Steam Generation from Waste Heat

Frédéric Bless

NTB
Interstaatliche Hochschule
für Technik Buchs
FHO Fachhochschule Ostschweiz

Handhout:

SCCER
EFFICIENCY OF
INDUSTRIAL PROCESSES

In cooperation with the CTI

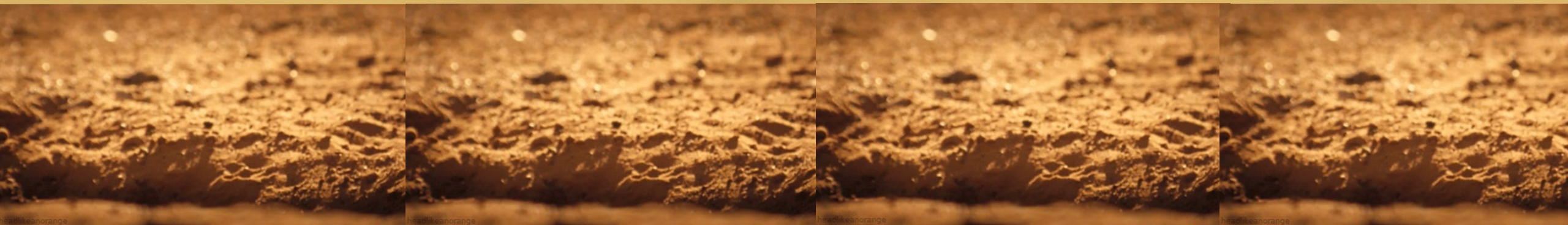
Energy funding programme
Swiss Competence Centers for Energy Research

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Commission for Technology and Innovation CTI

Steam Generation from Waste Heat



SCCER Networking 2016 was the start

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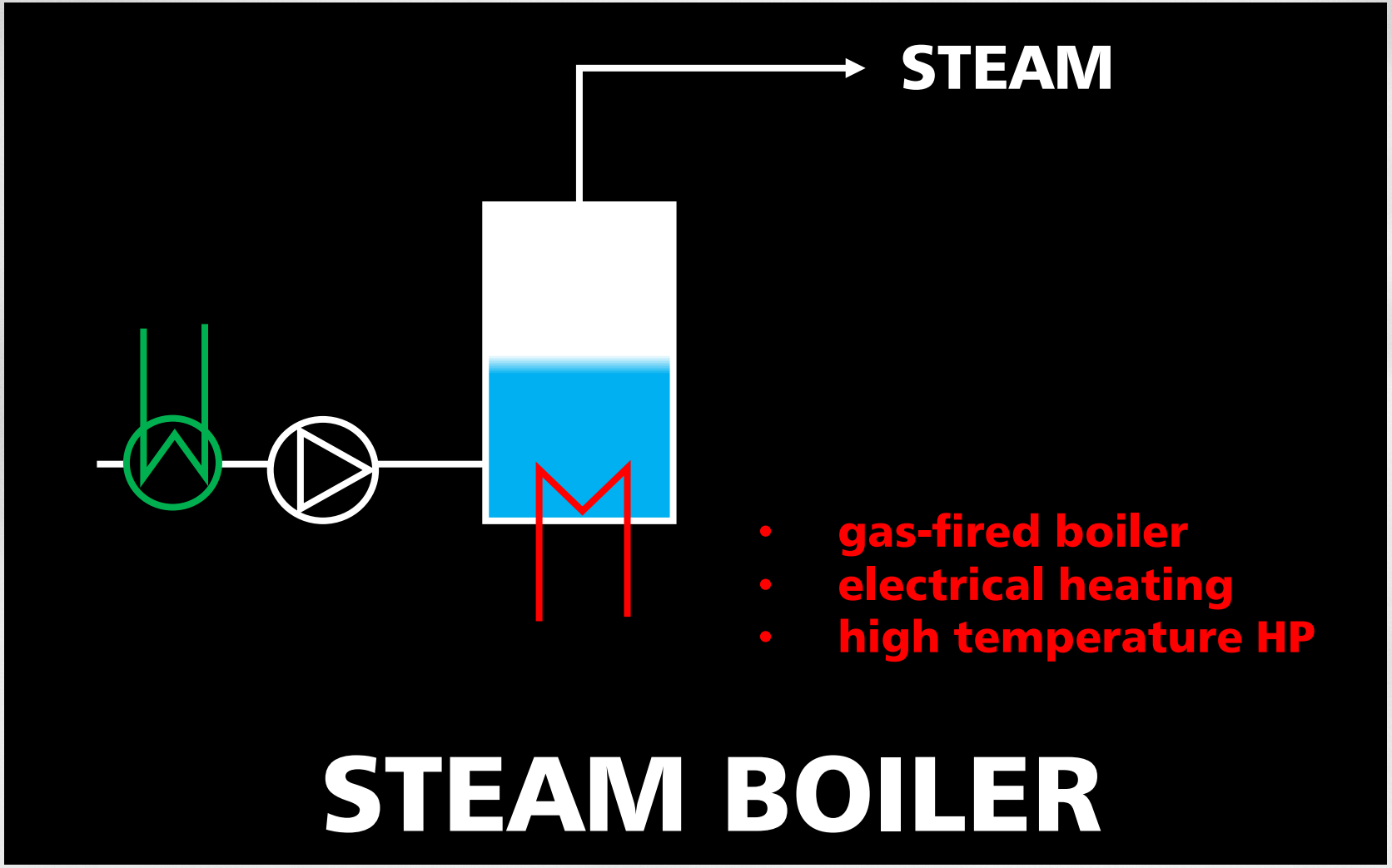

