INVESTIGATION OF DIFFERENT SOLAR HYBRID GAS TURBINES AND EXPLOITATION OF REJECTED SUN POWER

C. Kalathakis
Research Assistant

N. Aretakis
Assistant Professor

I. Roumeliotis
Assistant Professor

A. Alexiou
Senior Researcher

K. Mathioudakis
Professor

Laboratory of Thermal Turbomachines
National Technical University of Athens

Motivation & Objectives

- Fuel saving and emissions reduction → use of renewable energy
- Solar thermal power in Brayton cycle for air preheating

- Identify most promising GT configuration in terms of performance
- Study hybridization type: retrofitting existing engine or design for solar-only operation
- Exploit rejected Sun power to augment solar share and improve performance

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  - Design Specifications & Operating Scenario
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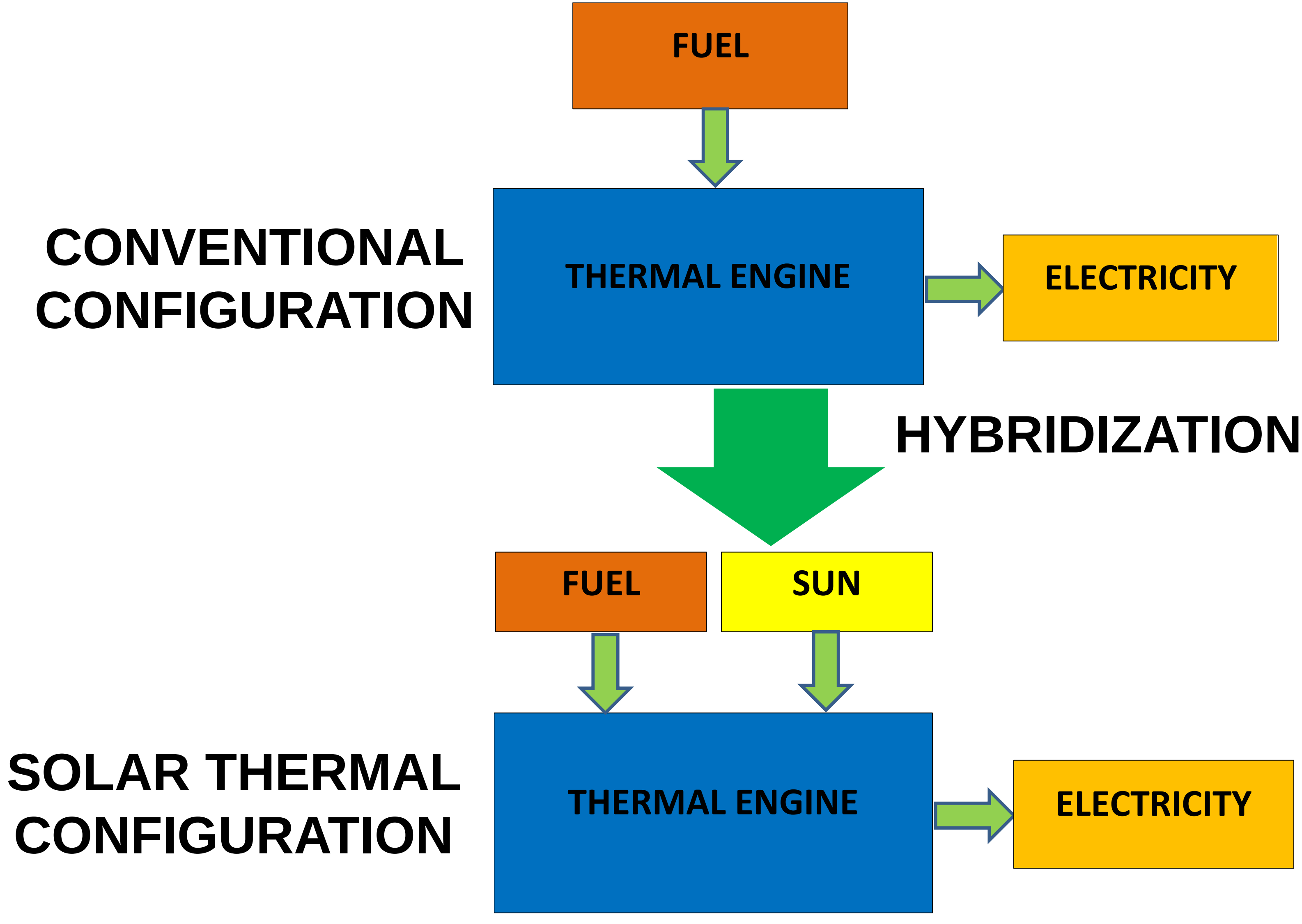
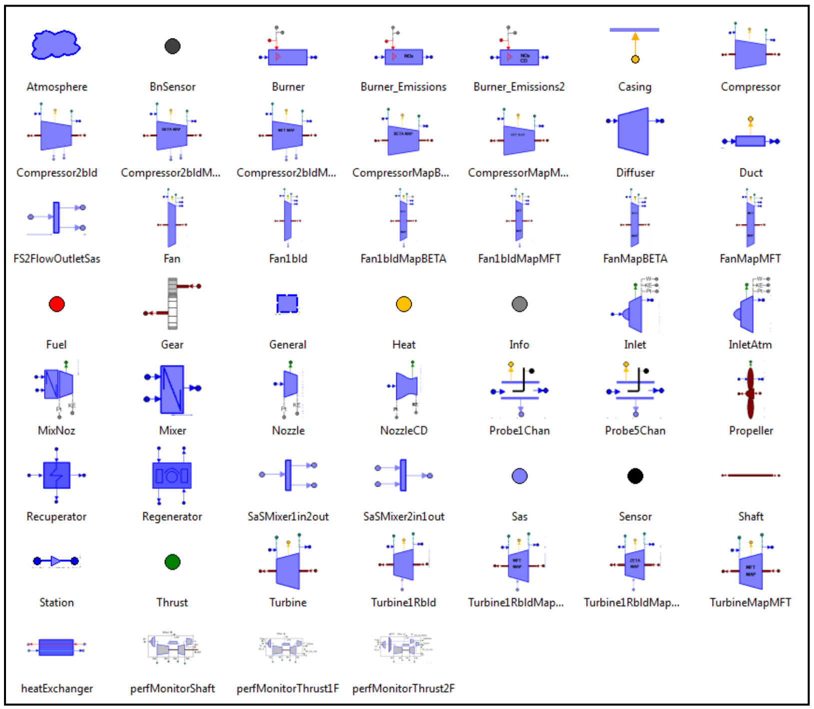
  - Engines With Solar-Only Operation At Design (SDP)
- DUAL FLUID RECEIVER
- SUMMARY & CONCLUSIONS

