UNIVERSITEIT GENT

FACULTEIT INGENIEURSWETENSCHAPPEN EN ARCHITECTUUR

ORCNext
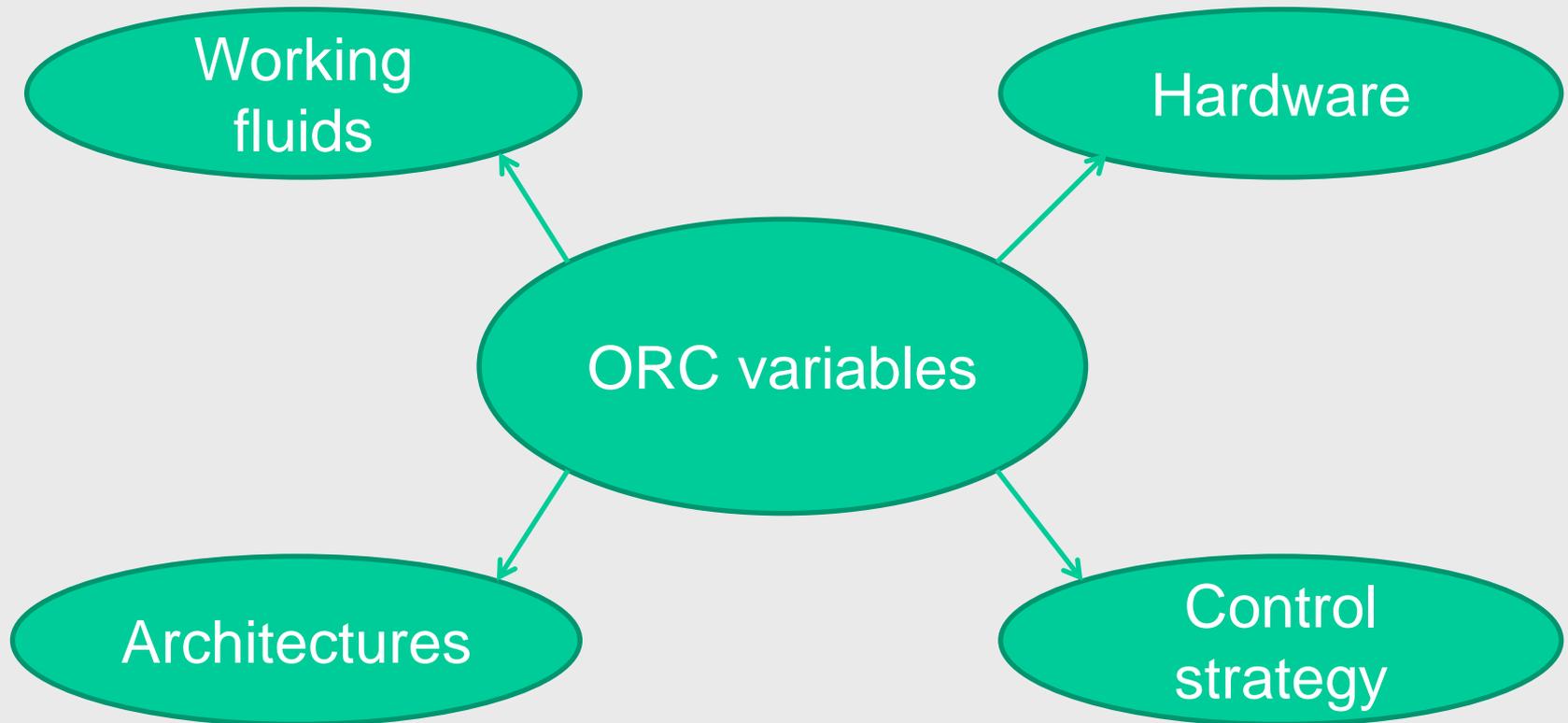The next generation Organic Rankine Cycles

