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Spiky Central Receiver Air Pre-heater (SCRAP)

an introduction

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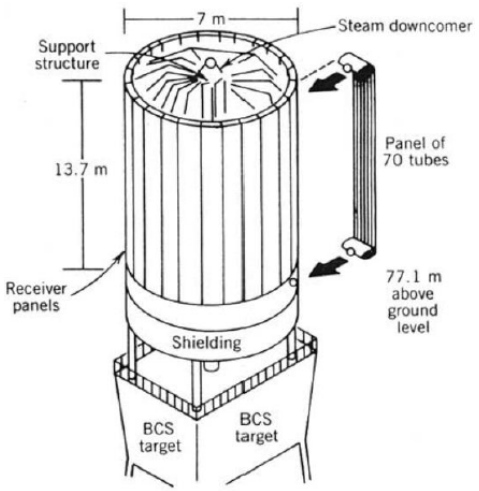
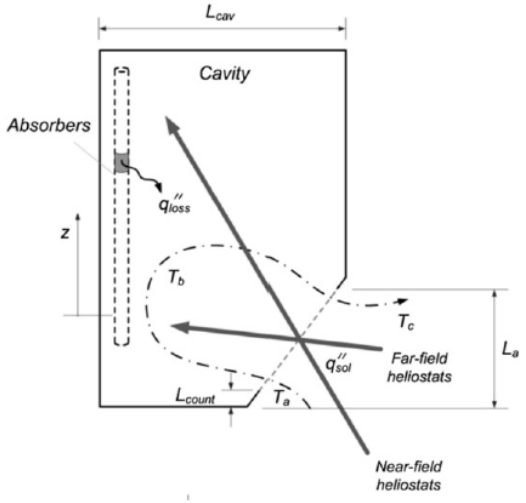
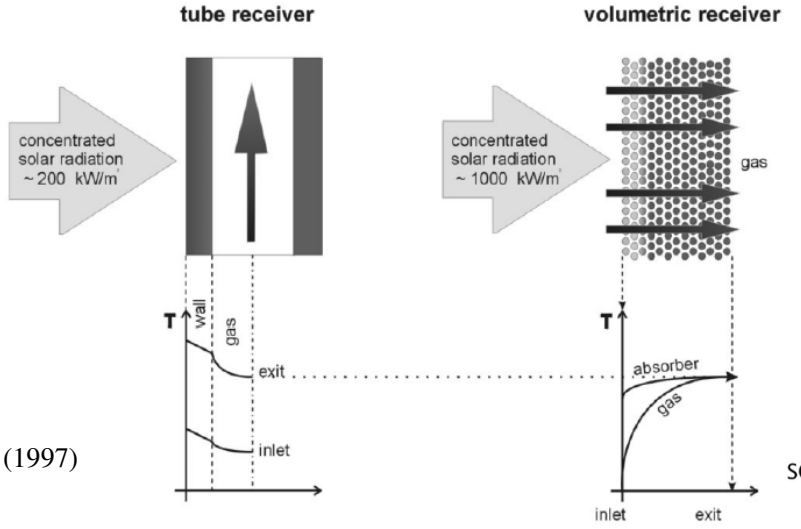
Receiver categories

- External cylindrical[a] and cavity[b] receiver receiver





- Tubular and volumetric absorber[c]:



a) Stine & Geyer (2001)
b) Soo Too & Benito (2013)
c) Romero et al. (2002), based on Hoffschmidt (1997)

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Receiver efficiency and important losses