Hybridization

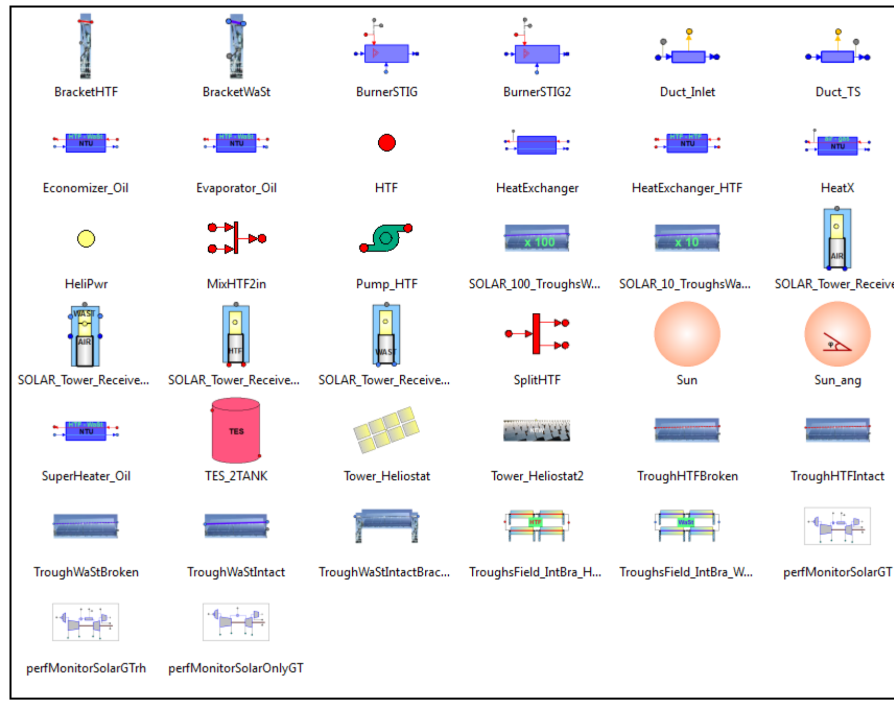


Modeling

- PROOSIS: Object oriented simulation environment
- Library components: Mathematical model of real world component
- TURBO: Brayton cycle components
- SOLAR: Solar part components