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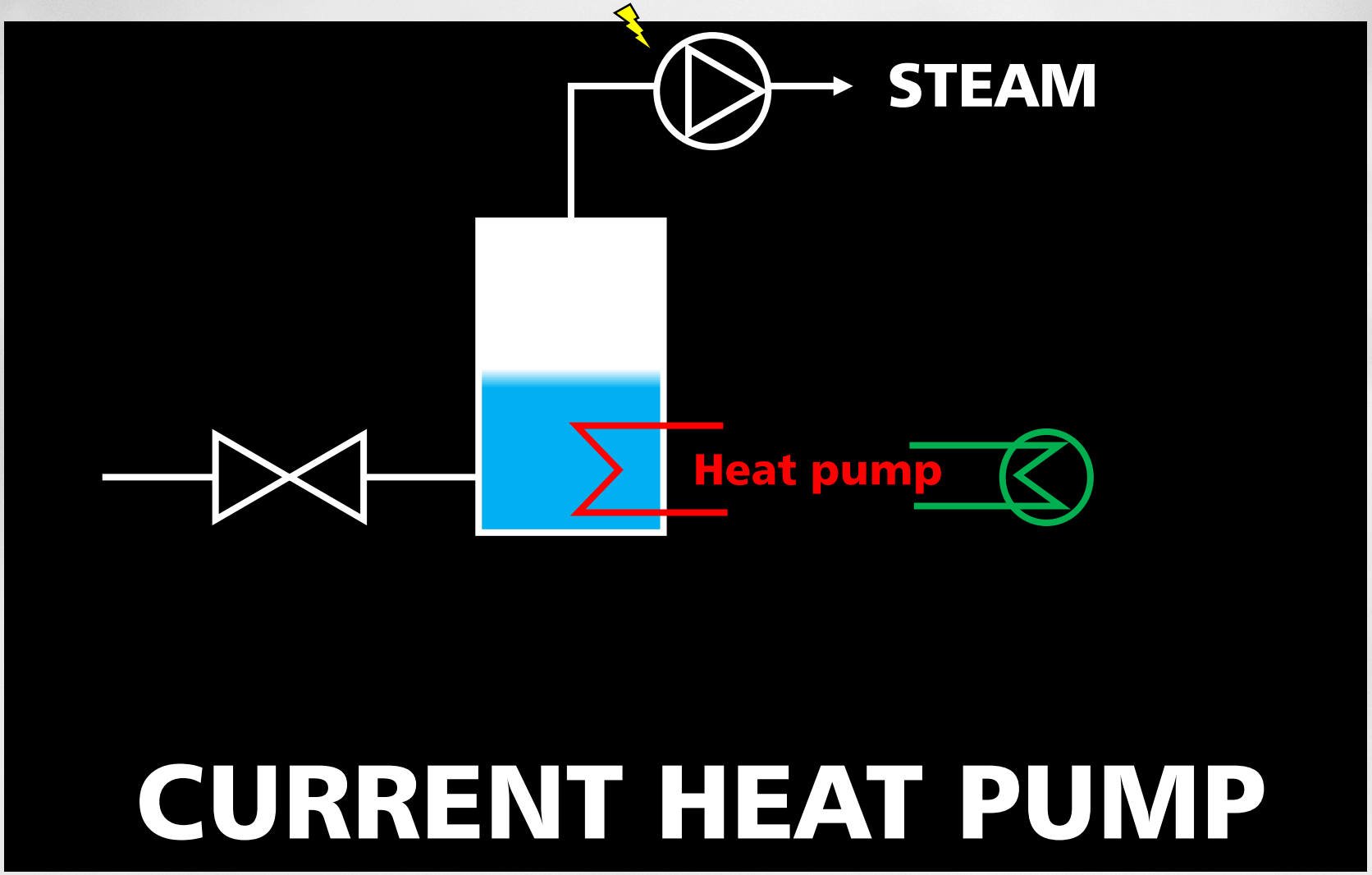
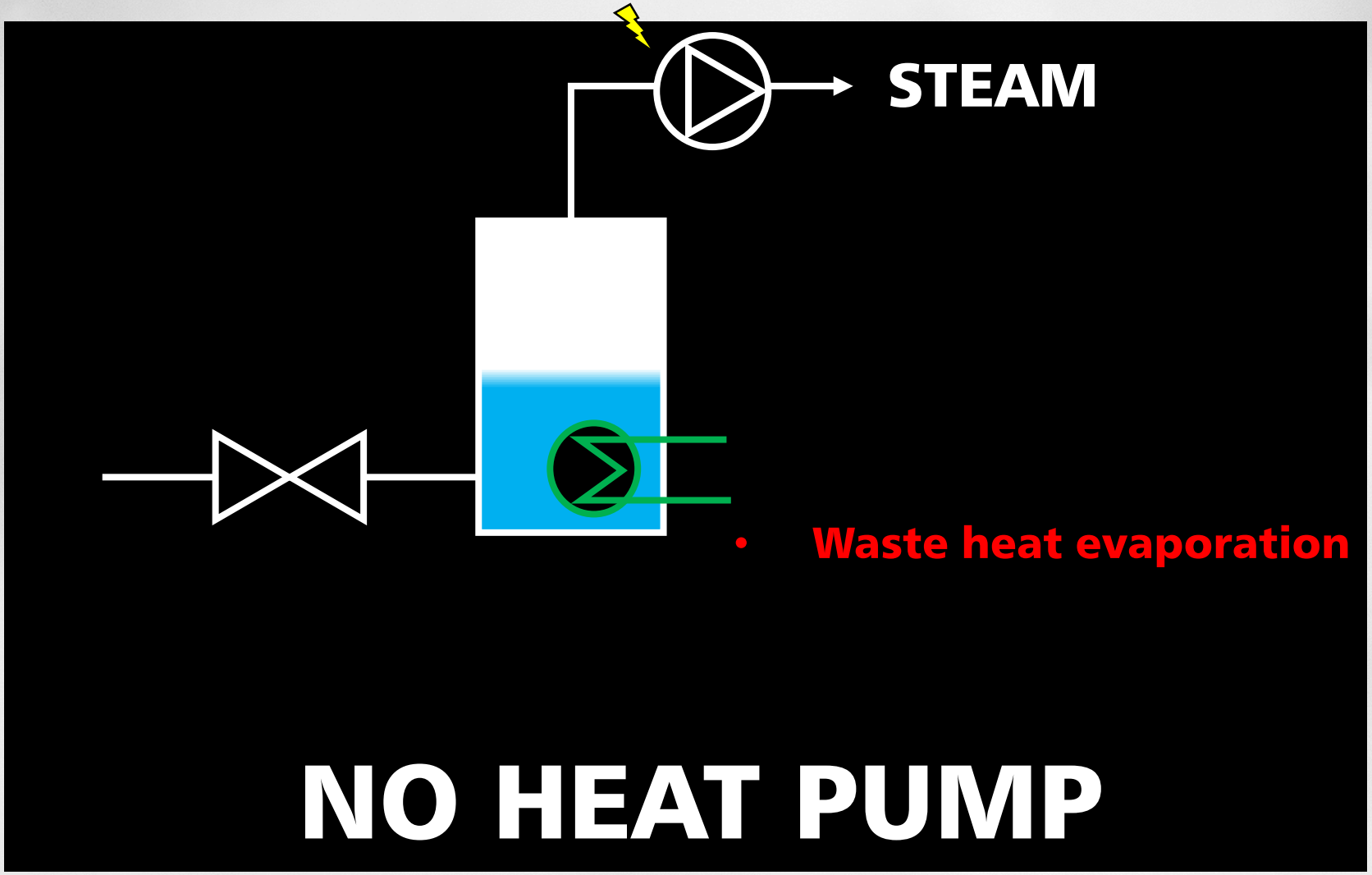
