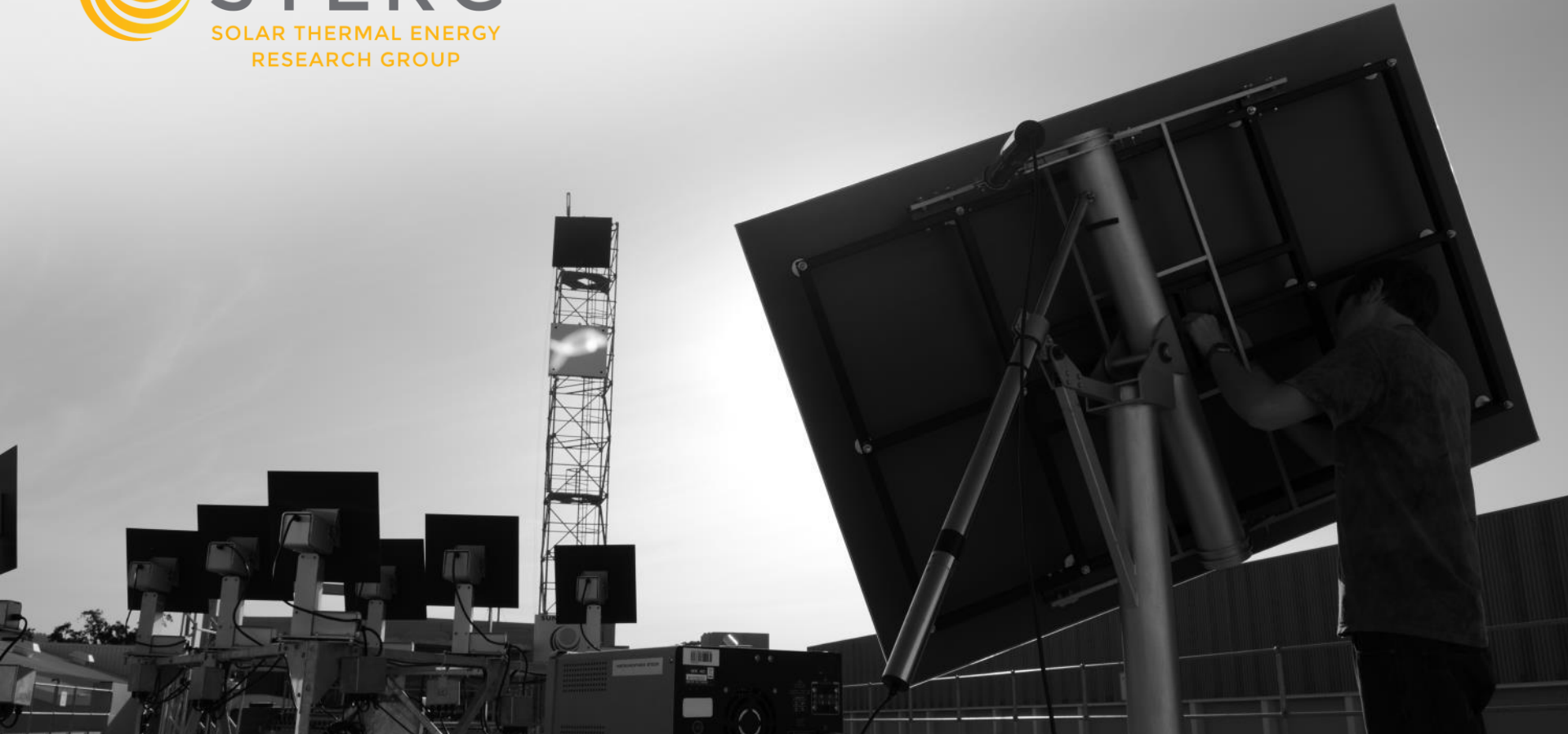




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SOLAR THERMAL ENERGY
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Simulating the effect of solarisation on the performance of a gas turbine