Thermodynamic analysis of the partially evaporating trilateral cycle
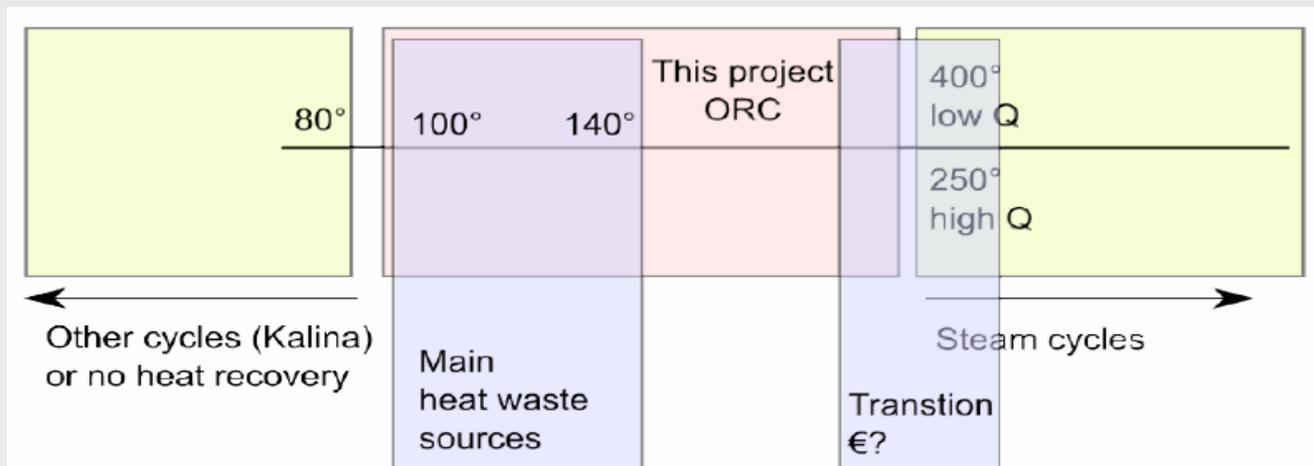
S. Lecompte

M. van den Broek

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Next Generation Organic Rankine Cycles

Working fluids

Hardware

ORC variables

Architectures

Control strategy

Why advanced cycle architectures?

- Improve **efficiency**
  - ‣ Increase cost effectiveness
  - ‣ Beneficial for the environment

- Increase **operating range** to lower input temperatures

Heat input and efficiency

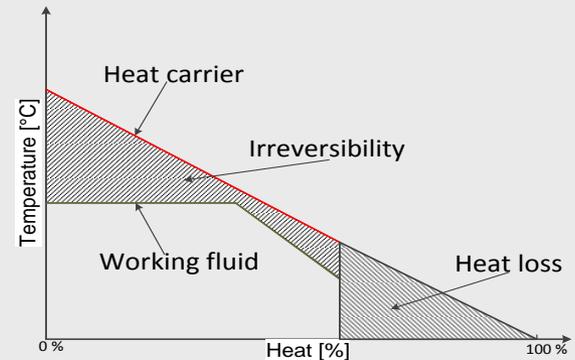$$\dot{W}_{out,net} = \eta_{th} \cdot \dot{Q}_{heat,in}$$

