Research and Development in CSP

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Research & Development Objectives

- Cost reduction (LCOE)
- Expansion of the location possibilities
- Electricity generation around the clock
- Expansion of uses

SITEF: A public funded project (SOLAR-ERA.NET) at Plataforma Solar Almeria

Proof of Concept / Qualification of HELISOL® 5A at 425°C and beyond

by courtesy of CIEMAT

EPC, CSP-Developer	Component Suppliers	Ownership, operation	Certifier
Engineering /Upgrade: ▪ TSK-Flagsol FS, ▪ CIEMAT CI, ▪ TÜV-Nord TN, ▪ DLR	▪ REPAS: Senior Flexonics SF ▪ Receiver: Rioglass ▪ HTF: Wacker WA	▪ CIEMAT CI	▪ Lab analysis: DLR ▪ techno-economic evaluation: DLR, FS ▪ Risk evaluation: TN, DLR, FS, WA ▪ external evaluation: RWE

SITEF project is funded by the governments of Spain and Germany

Source: www.dlr.de

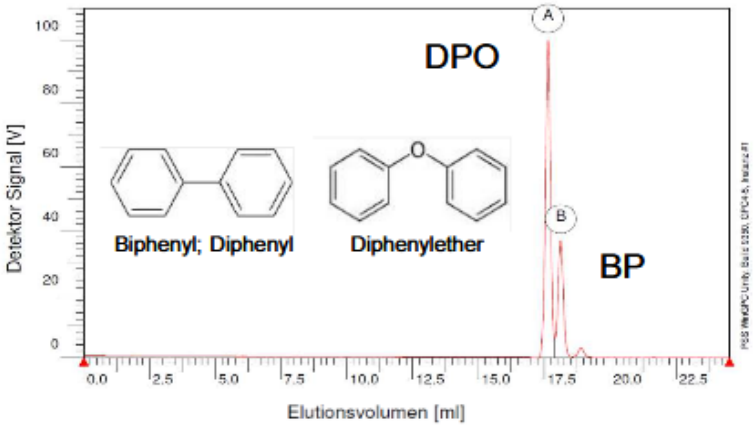
SITEF Objectives

- Demonstrate functionality and practicality of Silicone heat transfer oil HELISOL® in interaction with parabolic trough collector operating temperatures up to 450 °C
- Significant increase operating temperature enables significant increase overall power plant efficiency
- SITEF links seamlessly to the previous project SI-HTF, whose activity with experimental durability tests on a laboratory scale demonstrated the suitability of HELISOL® for use in parabolic trough power plants
- Additionally SITEF houses the development, deployment and demonstration of necessary and specially adapted receiver tubes from SCHOTT and REPAs of Senior Flexonics to be used with silicone heat transfer fluids
- Subsequently: Operation and Maintenance (SIMON) project; Timeline: Oct. 2017 – Sept. 2019

Differences between HELISOL® 5A and BP/DPO

BP/DPO eutectic mixture

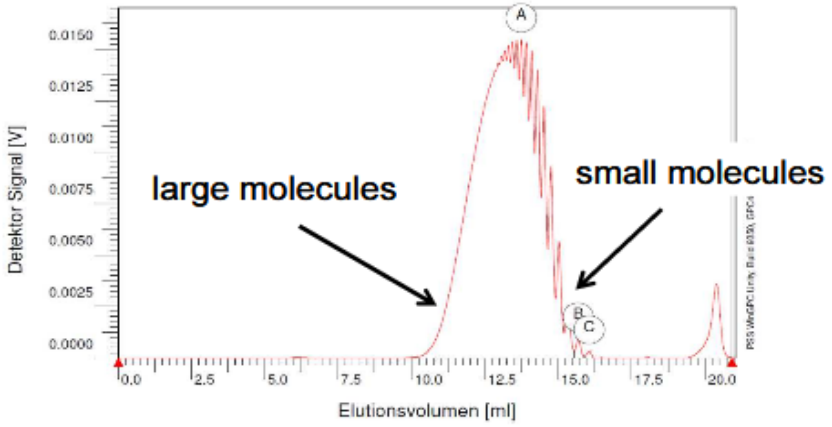
- 25-28% BP, 72-75% DPO
  (Diphyl, Dowtherm A, Therminol VP1)