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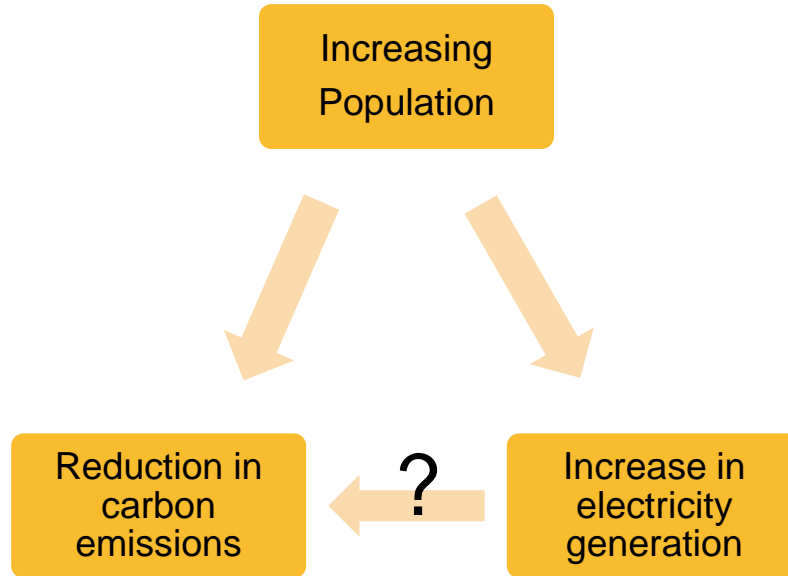
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Contents



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- Problem statement
- Methodology
 - Thermodynamic analysis
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- Results
- Conclusion
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Background

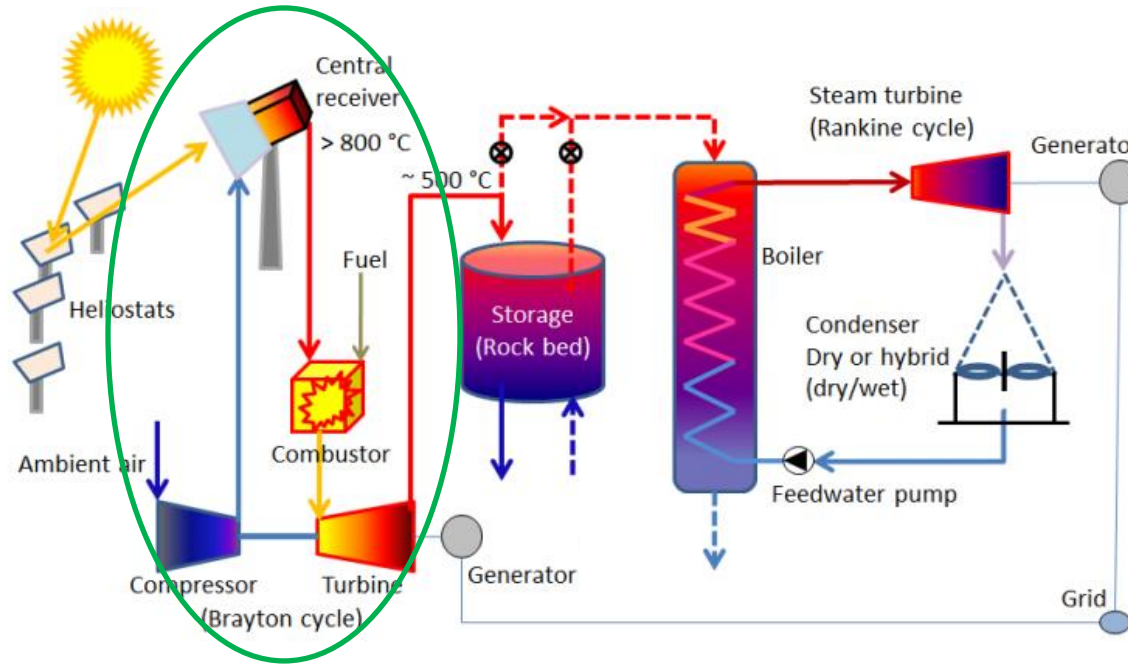


- Biofuels
- Wind
- Hydro schemes
- Tide energy
- Solar energy

Background



SUNSPOT cycle (Kröger, 2011)



Solar-hybrid gas turbine

- Low water consumption
- High conversion efficiency
- Quick start-up/shut-down times
- System reliability