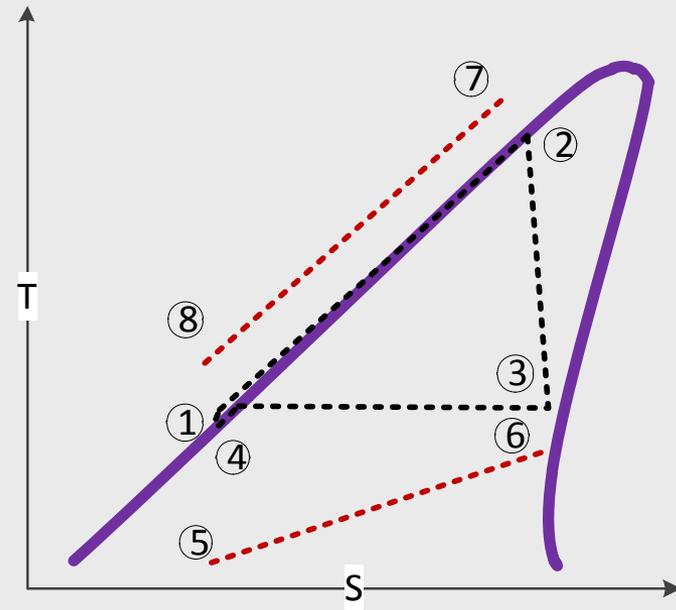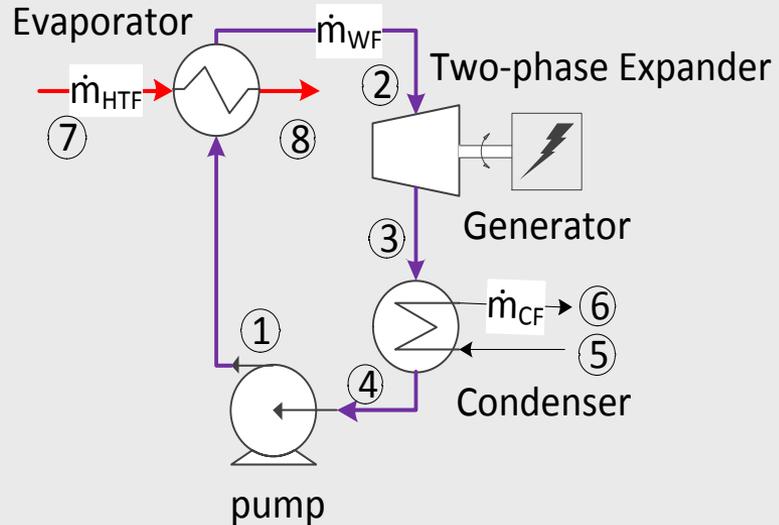**Thermal efficiency**

- $\eta_{th,carnot} = 1 - \dfrac{T_L}{T_H}$
- T_L
- T_h

Heat input

The Trilateral cycle

Trilateral cycle: overview

- 14% to 20% **net power improvement** versus basic ORC

  Fischer et al.

- **Two-phase expander** needed

- **High volume ratio** over **expander**   Smith et al.
  ‣ Water/steam not suitable