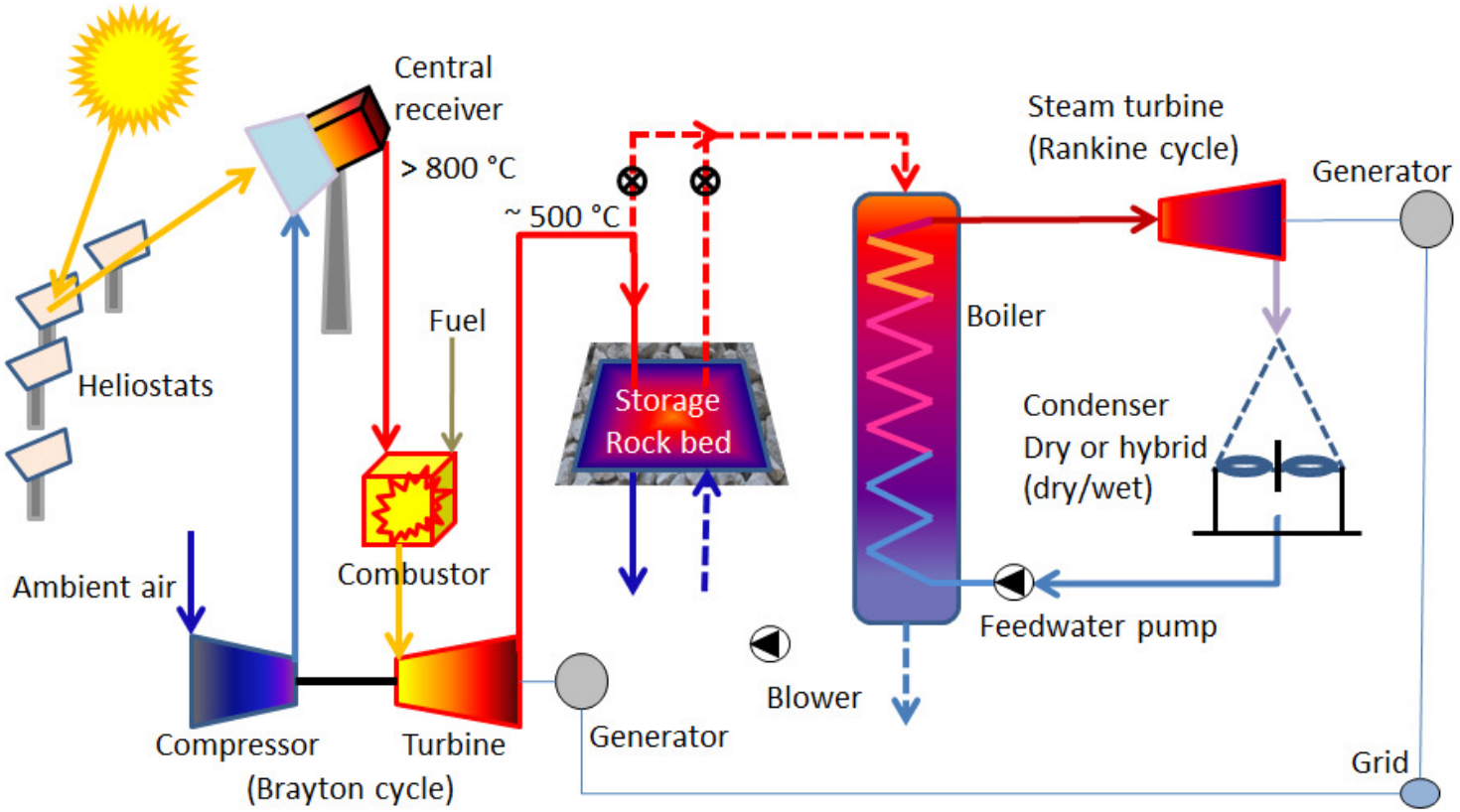
- Efficient heat transfer from concentrated solar energy to a heat transfer fluid

$$\eta_{\text{thermal}} = \frac{\dot{Q}_{\text{out}}}{\dot{I}_{\text{in}}}$$

- Important losses reflecting on receiver efficiency:
  - **Optical** → Reflection
  - **Thermal** → Radiation, convection, conduction

- Operating temperature, heat transfer fluid, receiver capacity (and many more) influence the optimal design for an application

An introduction to the **S**tellenbosch **UN**iversity **S**olar **PO**wer **T**hermodynamic (SUNSPOT) cycle



The SUNSPOT cycle[a]

a) Kröger (2012)

Air – The challenge

- Comparison of HTF fluids for CSP[a]:

	Unit	Synthetic oil	Solar Salt	steam	Air (20bar)
Minimum op. temp.	°C	292	222	250	-
Maximum op. temp.	°C	393	593	~600	1 000 (reference)
Density	kg/m^3	815-673	1900-1720	815-52.0[b]	18.7-5.47
Specific heat cap.	kJ/(kg K)	2.37-2.73	1.49-1.55	4.19 (-10.4)-2.76	1.02-1.19
Viscosity	mPa s	0.25-0.12	3.50-1.03	0.110-0.0338	0.0221-0.0509
Therm. conductivity	W/(m K)	0.0953-0.0771	0.50-0.55	0.634-0.0952	0.0321-0.0818