- Working temp.: 60 to 400 °C
  Freeze Point: 12 °C → freeze protection

HELISOL® 5A

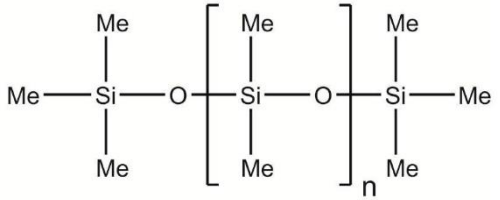
- HELISOL® 5A is a low viscosity polydimethylsiloxane, a multi-component mixture of molecules with various molecular weights



- Working temp.: -40 to 425 °C
  Freeze Point: -65°C

Source: www.dlr.de

Structural formula:



LCOE – Levelized Cost of Energy

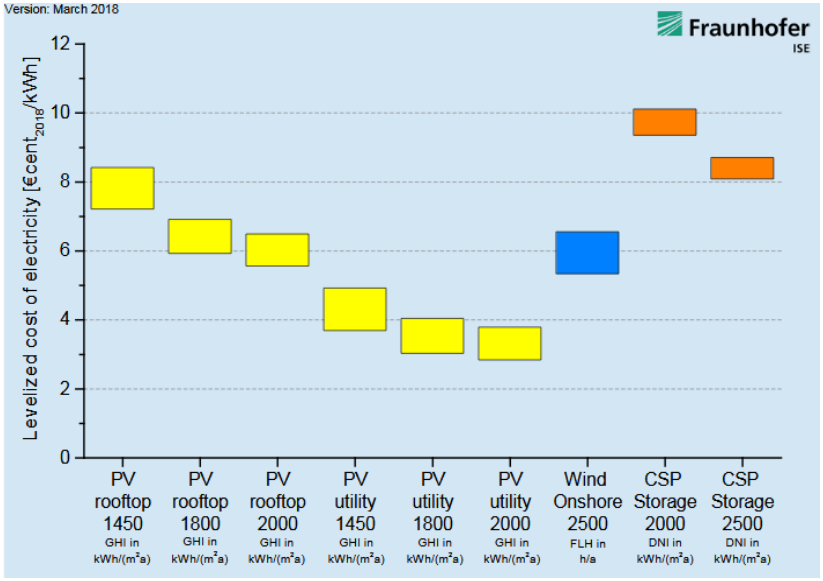
- Reduced costs TES
- No Ullage system needed for viscosity control
- No freeze protection
- Higher vapor pressure

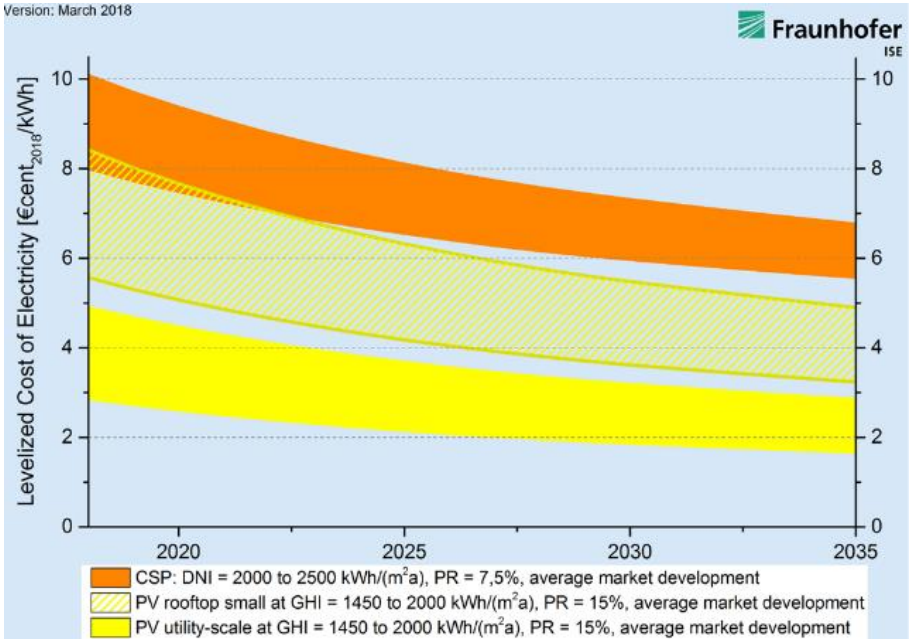
- No recirculation for freeze protection
- Easier maintenance
- Less pump energy (low viscosity)
- Shorter start up period
- Lower degradation/exchange rate @ same temp.
- Lower H2 generation
- No fouling