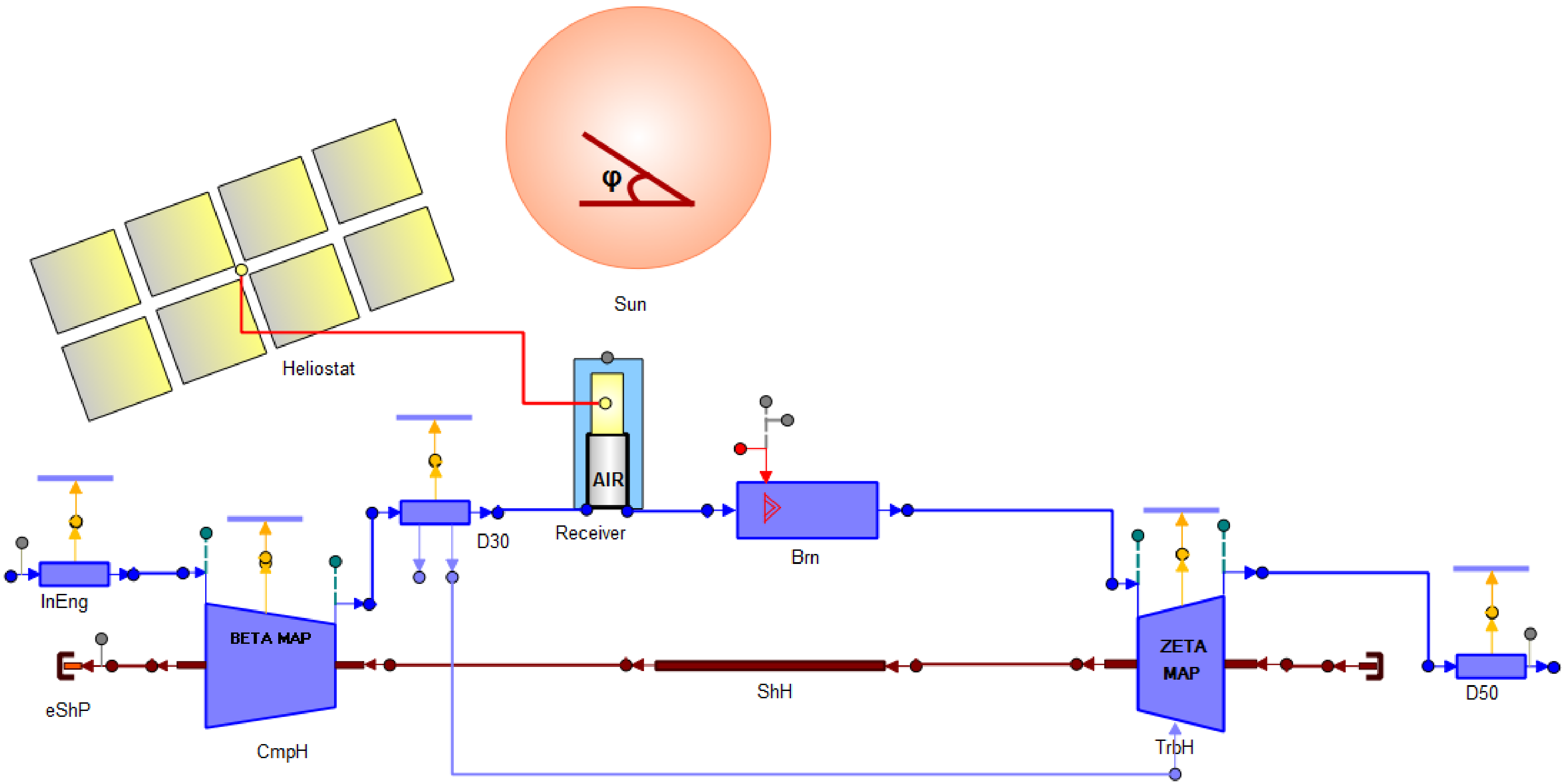


TURBO library



SOLAR library

Modeling



Hybrid GT model in PROOSIS

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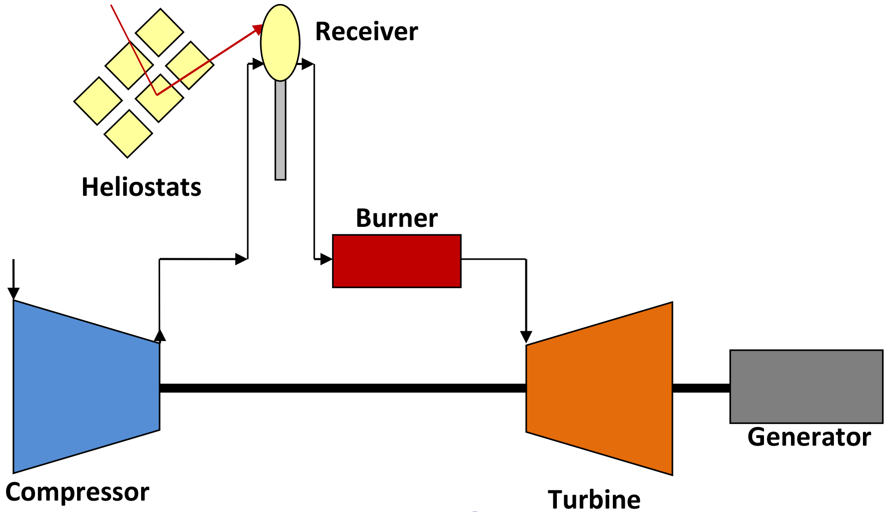
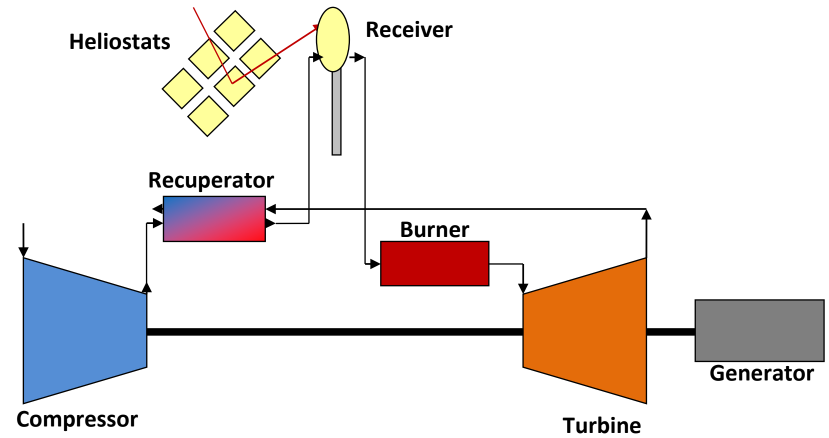
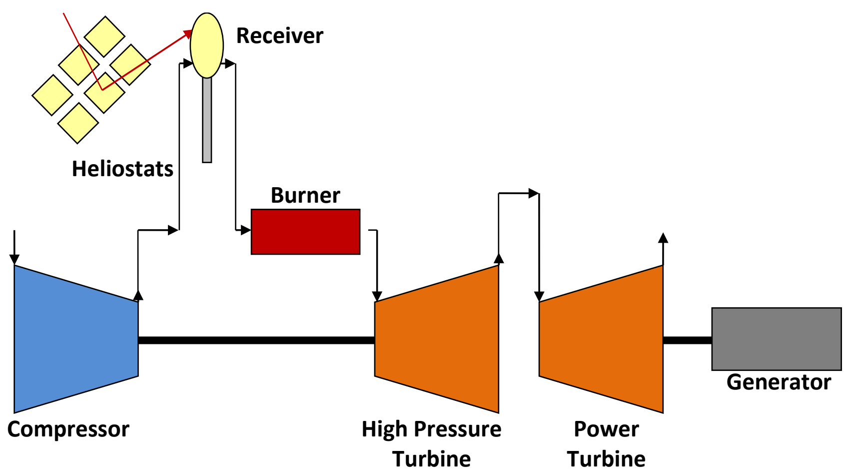
Studied Configurations



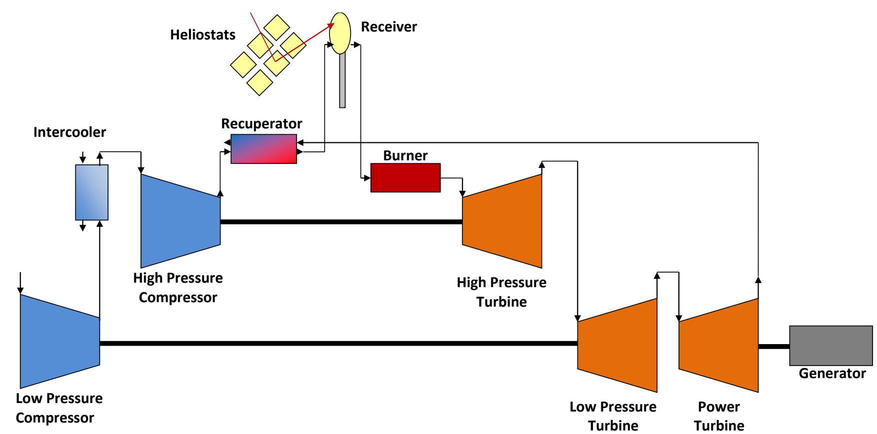
Single Shaft (SS)



Single Shaft Recuperated (SS_R)



Twin Shaft (TS)



2Sp 3Sh Inter. Rec. (2Sp3Sh_I_R)

Type Of Hybridization

- **Fuel-only engines solar retrofitted (FRS)**
  - **Fuel-only operation at design point → Retrofitting → Solar hybrid operation**
- **Engines with solar-only operation at design (SDP)**
  - **Designed with solar-only operation at design point**