- Peak flux for standard billboard receiver[c]:

	Unit	Air	Steam	Molten salt
Tolerable peak flux	MW/m^2	0.15-0.2	0.4	0.8

a) All data from Heller (2013)
b) at 190 bar
c) Schiel et al. (1988)

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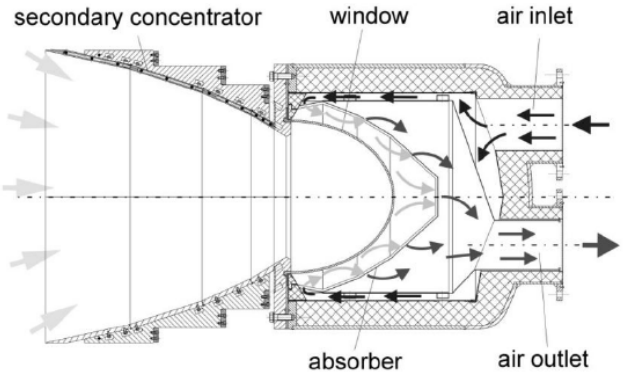
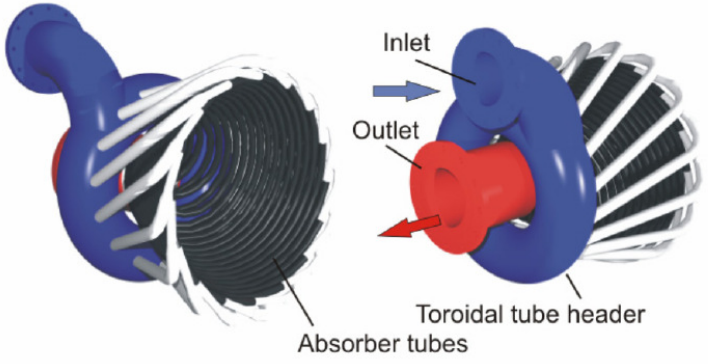
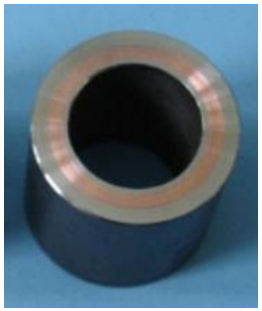
Brief review on current press. air receivers

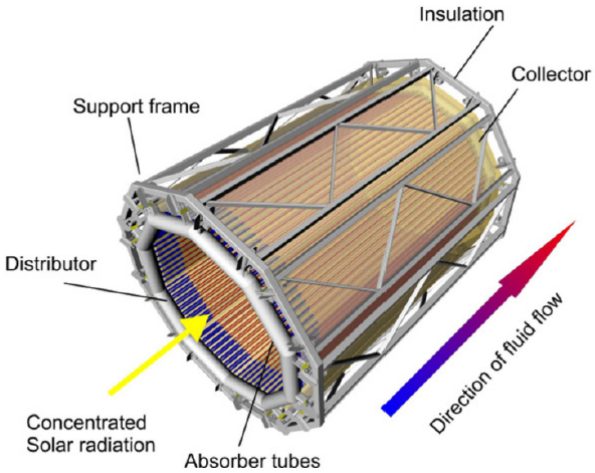


The **REFOS** receiver[a]

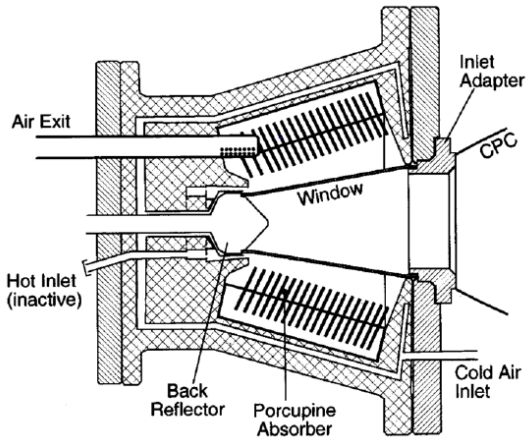


The **SOLGATE** pre-heater[b]





The **SOLUGAS/SOLHYCO** receiver[c]



The DIAPR receiver[d]

a) Buck et al. (2002)
b) Solgate Report (2005)
c) Korzynietz, Quero and Uhlig (2012)
d) Kribus et al. (2001)

