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SOLAR THERMAL ENERGY RESEARCH GROUP

Dual-Pressure Air Receiver Cycle

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Fakulteit Ingenieurswese
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Faculty of Engineering

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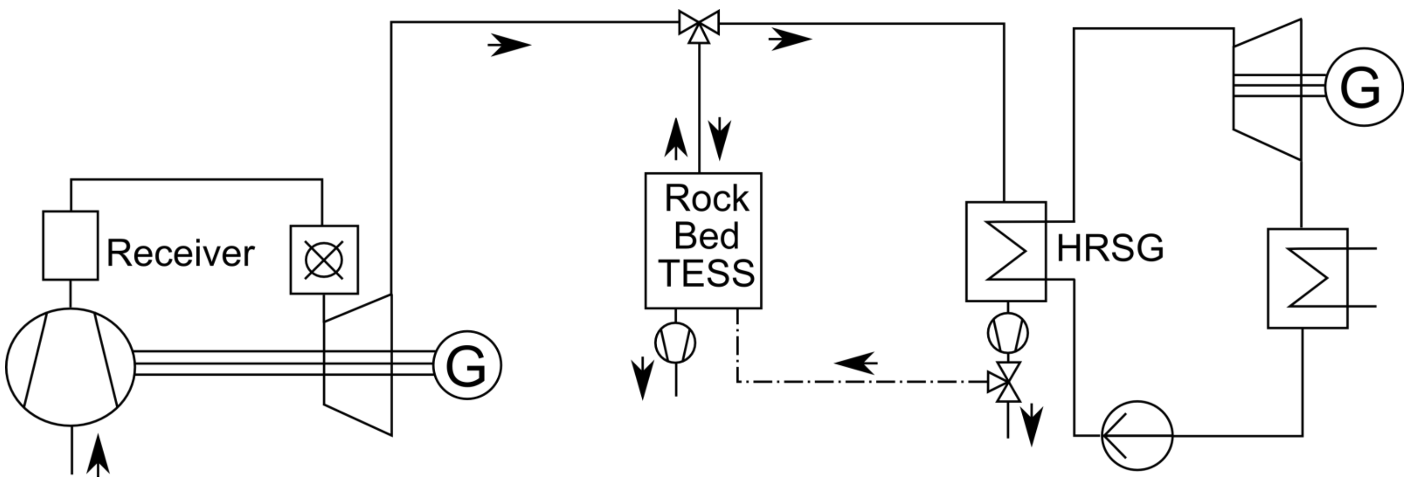
SUNSPOT modeling

Goals:

- High solar share
- Demonstration of CSP's baseload capability



Scheme of the SUNSPOT cycle, as proposed by Kröger (2012).

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SUNSPOT simulations

Parameter	Design Case 1	Design Case 2	Design Case 3
Gas turbine nominal rating		5.25 MW_e	
Solar multiple		1.9	
Steam Turbine nominal rating	1.0 MW_e	1.9 MW_e	1.9 MW_e
Storage Volume		785 m^3	
Fuel firing when storage depleted	No	No	Yes
Annual hybridization rate	5.2 %	5.2 %	35.9 %
Annual power generation	19.9 GWh_e	21.8 GWh_e	30.5 GWh_e
Annual time of no power generation	361 h	1838 h	0 h
Annual dumped energy through defocusing	30.8 GWh_{opt}	30.8 GWh_{opt}	28.9 GWh_{opt}