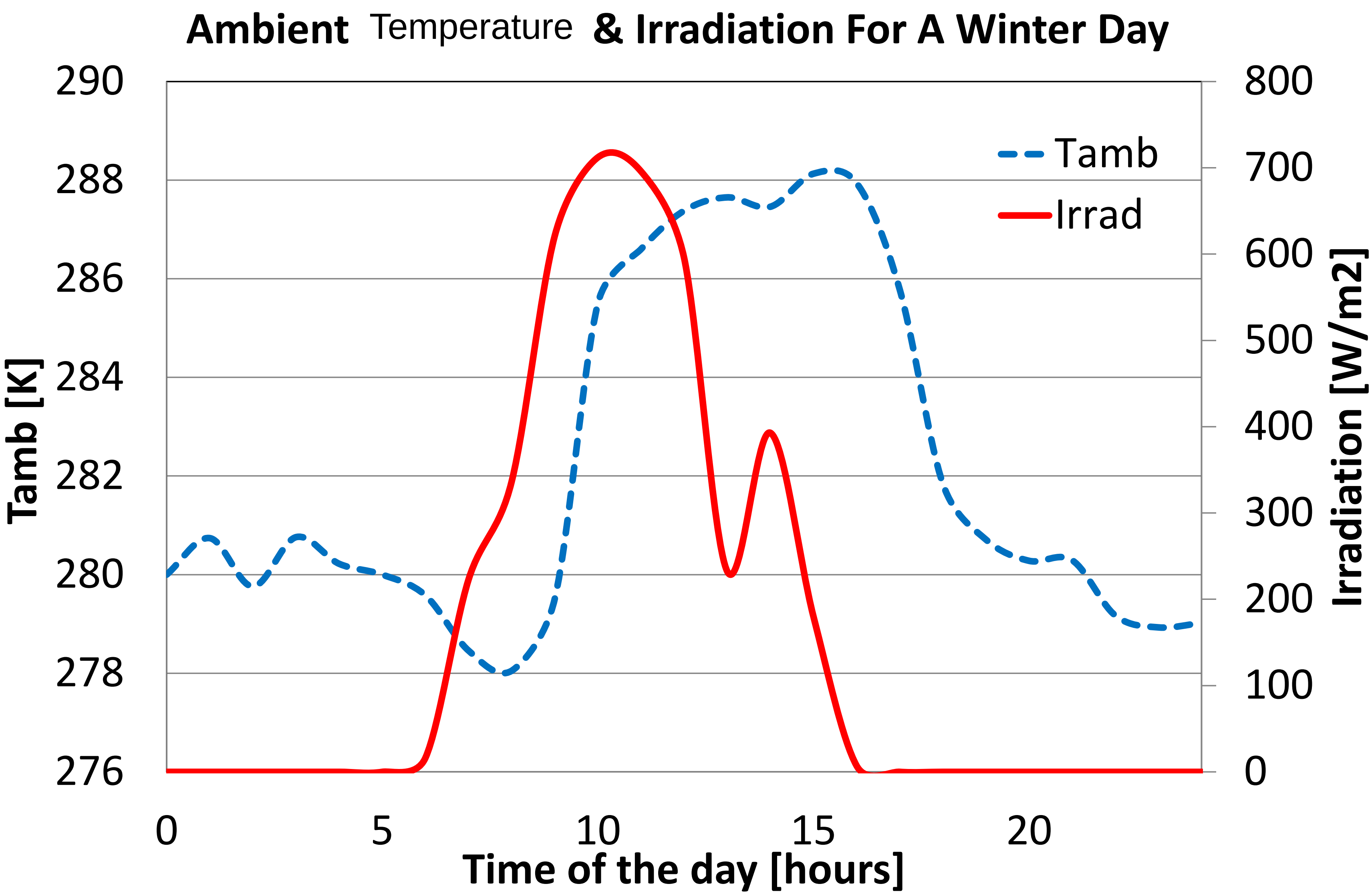
Design Specifications

- First (pilot) plants MW scale – Demonstrated hybrid GT 4.5MWe on Tower
  - 5MW engines chosen
- Receiver range: Up to 1000^{o}C and 10bar
  - High solar share & specific power → TIT = 1000^{o}C & PR = 10
- Heliostat field
  - Receiver outlet temperature = TIT @ 600W/m^2 Summer solstice