- Expanders with high isentropic efficiency possible
  ‣ double screw expanders

- Resulted in own study: **partially evaporating TLC**

Cycle with partial evaporation
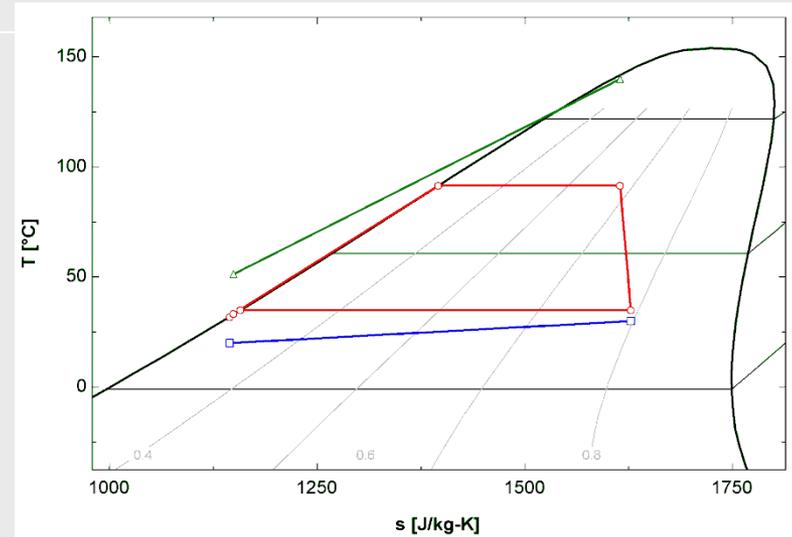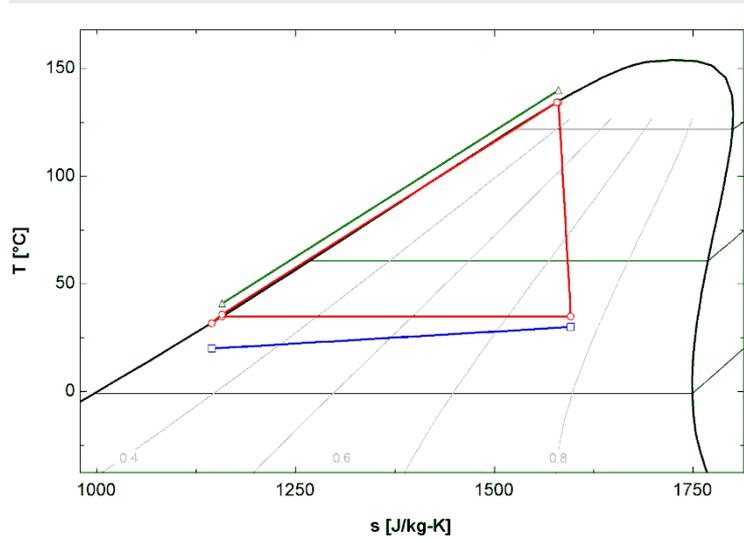
- Increased power output compared to subcritical ORC
  - Reduced pump size compared to TLC
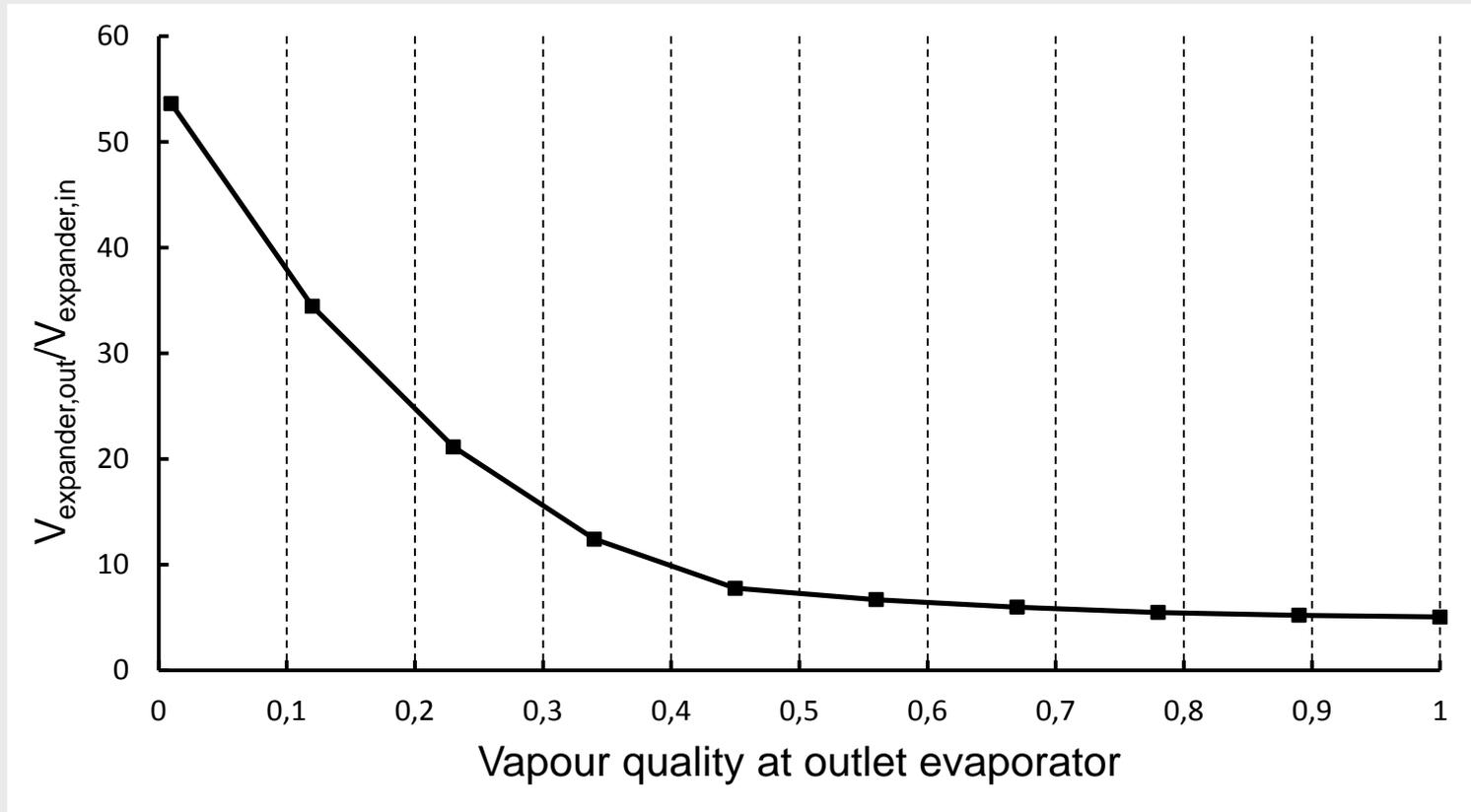- Reduced volume ratio over expander compared to TLC