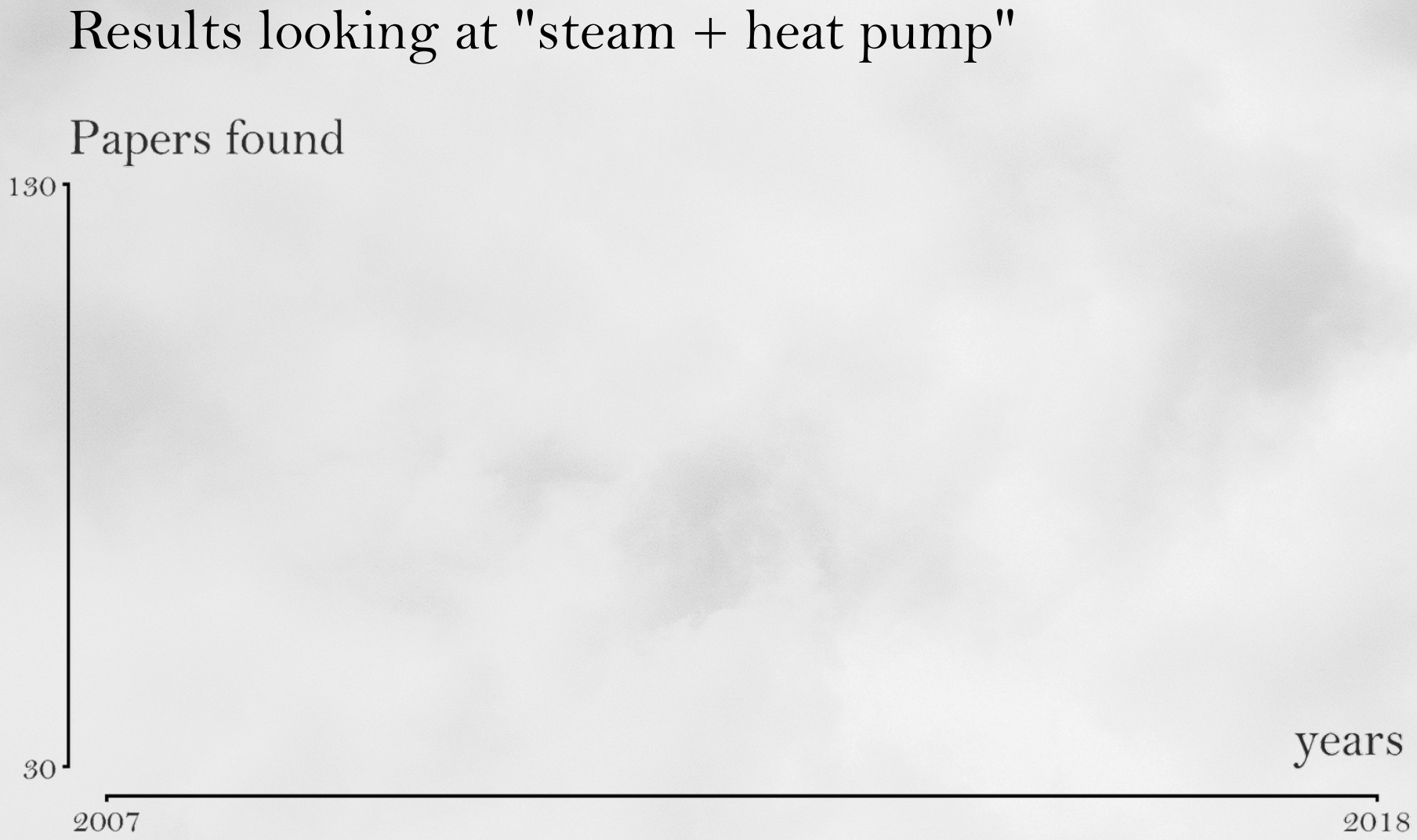