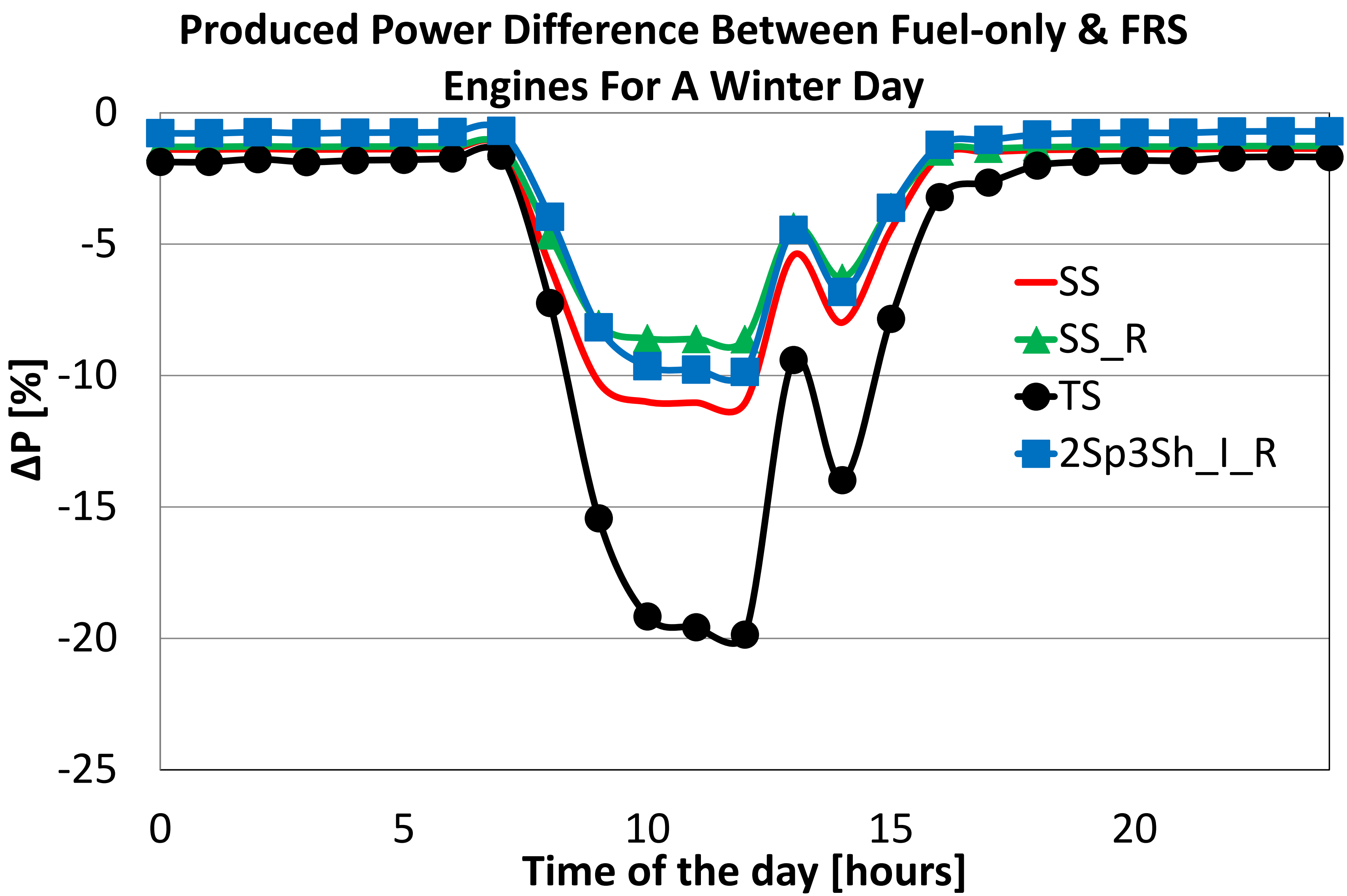
Operating Scenario

- **Operating scenario**
  - **Yearly continuous baseload operation → TIT constant**
- **Performance simulation**
  - **Hourly performance simulation → Integration → Annual performance**