Objectives

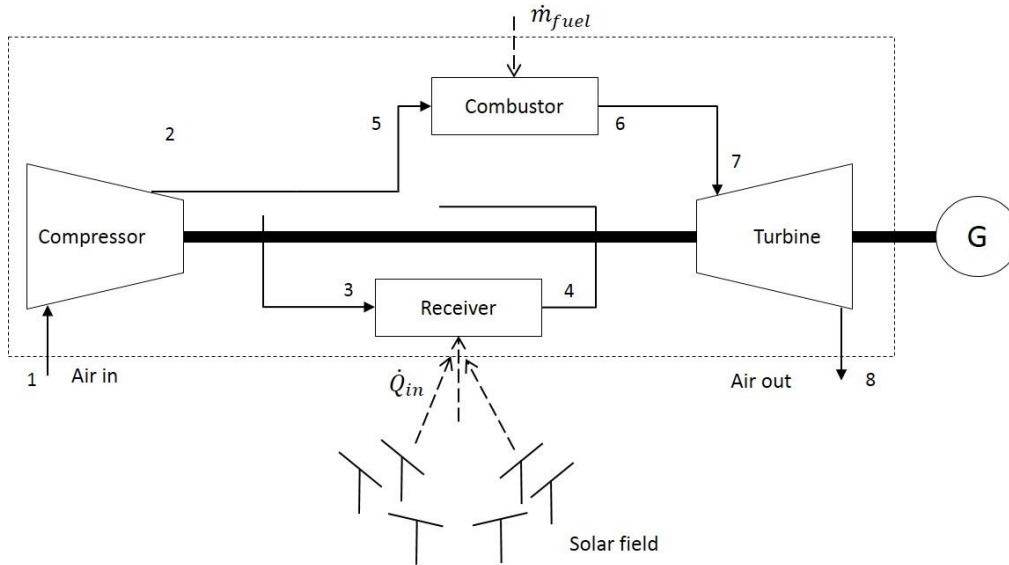


- Model the Rover gas turbine
- Design and model a solar hybrid Rover gas turbine
- Adapt and re-evaluate both the existing Rover gas turbine and solar hybrid Rover gas turbine, including a newly designed compressor
- Field testing of the Rover gas turbine
- Design and evaluate an interconnection device
- Feasibility of scaling

Thermodynamic analysis



Evaluating the Brayton cycle



Assumptions

- 5% pressure drop over combustor
- Turbine inlet temperature limit: 1032 K (manual)

Equation summary

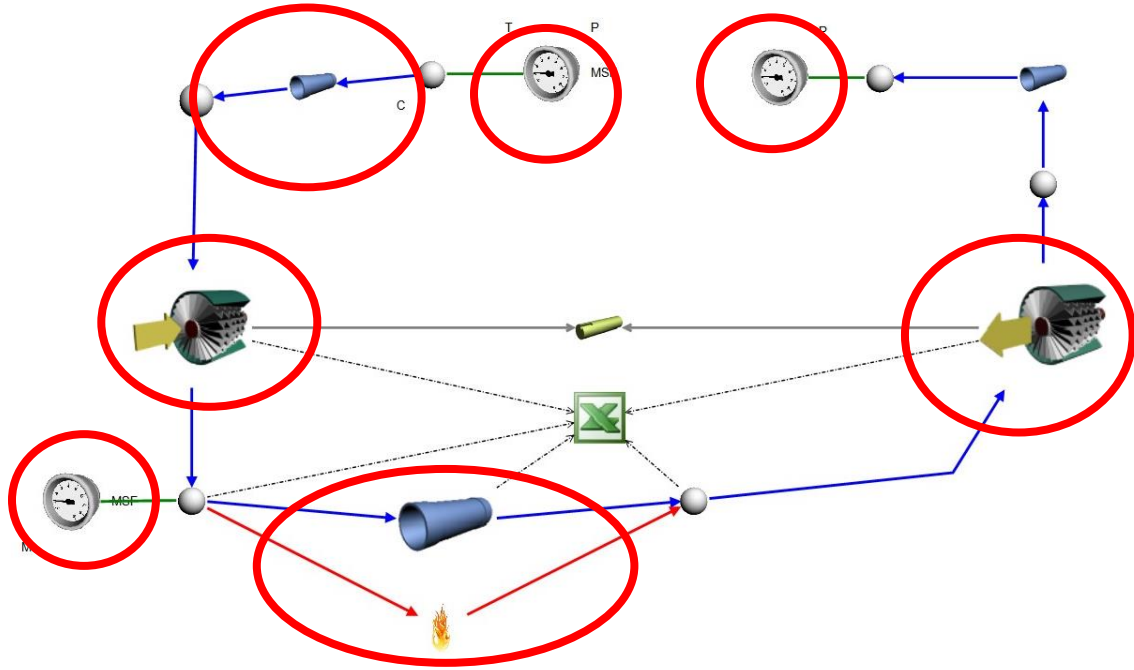
$$\dot{W}_{net} = \dot{W}_t - \dot{W}_c$$

$$\eta_{th} = \frac{\dot{W}_{net}}{q_{combustor} \dot{m}}$$

Flownex Simulation Environment



Rover gas turbine



- Intake system
- Compressor
- Turbine
- Combustion chamber
- Boundary conditions