SCCER Networking 2016 was the start



The literature is slowly growing



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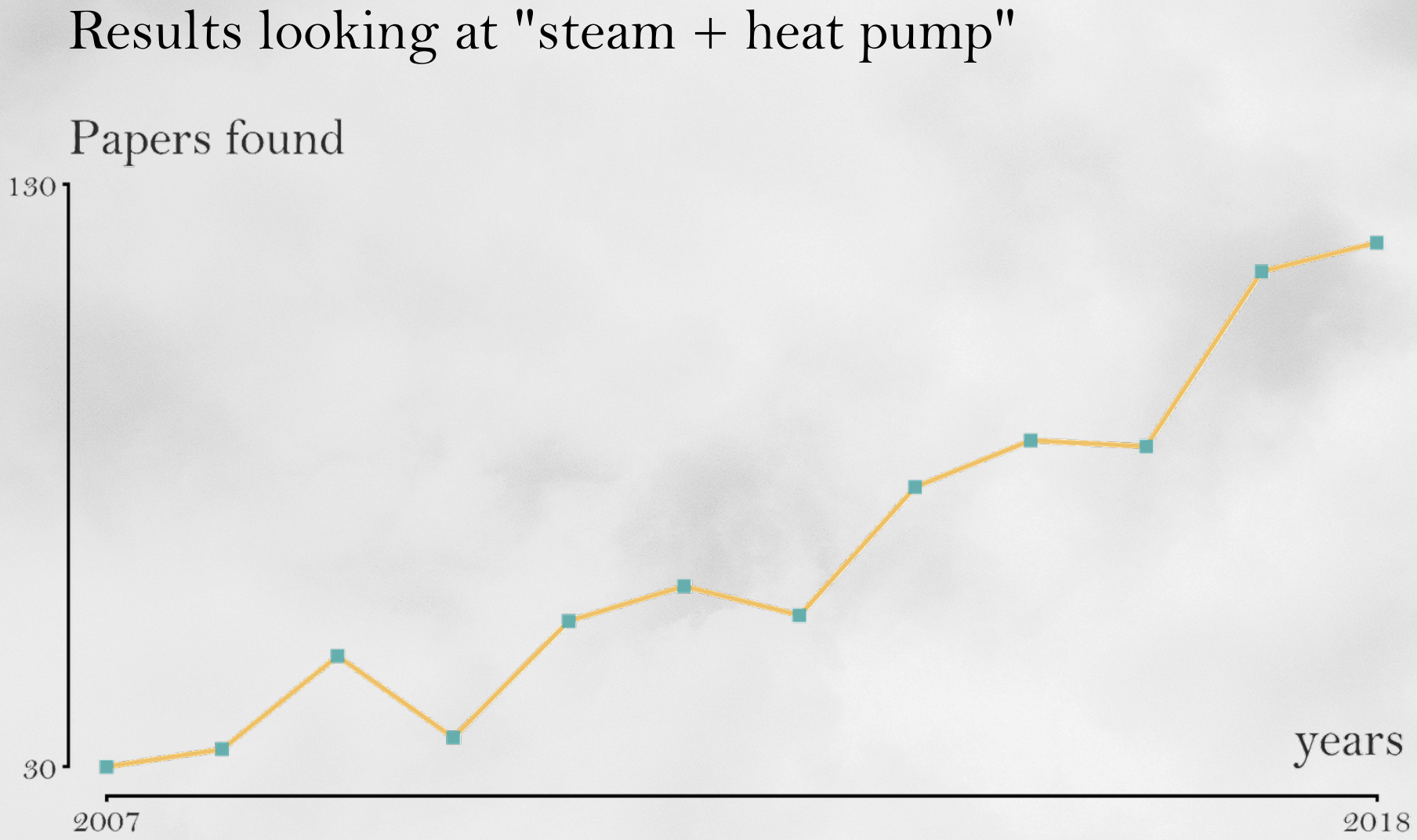

Case studies exist in Japan

Hokkaido Bioethanol Co. Ltd.