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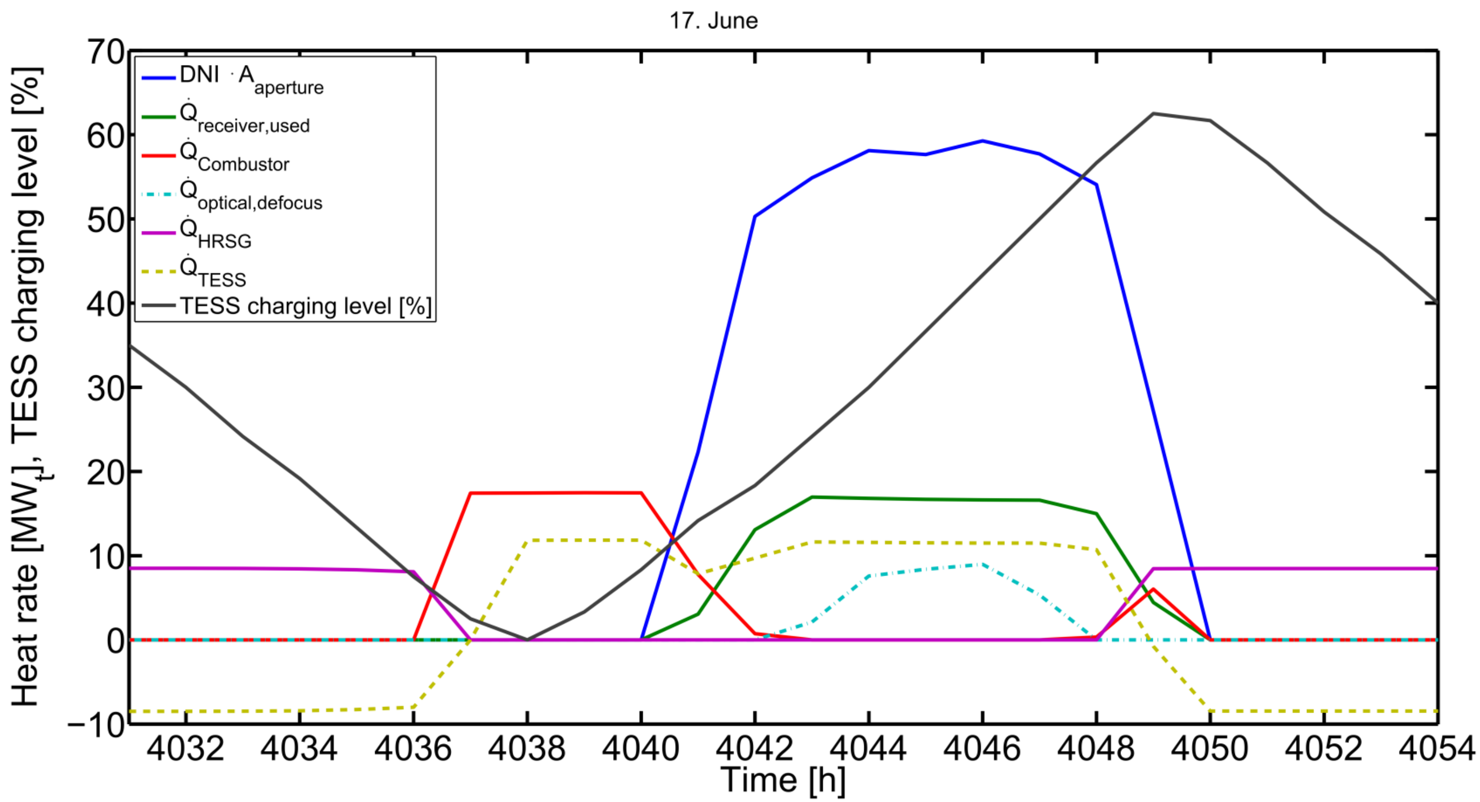
SUNSPOT simulation result (Design Case 3)



Energy flows in the modeled plant for a winter day.