Results



Model Validation

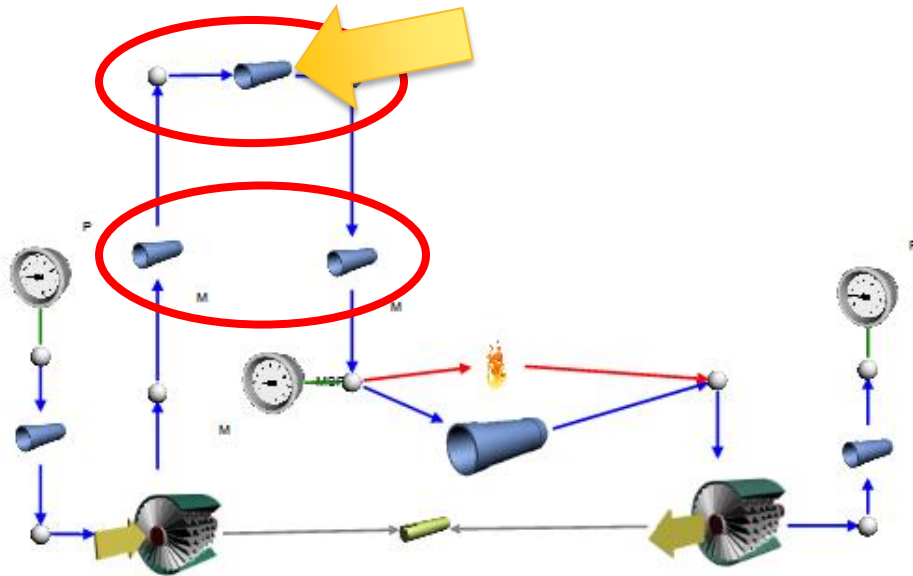
	Thermodynamic analysis	Flownex gas turbine model
Work output [kW]	43.32	42.41
Thermal efficiency	10.39%	10.59%
Combustion chamber ΔP [kPa]	14.18	13.95
Compressor efficiency	69.91%	70.00%
Turbine efficiency	85.14%	84.97%