Trilateral cycle: results partial evaporation (R245fa)

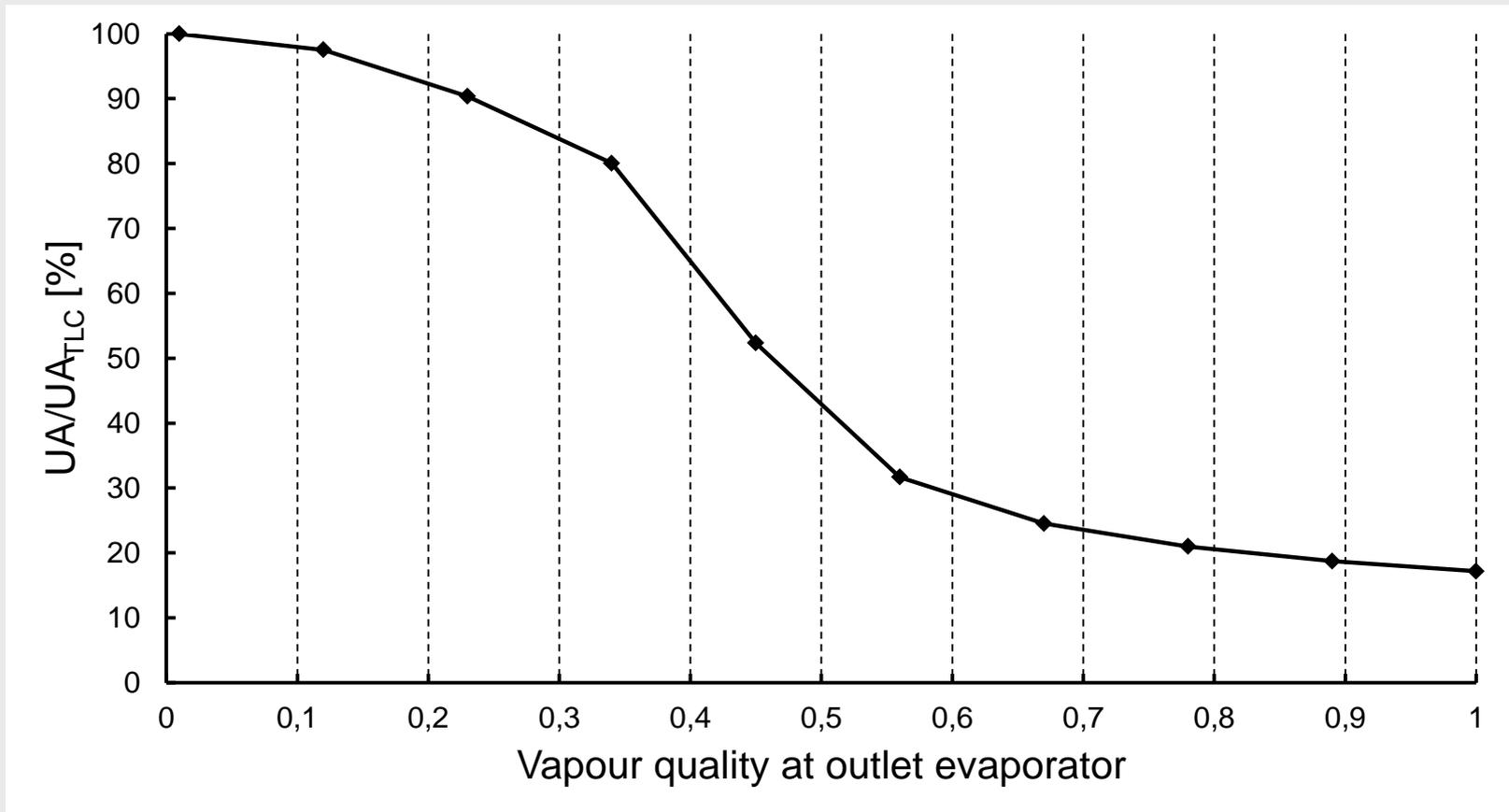|			
Cycle	Isentropic pump efficiency	30%	
	Isentropic turbine efficiency	70%	
	Subcooling	3°C	
	ΔT pinch evaporator	5°C	
	ΔT pinch condenser	5°C	
Heat source	Inlet temperature waste heat	100/120/140 °C	
	Mass flow rate waste heat	1 kg/s	
