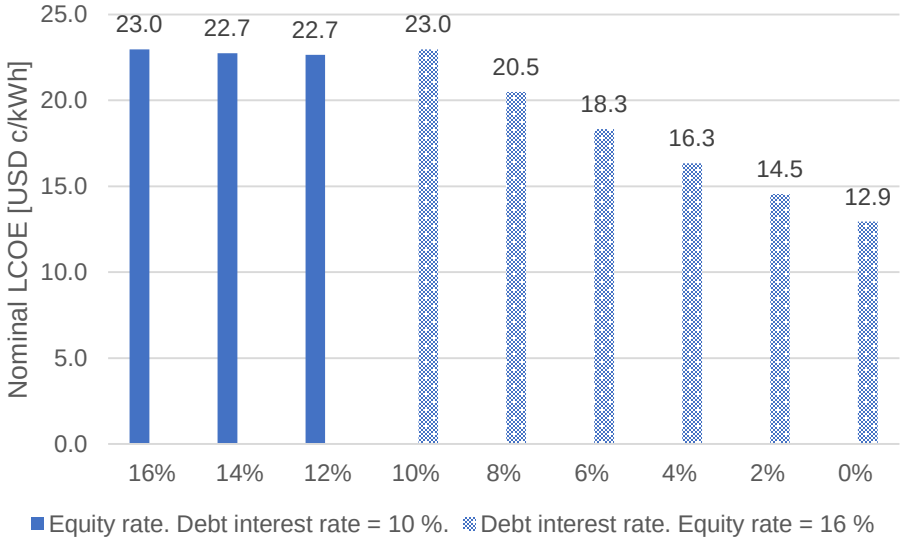
HTF and TES model





Sensitivity Analysis

Effect of reducing equity rate and interest rate



Modified Parameter:

- Decrease DSCR from 1.35 to 1.2
- Results are not affected.

Conclusion

- **Most important cost drivers**: installed cost dominated by the solar field; financing costs (interest payment).
- **Most promising cost reduction paths**:
  1. Reduce capital cost: solar field offers more opportunity
  2. Improve financing conditions to reduce interest payment. Public financing tools are important to reduce the perceived financial risk.
  3. Performance improvement: molten salt heat transfer fluid and direct two-tank storage.
- **Cost reduction potential**:
  1. Ultimate Trough (also other large collectors) found to reduce nominal LCOE by 4 %. Could be more.
  2. Hitec XL is currently more appropriate as molten salt HTF: ~14 % reduction in LCOE.
  3. Decreasing interest rate by 4 %: ~19-22 % reduction in LCOE.
  4. Investment tax credit: LCOE reduction by 1.7 USD c/kWh for every 10 % credit.
  5. Cumulative cost reduction potential: 38-41 %

Future Work

- Validation of the findings with a different modelling software.

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THANK YOU

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