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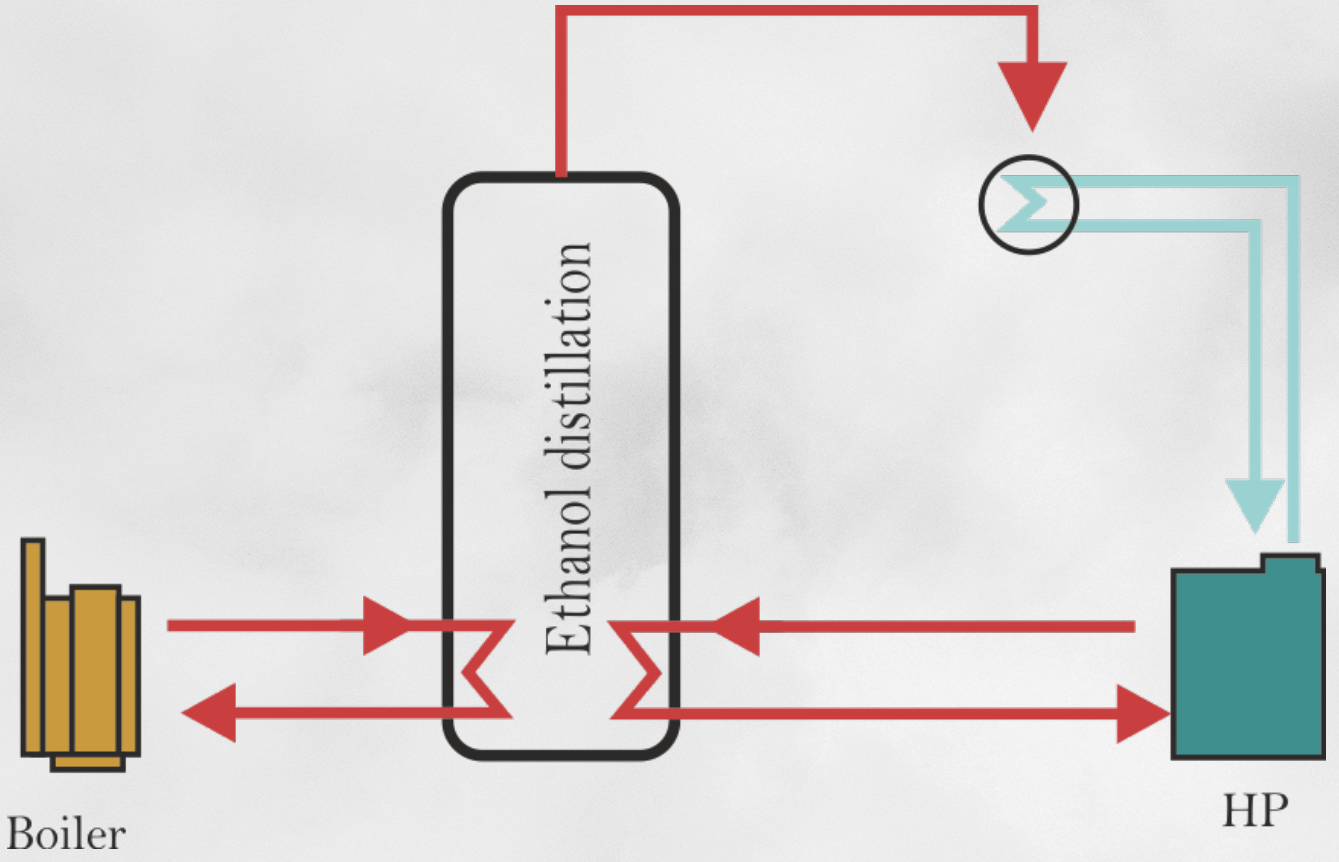
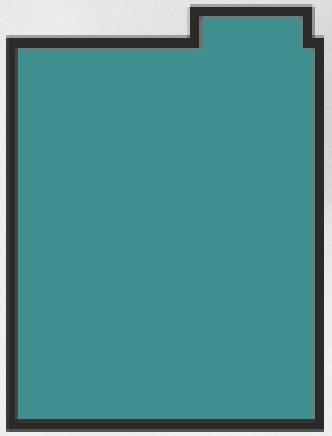
Hokkaido Bioethanol Co. Ltd.