Heat sink	Inlet temperature cooling water	20 °C	
	Outlet temperature cooling water	30 °C	
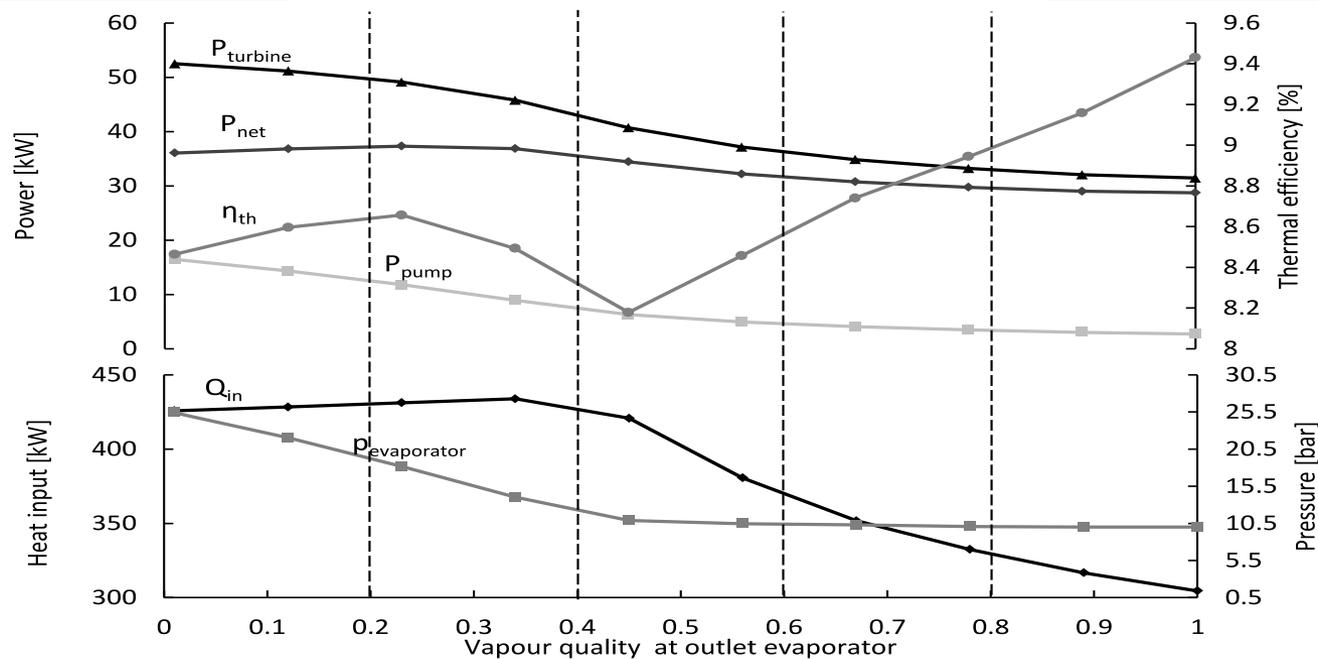
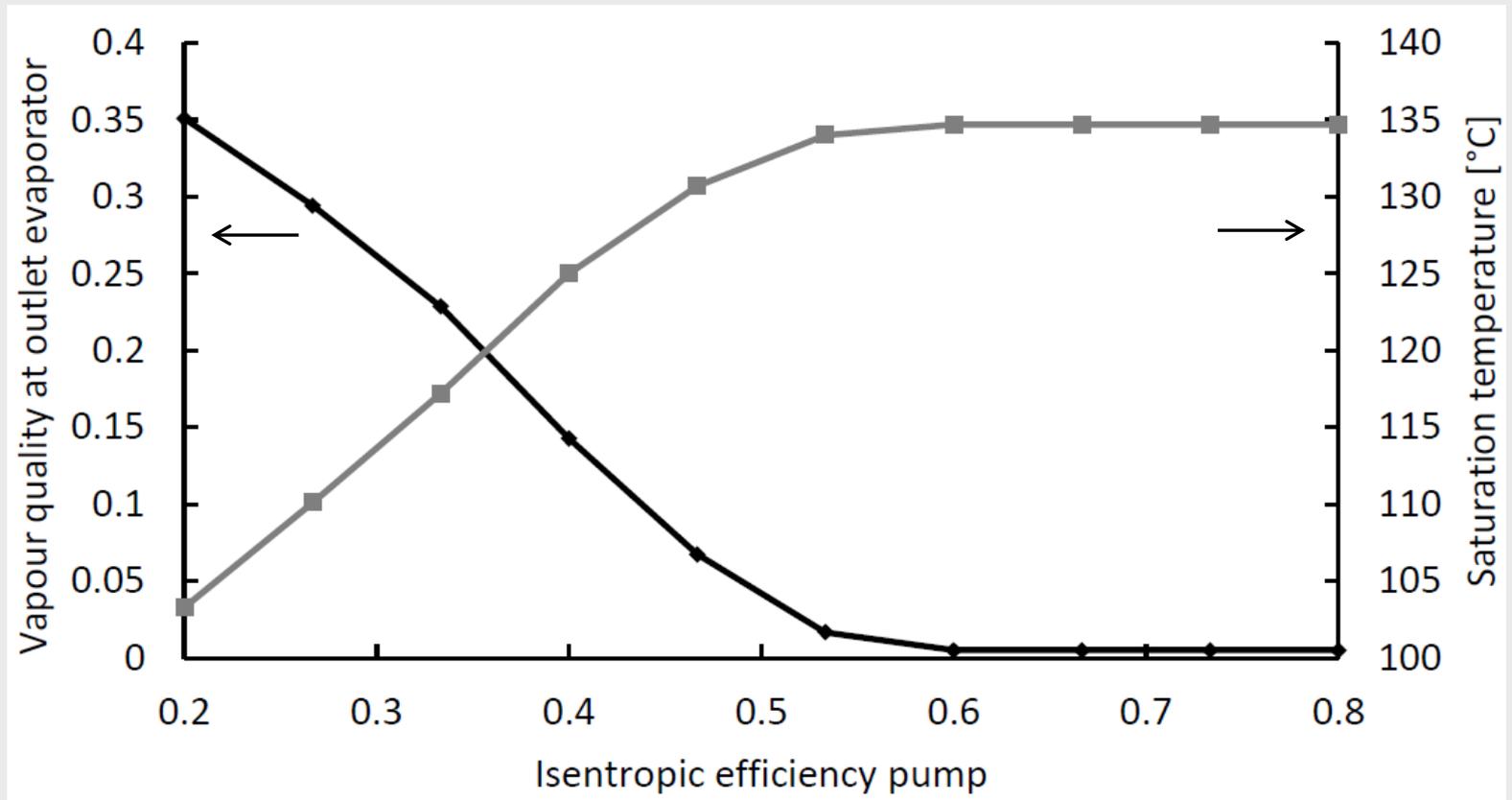Thermodynamic analysis of partially evaporating TLC, Submitted abstract, ORC2013
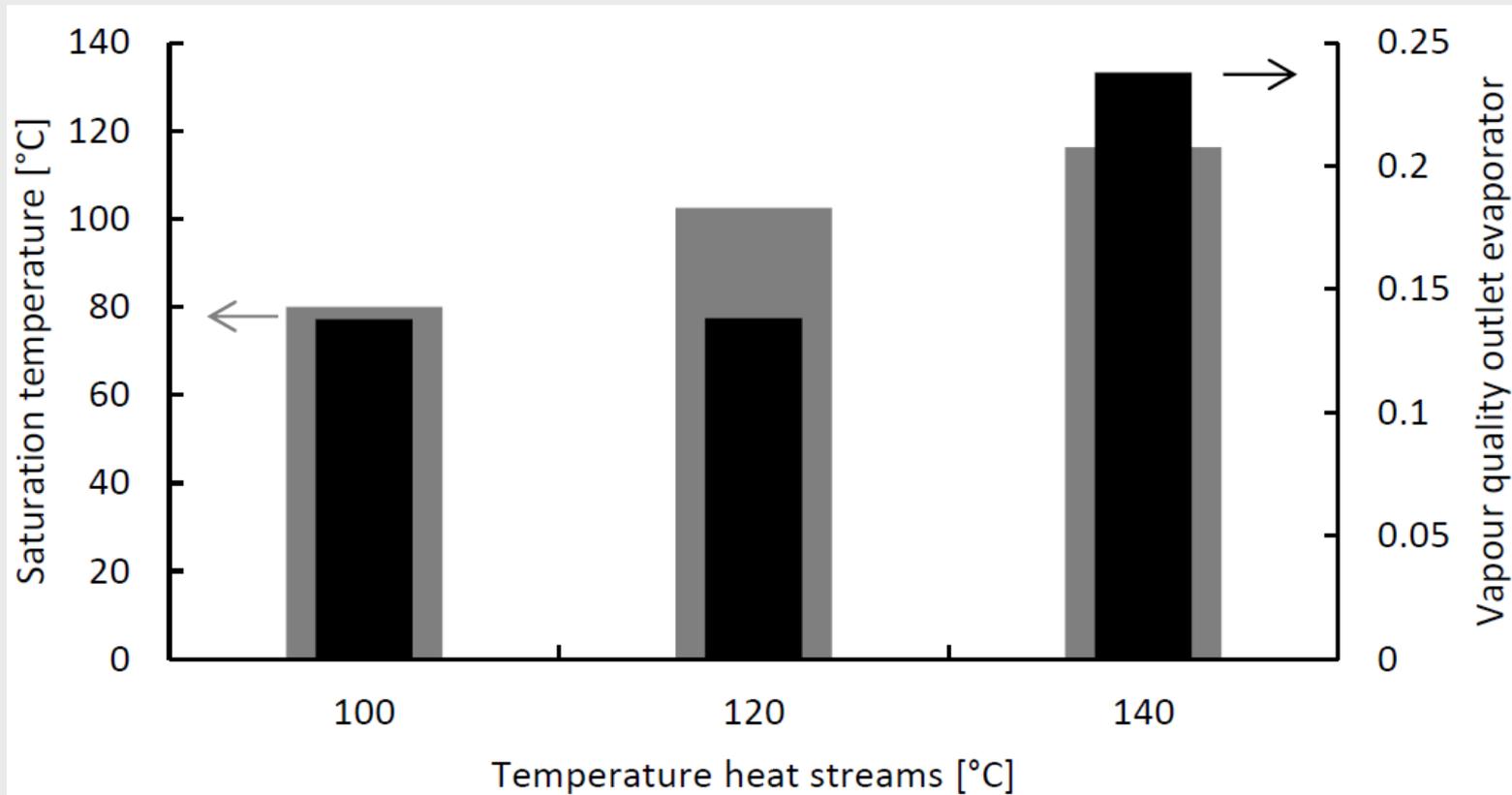
Trilateral cycle: results volume ratio

Effect on UA value

Effect of pump isentropic efficiency

Department of Flow, Heat and Combustion Mechanics – www.FloHeaCom.UGent.be
Ghent University – UGent

Effect of heat carrier temperature

Conclusions

- Increase in power output with 29% compared to subcritical ORC

- Reduction in pumping power with 24% compared to pure TLC

- Volume ratio 3 times lower compared to TLC

- Decrease in UA value with 20% compared to TLC

- Partial evaporation is promoted when the pump isentropic efficiency is low

Thermodynamic analysis of the partially evaporating trilateral cycle

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