Summary of current receiver types

	DIAPR	REFOS	SOLGATE Pre-heater	SOLHYCO	SOLUGAS
Maximum op. temp.					
Pressure drop					
Optics (CPC)					
Optics (accepting surrounding field)					
Thermal efficiency					
Robustness, durability					
Cost/simplicity					
Flux density					

- Excellent
- Only predicted value available
- Good
- Undesired
- Insufficient information available

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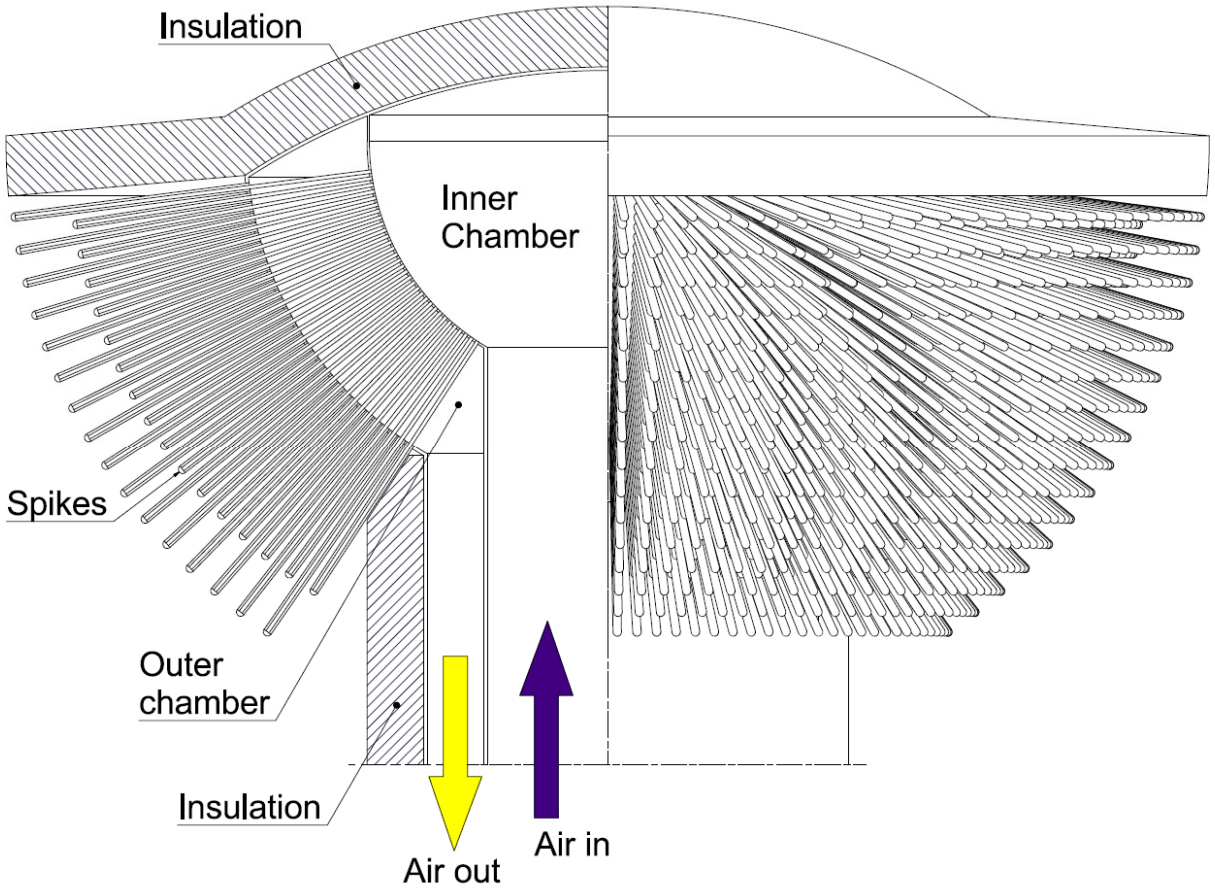
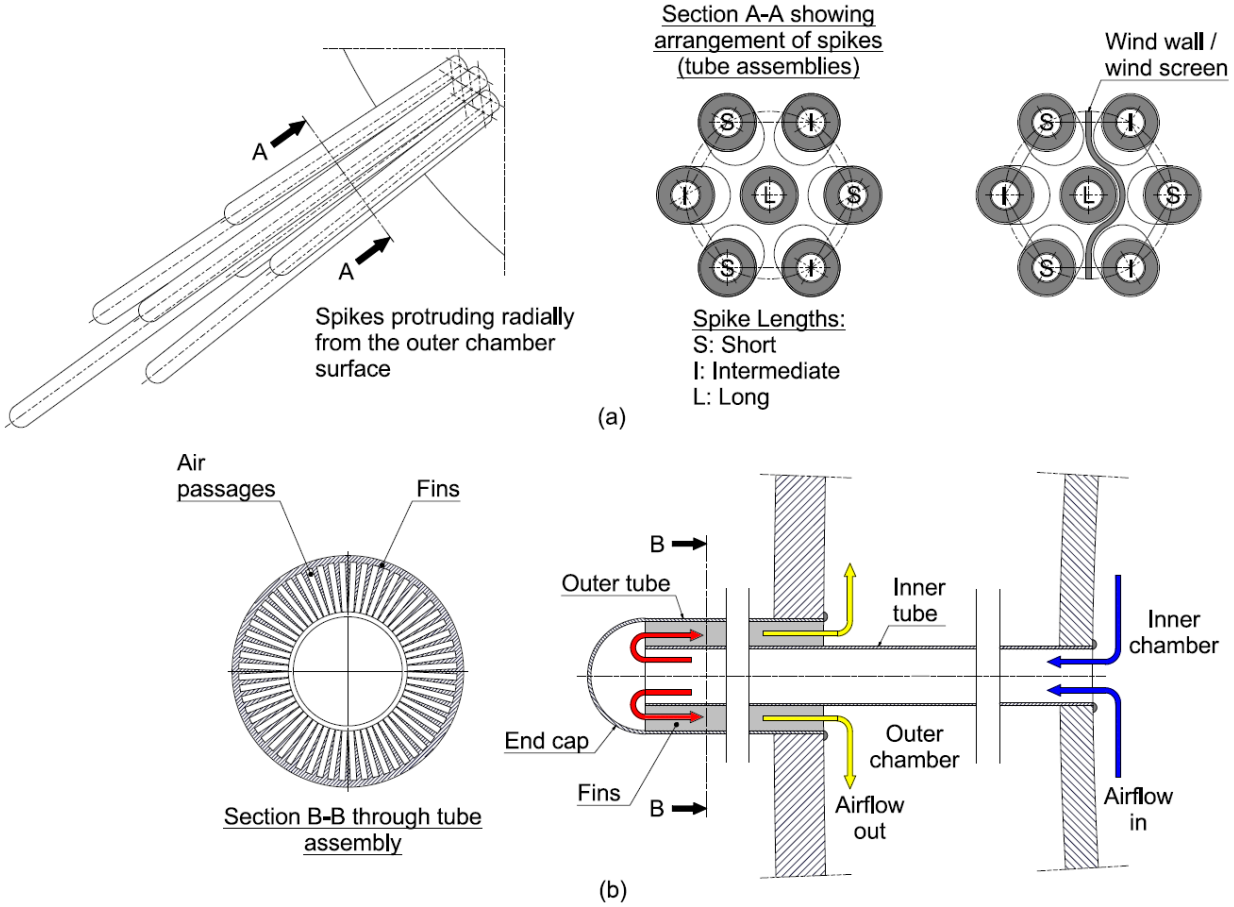
The SCRAP receiver



Spiky **C**entral **R**eceiver **A**ir **P**re-heater[a] (**SCRAP**) Concentric spherical surface chamber (left half in section)

a) Kröger (2008)

The SCRAP receiver



SCRAP tube assembly (spike) details[a]: (a) tube arrangement, (b) tube geometry

a) Kröger (2008)

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Comparison of pressurized air receivers

	DIAPR	REFOS	SOLGATE Pre-heater	SOLHYCO	SOLUGAS	SCRAP
Maximum op. temp.						
Pressure drop						
Optics (CPC)						
Optics (accepting surrounding field)						
Thermal efficiency						
Robustness, durability						
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Steps forward

- Study of heat transfer of the internally finned tubes
- Develop a spike tip cooling solution
- Optimization of internal tube geometry for different spike length for uniform pressure drop and temperature rise
- Optimization of receiver efficiency by optimizing spike length and spike arrangement for the full receiver
- Generate key results of the SCRAP concept : Feasibility, efficiency, pressure drop, operating temperature...

Questions?