Case studies exist in Japan

Hokkaido Bioethanol Co. Ltd.

High efficiency steam supply heat pump
Kobe Steel, Ltd.
Four units (normal operation)
One unit (back-up)
Steam pressure：0.1MPa
Steam temperature：120℃
Amount of steam：0.51t/h/ unit
Heating capacity：370kW/ unit
COP：3.5



HP

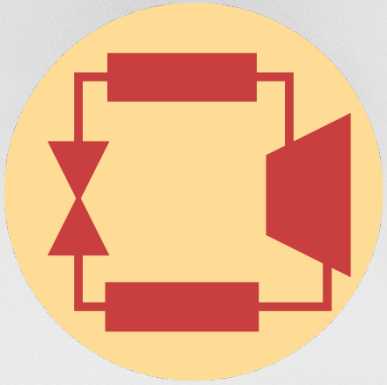
Case studies exist in Japan

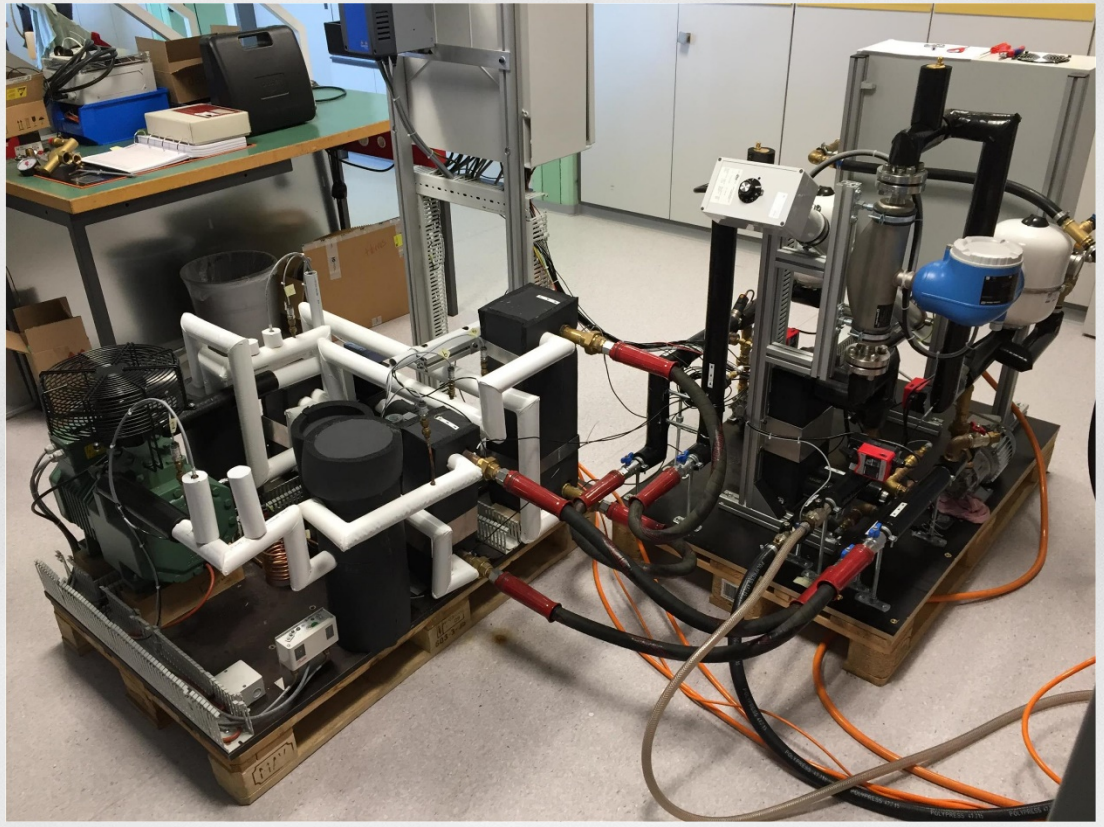
Meito Sangyo Co., Ltd. (Methanol Distillation)