$$LCOE = \frac{CRF^* \sum CAPEX + \sum OPEX\_annual}{Electricity\_annual}$$

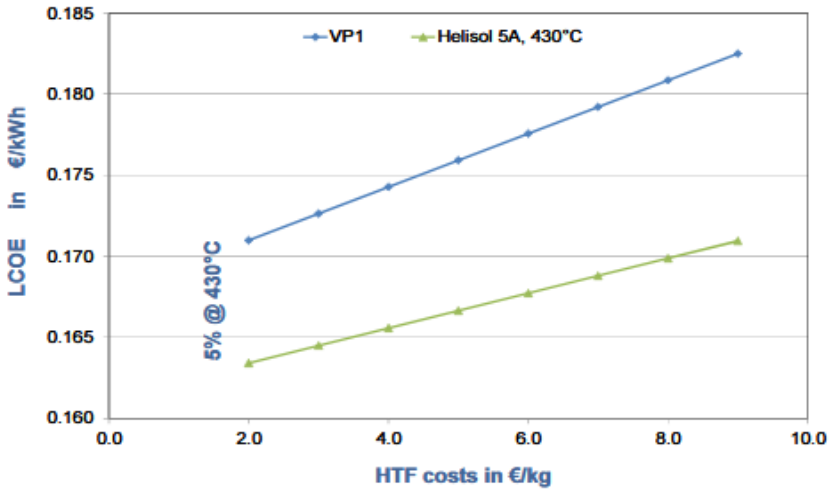
Working temp.: - 40°C to 430°C,
EHTF: 60°C to < 400°C

LCOE – CSP vs PV





HELISOL®5A enables LCOE reduction of ~ 5%



Restrictions:

- Calculation is based on LCOE calculation in Guadix (E).
- Solarfield- and storage size are based on minimal LCOE.
- Specific solarfield costs are higher…
- Specific costs of the TES are lower…

Conclusion:

- HELISOL® 5A offers advantages over commonly used HTF`s
- in terms of applicability for HELISOL® 5A in CSP plants no hindering issues were found