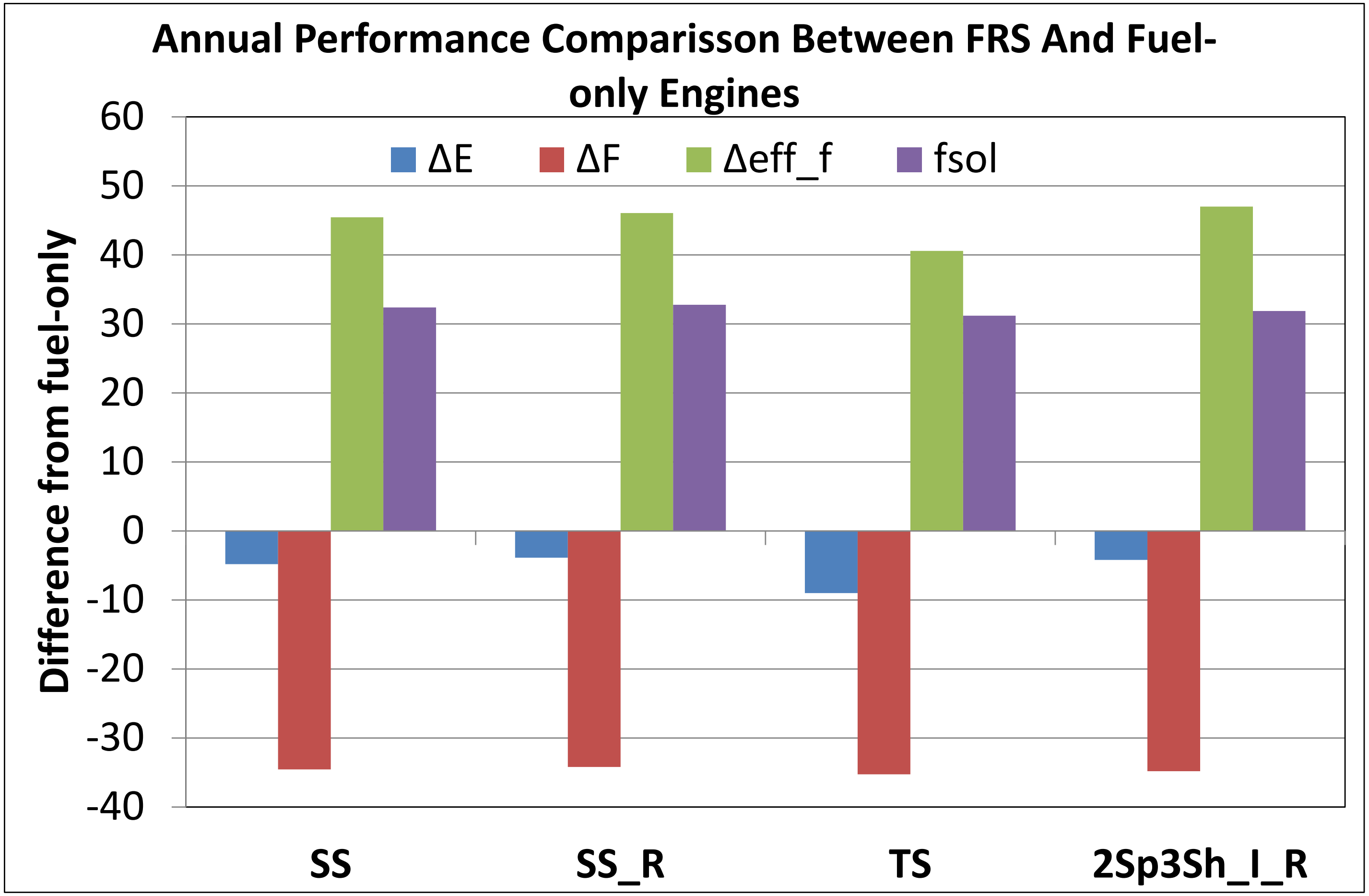
Ambient Data



Daily Performance Of FRS Engines

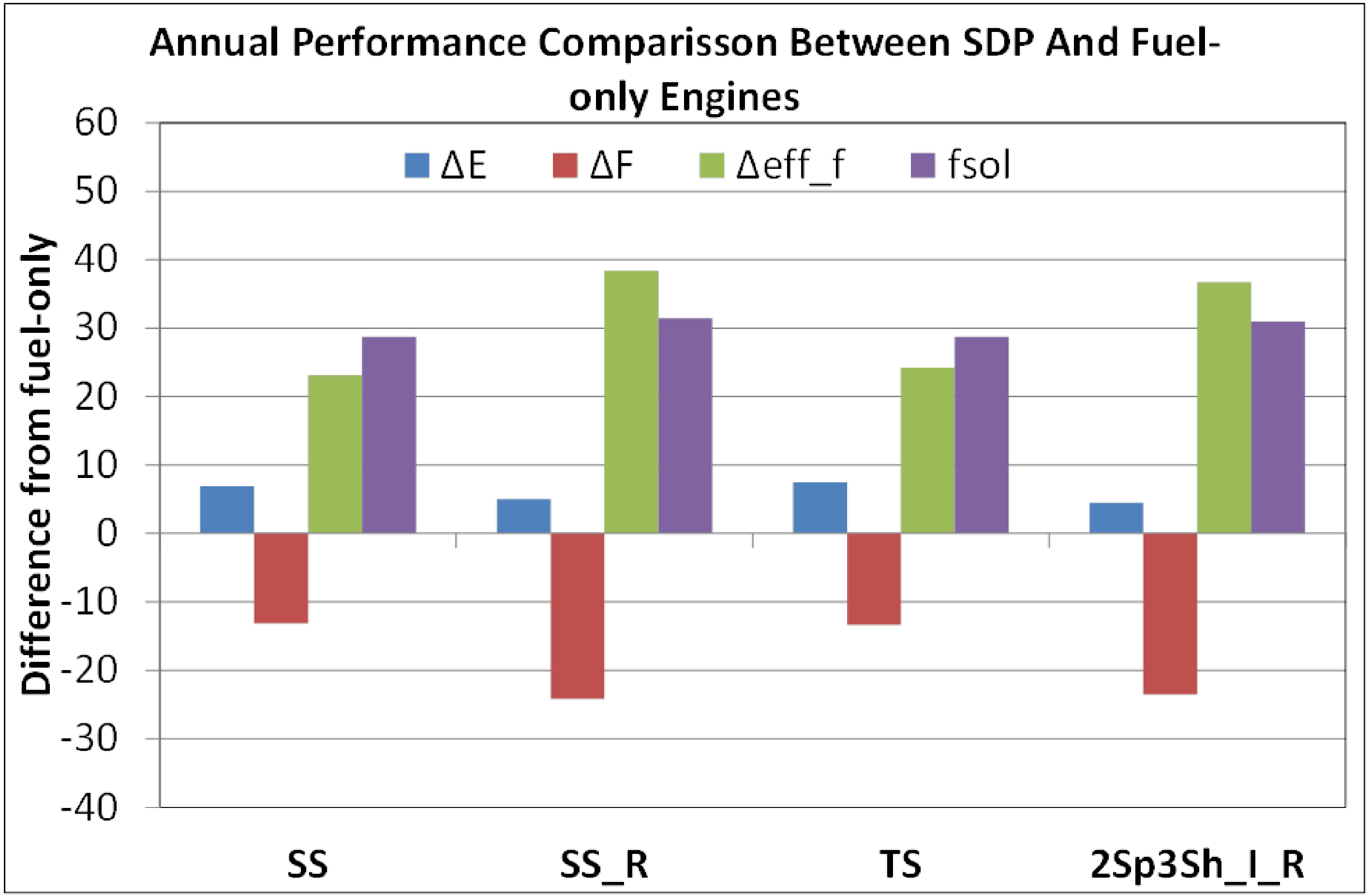


Annual Performance Of FRS Engines



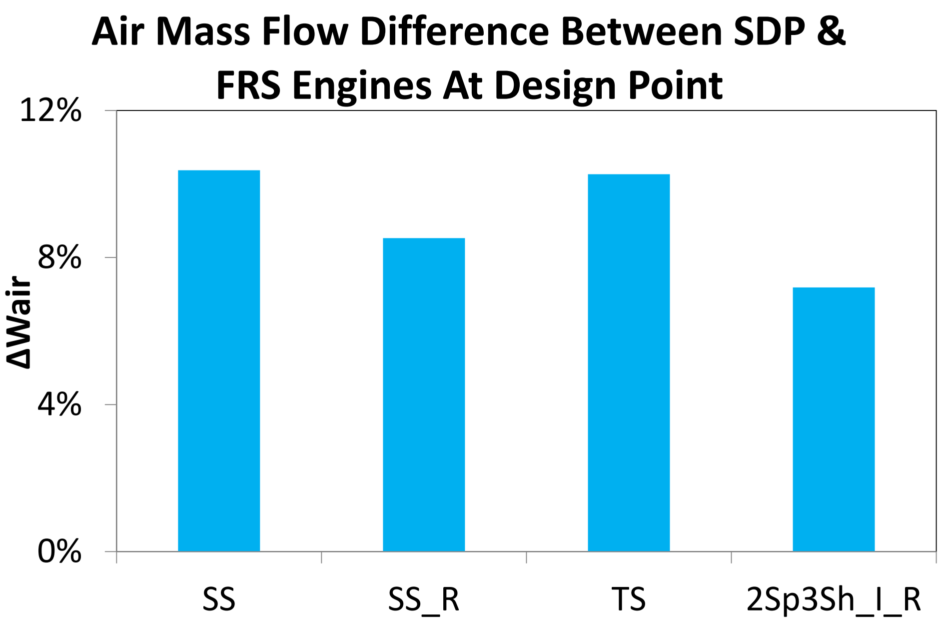
- **Energy reduction: a) Receiver pressure drop, b) working fluid change**
- **Recuperated configurations → higher solar share and fuel efficiency, lower energy production penalty**