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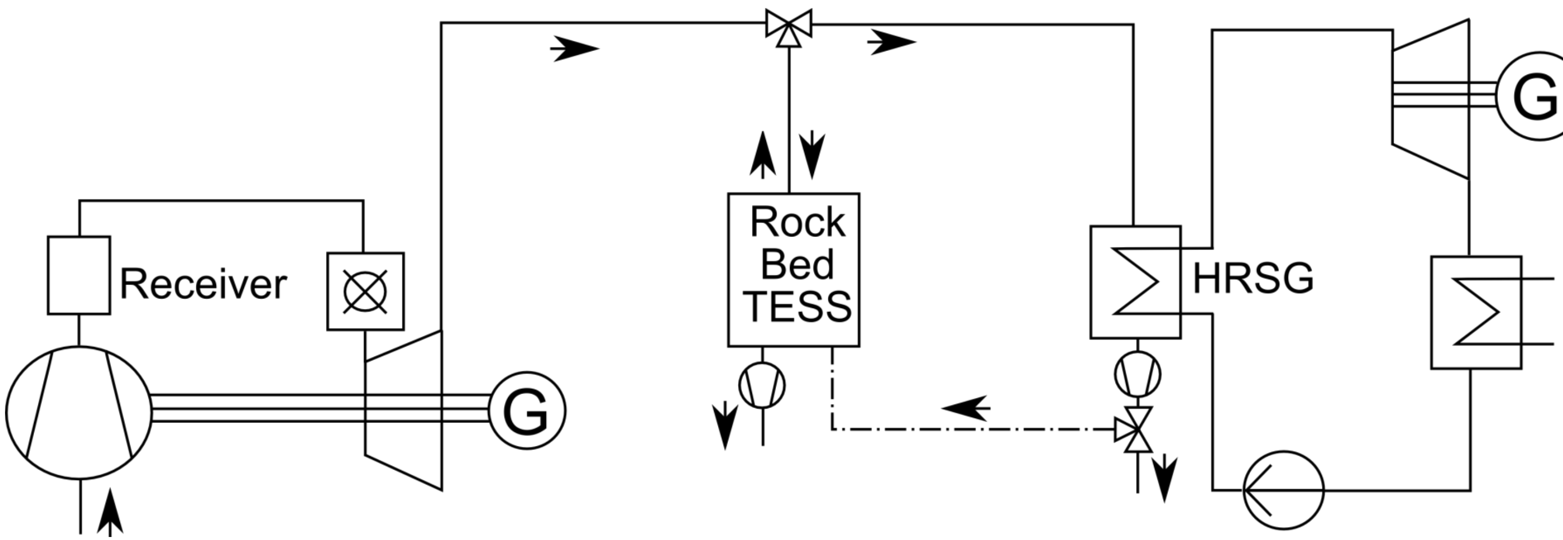
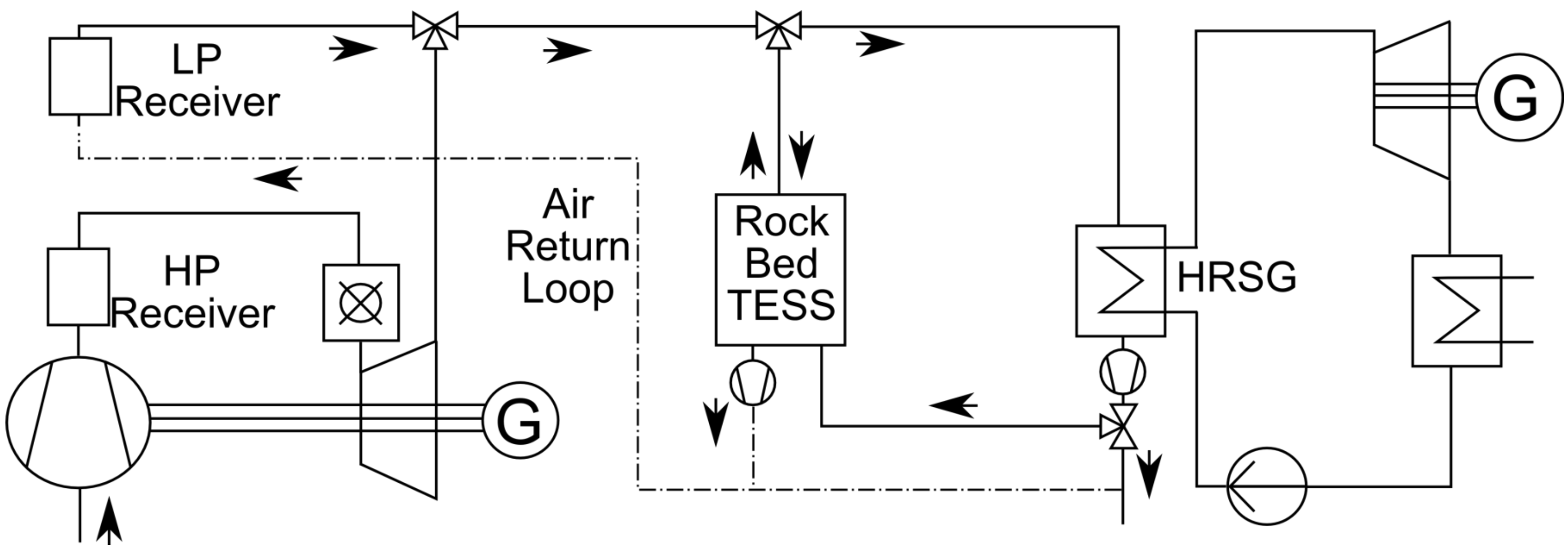
SUNDISC cycle