- Less than 3% difference between analysis and Flownex model

Flownex® Simulation Environment



Solar-hybrid gas turbine model

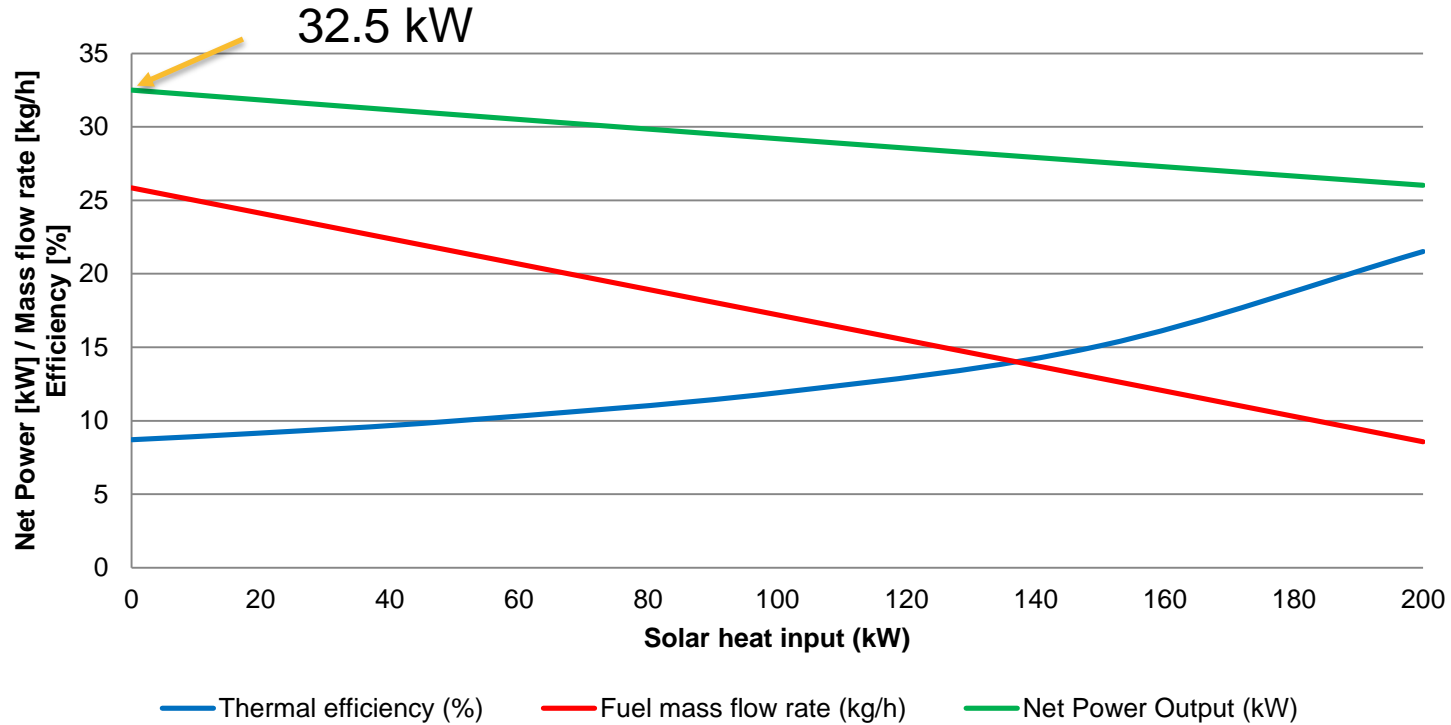


Solar receiver

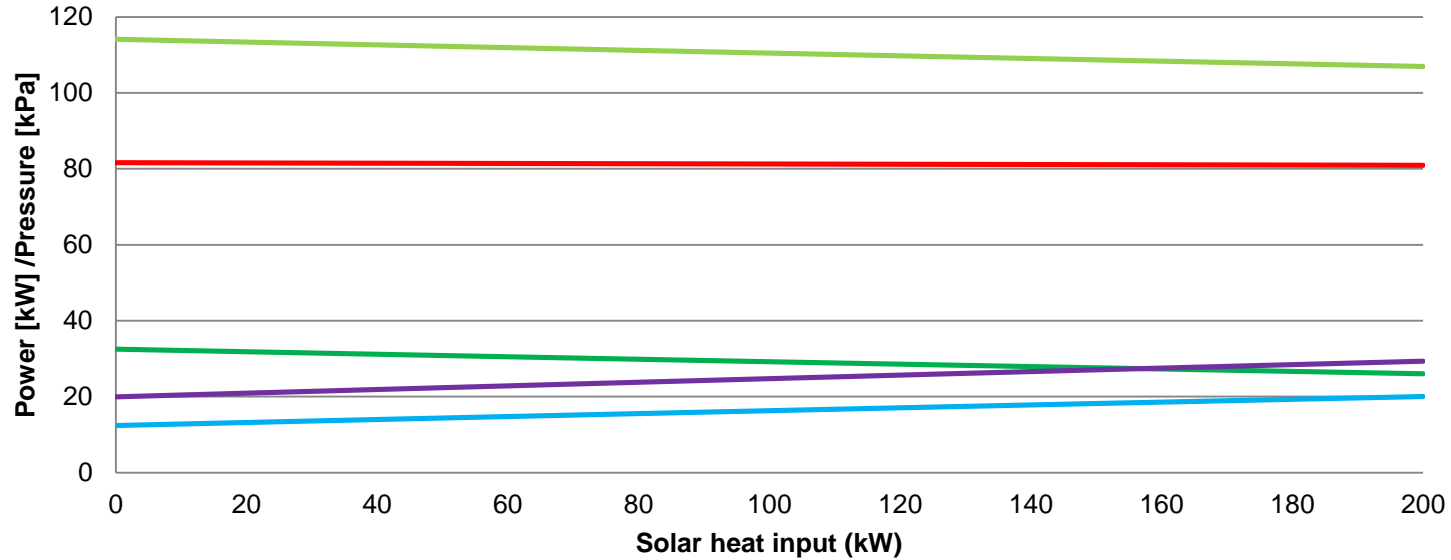
- Pressure drop 12 kPa (SOLGATE receiver)

Piping up and down the tower

Results



Results



$$\Delta P = K \frac{1}{2} \rho V^2$$

- Net Power Output (kW)
- Compressor Power Required (kW)
- Turbine Power Produced (kW)
- Receiver ΔP (loss)
- Piping ΔP (loss)

Conclusion



- Simulations predicted Rover gas turbine performance within 3%
- Solar-hybrid gas turbine
 - Increase in efficiency
 - Decreased net power output

Future work



- Implement newly designed compressor
- Further refinement of the model
- Gas turbine field testing
- Design and analyse interconnection device
- Feasibility of scaling

References



- Flownex (2014) *Flownex Library Manual*, [online]
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www.flownex.com/info@flownex.com.
- Quarta, N. J. (2012) *Simulation of a Hybridised Solar Gas Turbine System*, University of the Witwatersrand, Johannesburg.
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Thank you

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NRF
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