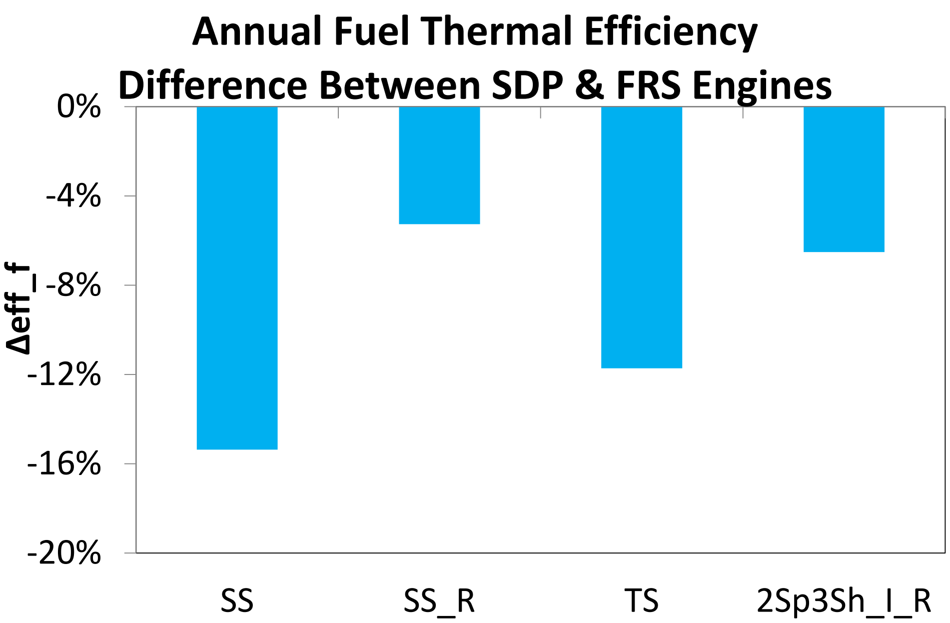
Annual Performance Of SDP Engines



- **Energy augmentation due to higher mass flow**
- **Recuperated configurations: higher solar share and fuel efficiency, lower energy augmentation**

Comparison Between FRS And SDP





- **FRS → higher specific power**
- **FRS → higher fuel efficiency**

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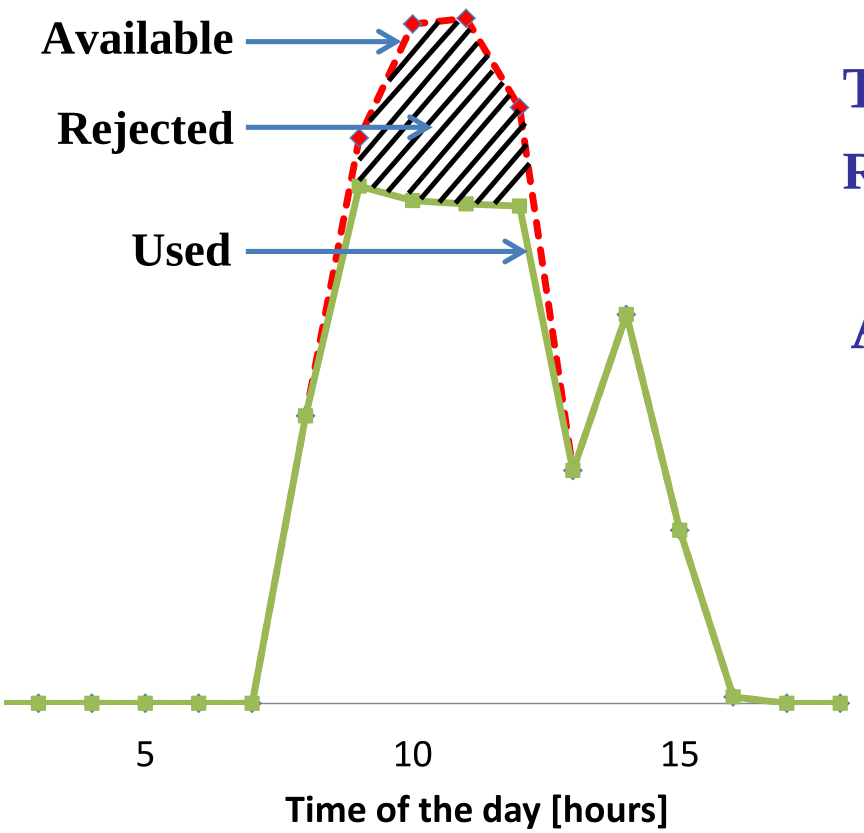
Exploitation of Rejected Sun Power