SUNDISC cycle

The **S**tellenbosch **UN**iversity **DI**rect **S**torage **C**harging Dual-Pressure Air Receiver cycle



Scheme of the SUNDISC cycle.

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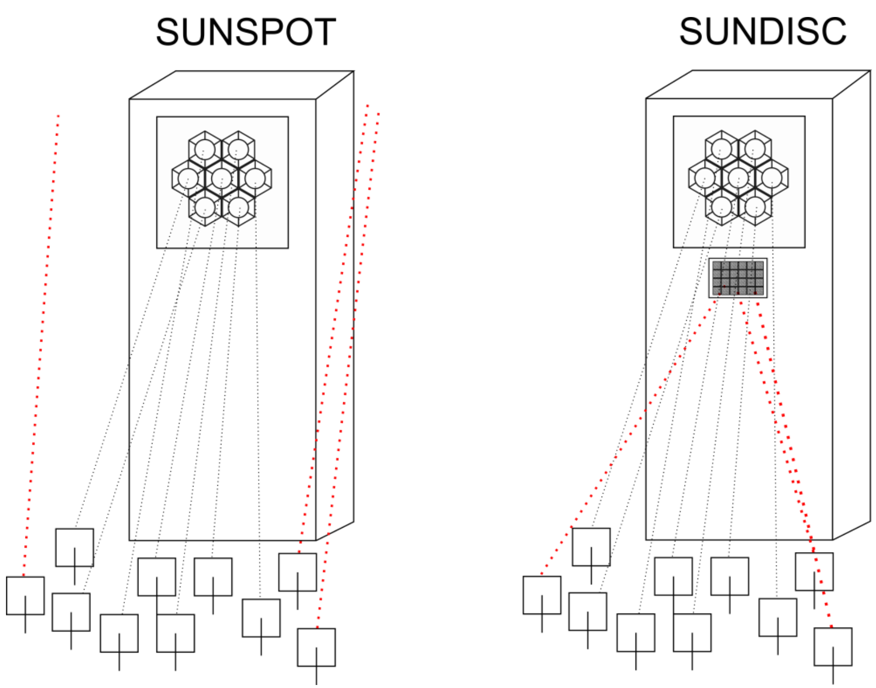
Expected Benefits – Optical Energy

- Better utilization of available irradiation (less defocusing, alternative target).
- Utilization of larger solar multiples in a cost effective manner.



Schematic of avoided defocusing in the SUNDISC cycle.