Source: www.dlr.de

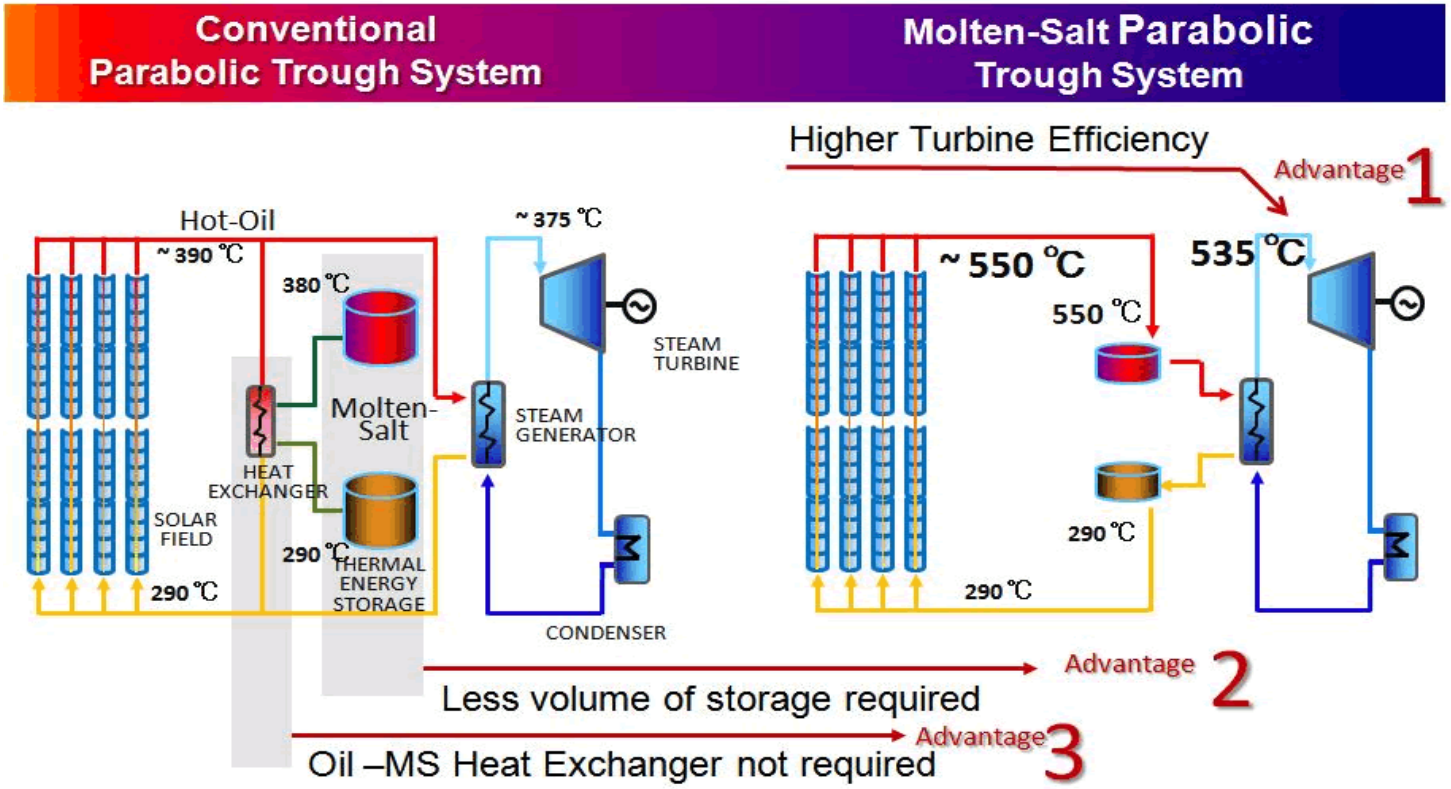
HPS2 (High Performance Solar 2) - Évora,Portugal

- Build and operate test Facility of a parabolic trough collector loop
- Molten salt (mix: 60% $NaNO_3$ - 40% KNO_3) instead of thermal oil
- Reduce the levelized electricity costs
- International consortium led by the DLR Institute of Solar Research
- Consortium: TSK Flagsol, Eltherm, Yara, Steinmüller Engineering, South African Energy Provider Eskom and University of Évora

Source: www.sencener.com

HPS2 – Why molten salt?

- Cost reduction – reduction of LCOE



Source: www.researchgate.net

HelioTrough® Parabolic Trough Collector

- Cost reduction by
  - Increasing efficiency and size
  - Reducing number of parts (mirrors, HCEs, steel parts, drives, swivel joints, control systems etc.)
  - Reduction assembly and alignment costs
  - Reduction Maintenance Costs
  - Increasing Lifetime

Source: http://www.heliotrough.com

Heliotrough - Summary

- HelioTrough· technology ~ 20 % less expensive
- Levelized Cost of Electricity ~ 10 % lower
- Prototype erection, assembly concept and optical accuracy validated
- Since 2009, HelioTrough collectors installed and continuously operated at Kramer Junction (USA) for testing and demonstration purposes
- Results show high expected performance
- Annual efficiency increased: 48 % vs 44 % SKAL ET collector
- Technology ready for commercial application

Capture: Solar Tower Project at Plataforma Solar Almeria, Spain

Source: http://capture-solar-energy.eu/

Capture: Objectives

- Reduce costs of CSP, in order to pave the way for its deserved competitiveness on the power market
- Increase plant efficiencies
- Reduce LCOE by developing all relevant components that allow implementing an innovative plant configuration
- Development of advanced power cycles and thermal storage integration: combined cycles with air or CO2 as primary fluid with T > 1000 ºC