Receiver outlet temperature limit → Defocusing mirrors → Rejected solar power

Higher solar share requires the exploitation of this power

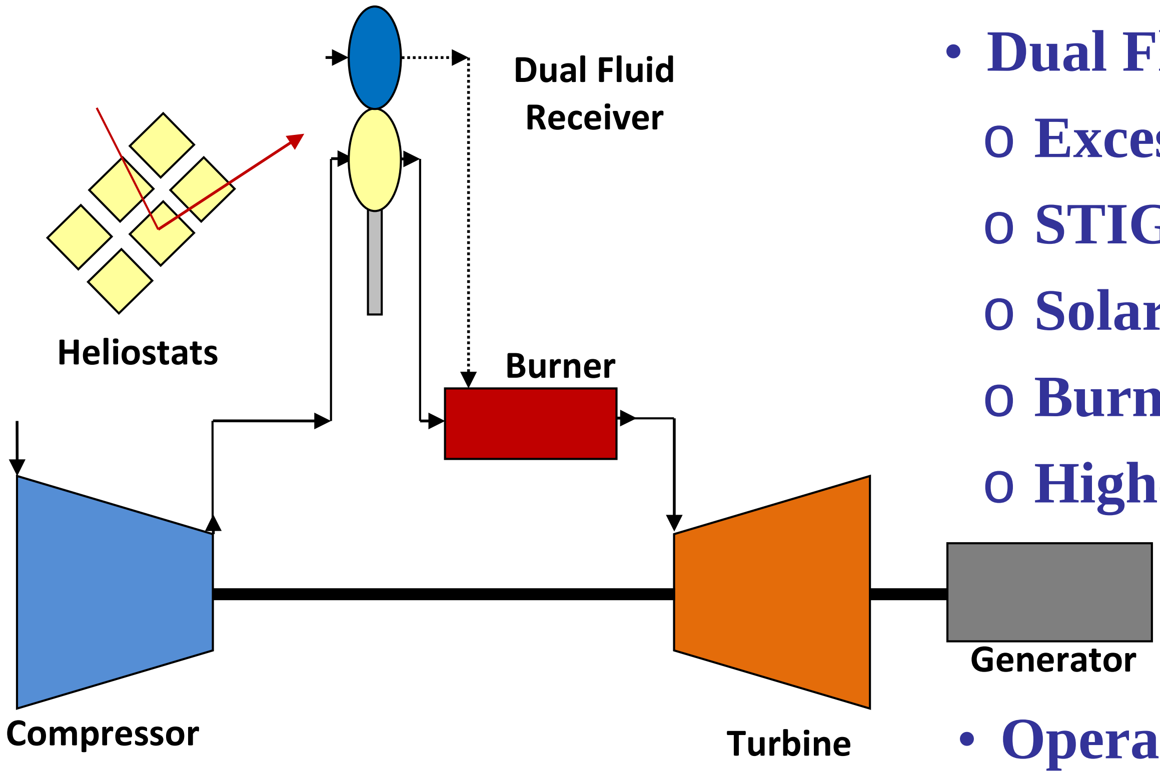


Thermal Storage (regenerative)

Research subject

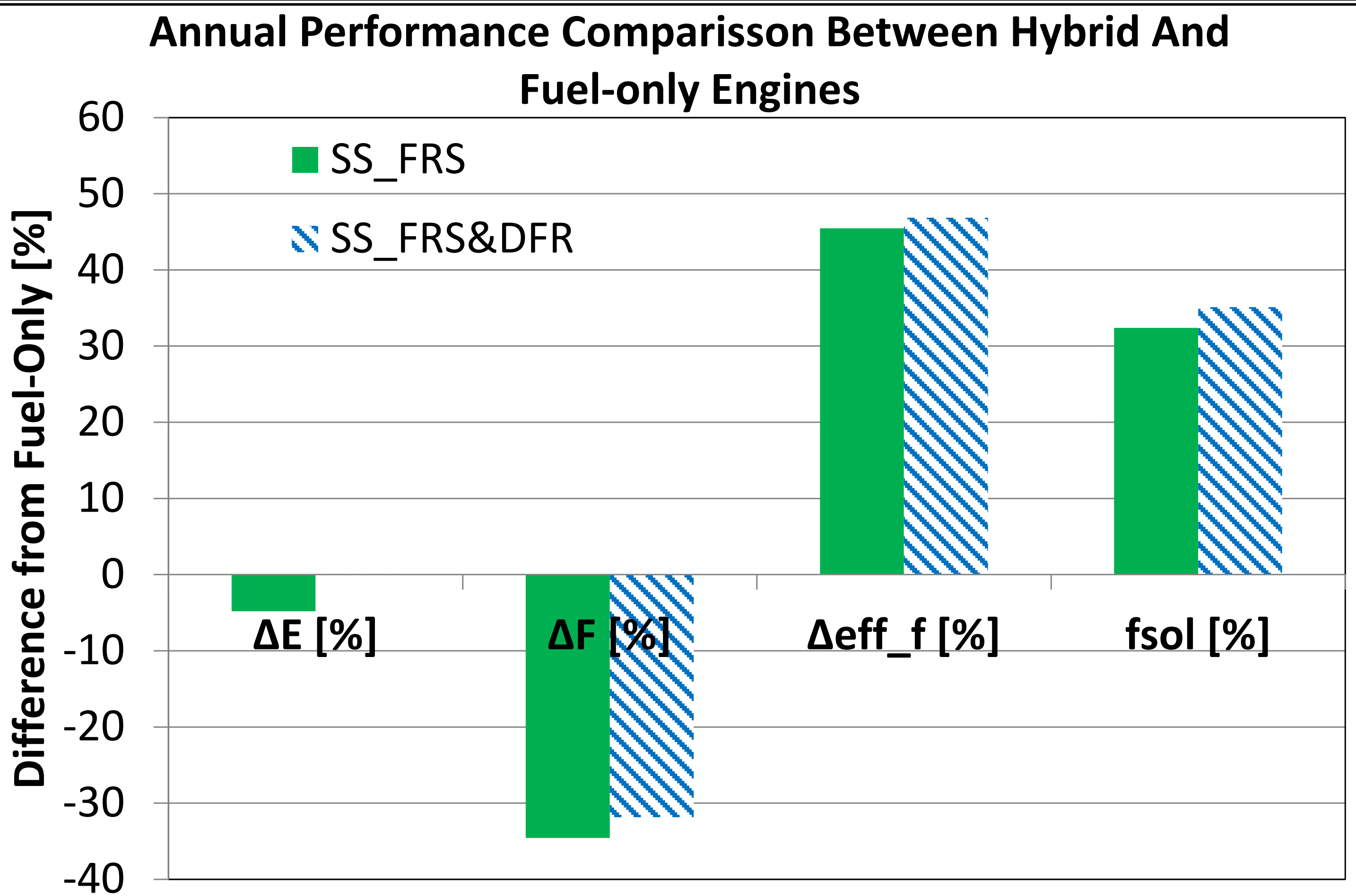
An alternative …

Dual Fluid Receiver (DFR)



- **Dual Fluid Receiver (DFR)**
  - **Excess power for STIG**
  - **STIG: Used technology**
  - **Solar steam: Used technology**
  - **Burner cooling**
  - **Higher solar share & power**
- **Operation**
  - **Focusing on secondary receiver**
  - **Steam pressure 20bar**
  - **Water flow → Saturated steam**
  - **Surge margin check**

Exploitation of Rejected Sun Power



- **No energy production penalty**
- **Higher solar share**
- **Same magnitude of fuel saving**

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Summary – Conclusions

- Developed Solar Library to enable solar hybrid GT cycle modelling
- Studied different gas turbine configurations and hybridization types
  - Recuperated schemes appear more suitable for solar hybridization
  - Fuel-only engines solar retrofitted (FRS) show higher specific power and fuel thermal efficiency compared to solar-only operation at design point (SDP)
  - Optimum design between FRS and SDP operation to be established
- An alternative to thermal storage for exploitation of rejected power was shown: Dual Fluid Receiver for STIG
  - Removes energy production penalty
  - Based on proven technologies (STIG & solar steam production)

THANK YOU

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