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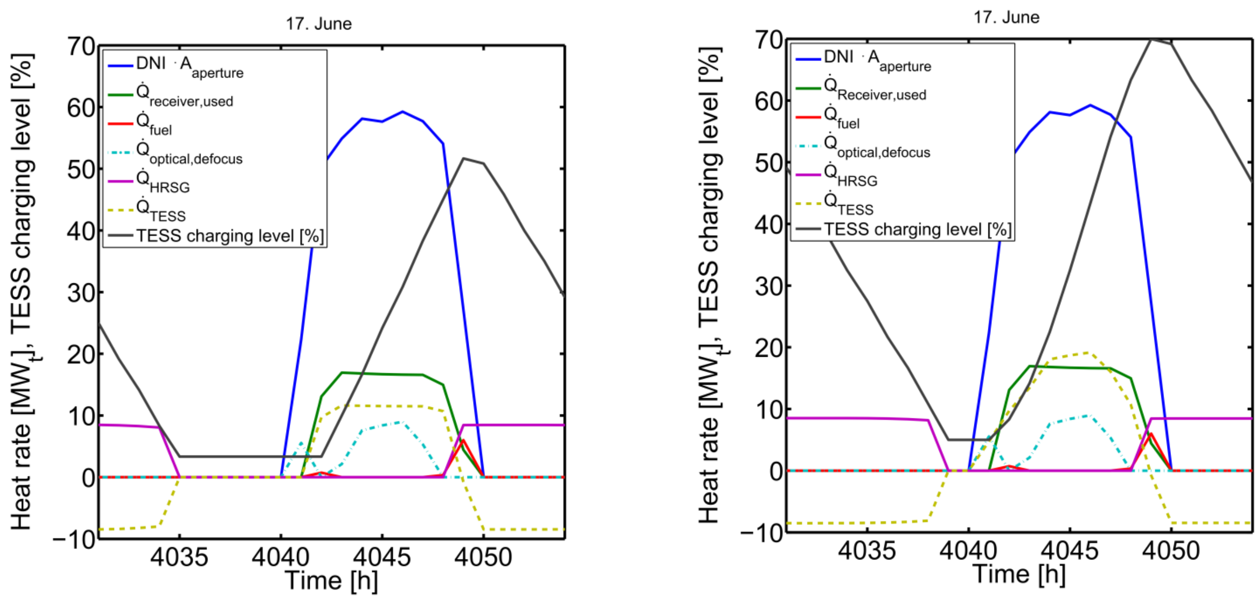
Expected Benefits – Continuous Generation

- Baseload performance/ better utilization of the steam turbine.
- Lower co-firing rate.



Energy flows without (left) and with (right) secondary receiver system.

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SUNDISC simulations

Parameter	**Design Case 4**	**Design Case 5**	**Design Case 6**
Gas turbine nominal rating		5.25 MW_e	
Solar multiple		1.9	
Steam Turbine nominal rating		1.9 MW_e	
LP receiver system nominal rating	0.00 MW_t	16.3 MW_t	16.3 MW_t
Storage Volume		1330 m^3	
Fuel firing when storage depleted	No	No	Yes
Annual hybridization rate	5.2 %	3.5 %	13.5 %
Annual power generation	22.1 GWh_e	24.3 GWh_e	27.2 GWh_e
Annual time of no power generation	1668 h	591 h	0 h
Annual dumped energy through defocusing	30.8 GWh_{opt}	586 MWh_{opt}	579 MWh_{opt}

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Summary of Expected Benefits

- SUNDISC cycle is **decoupled** and can easily be **adjusted** for differing demand profiles
- **Baseload characteristics** of power generation achievable
- Cost-efficient utilization of **high solar multiples**
- **High efficiency** for the combined cycle
- **High solar share**
- Limited hybridization for peak hours conceivable
- Distributed receiver system could benefit **solar field efficiency**

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Manifestations

- Decoupled low- and high-pressure receiver systems
- Hybrid-pressure receiver system (preheater or up to max. temperature)