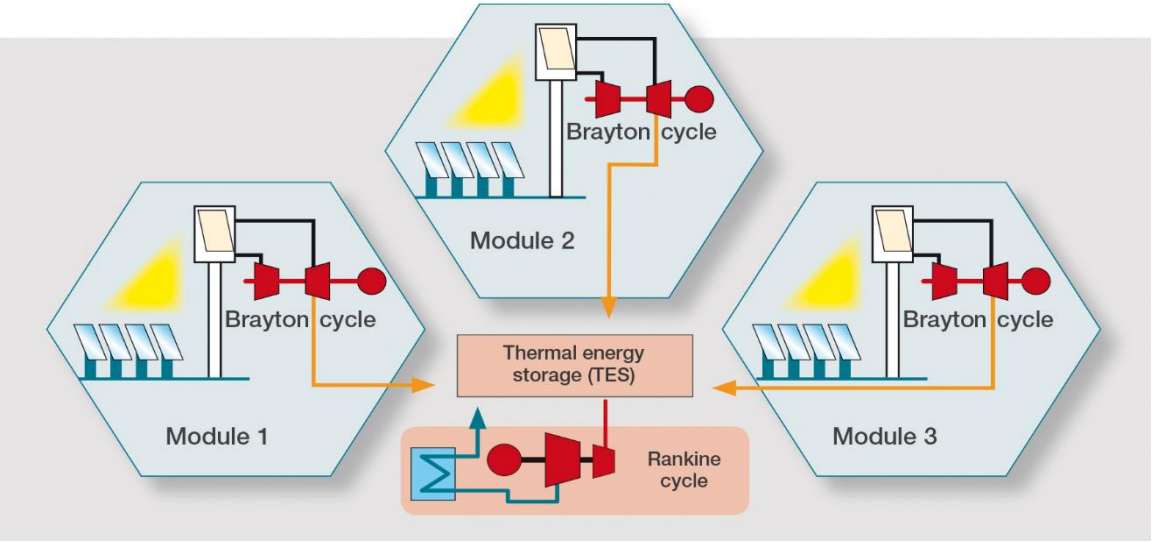
Capture: Administrative Details

- Project financed by EUREC (European Renewable Energy Research Centres)
- Part of Horizon 2020: 8th phase Framework Programme for research
- Duration: 48 months
- Coordinator: Fundacion Cener – Ciemat
- Number of Project Participants: 13

Source: http://capture-solar-energy.eu/

Capture: Decoupled Solar Combined Cycle Concept

- Multi-tower decoupled advanced solar combined cycle approach
- Avoids frequent transients and inefficient partial loads
- Maximizing overall efficiency, reliability and dispatchability
- Solar driven gas turbines allow implementation of combined cycle plants to maximize thermal-to-electric energy conversion
- Thermal Energy Storage guarantees dispatchable power generation



Source: http://capture-solar-energy.eu/

Capture: Heliostat Field

- Heliostat Field consits of relatively small flat mirrors
- Goal: US$ 100 / m^2 (industry average US$ 120/m^2)
- Reduce costs by:
  - Improved driving mechanism
  - Improved calibration system
  - Improved wind load

Source: http://capture-solar-energy.eu/

Capture: Key Performance Indicators

Description	KPIs defined at STE-EII		How KPI is Addressed
1. Overarching KPI	KPI-1	Reduce PPA (Power Purchase Agreement) needed to make projects happen	Up to 31% LCOE reduction
2. Increase efficiency and reduce costs	KPI-2	Increased solar-to-electricity conversion efficiency	Average annual efficiency 18-20% (up to 35% increase)
	KPI-3	Increase HTF Temperature	> 1000ºC at Brayton cycle inlet
	KPI-4	Reduced cost of installed products and O&M for state-of-the-art commercial plants	Up to 35% CAPEX reduction 15-25% OPEX reduction
	KPI-5	Reduce power block costs	See CAPEX analysis
	KPI-6	Reduce collector costs	Up to 30% cost reduction
	KPI-7	Reduce the specific cost of the HTF system	Air is freely available
3. Improve dispatchability	KPI-8	Investment cost of storage	Higher temperature reduces specific costs
	KPI-9	Increase efficiency of storage	
4. Environmental profile	KPI-10	Substantial reduction of water consumption	See Point "*Reducing life-cycle environmental impact*"

Source: http://capture-solar-energy.eu/

Thank you for attention

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