Steam production from heat pump technologies is coming

Laboratory HP produces steam at NTB

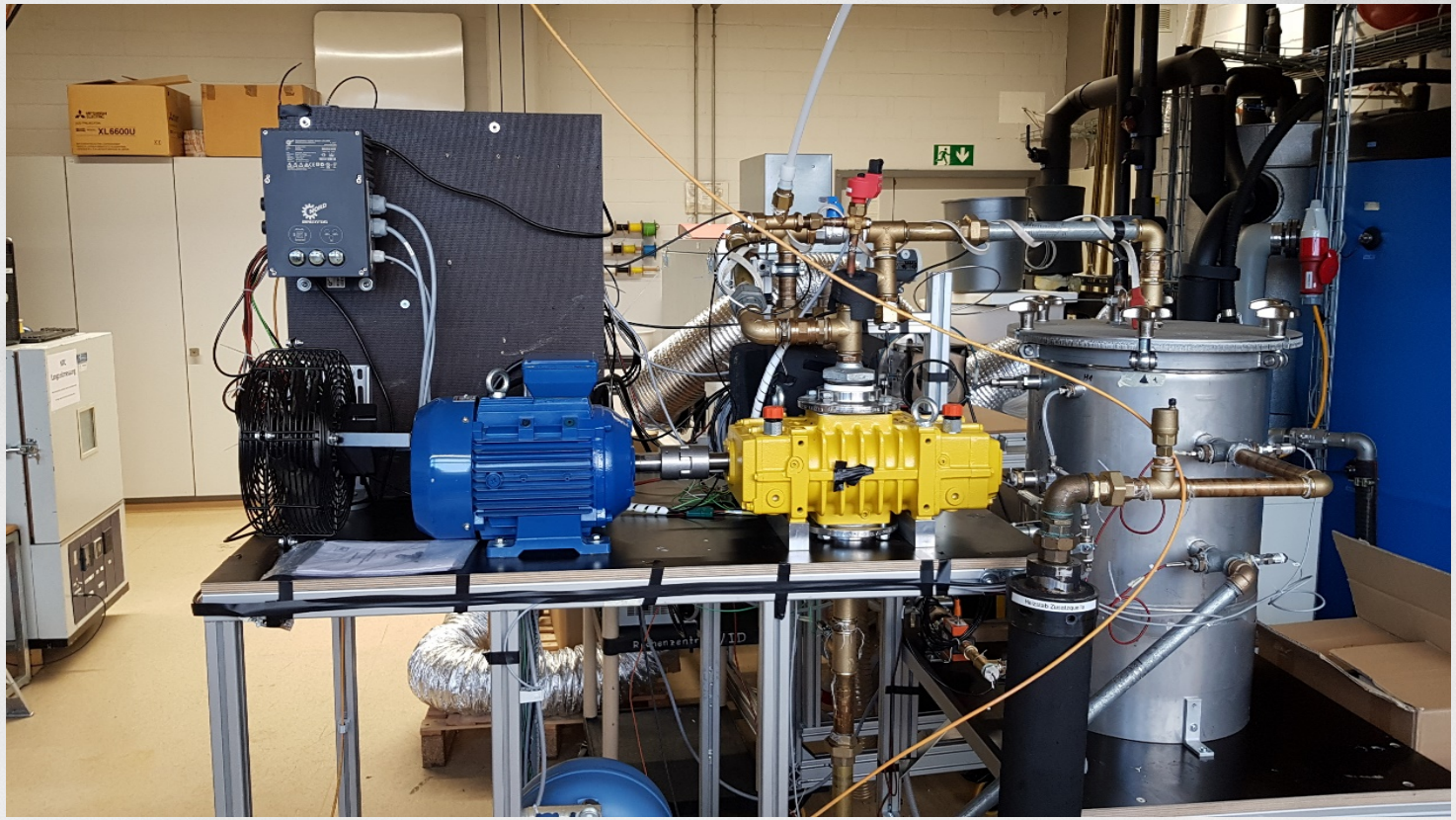
Cordin High Temperature Heat Pump





Laboratory HP produces steam at NTB

Ralph Kuster Semester-project

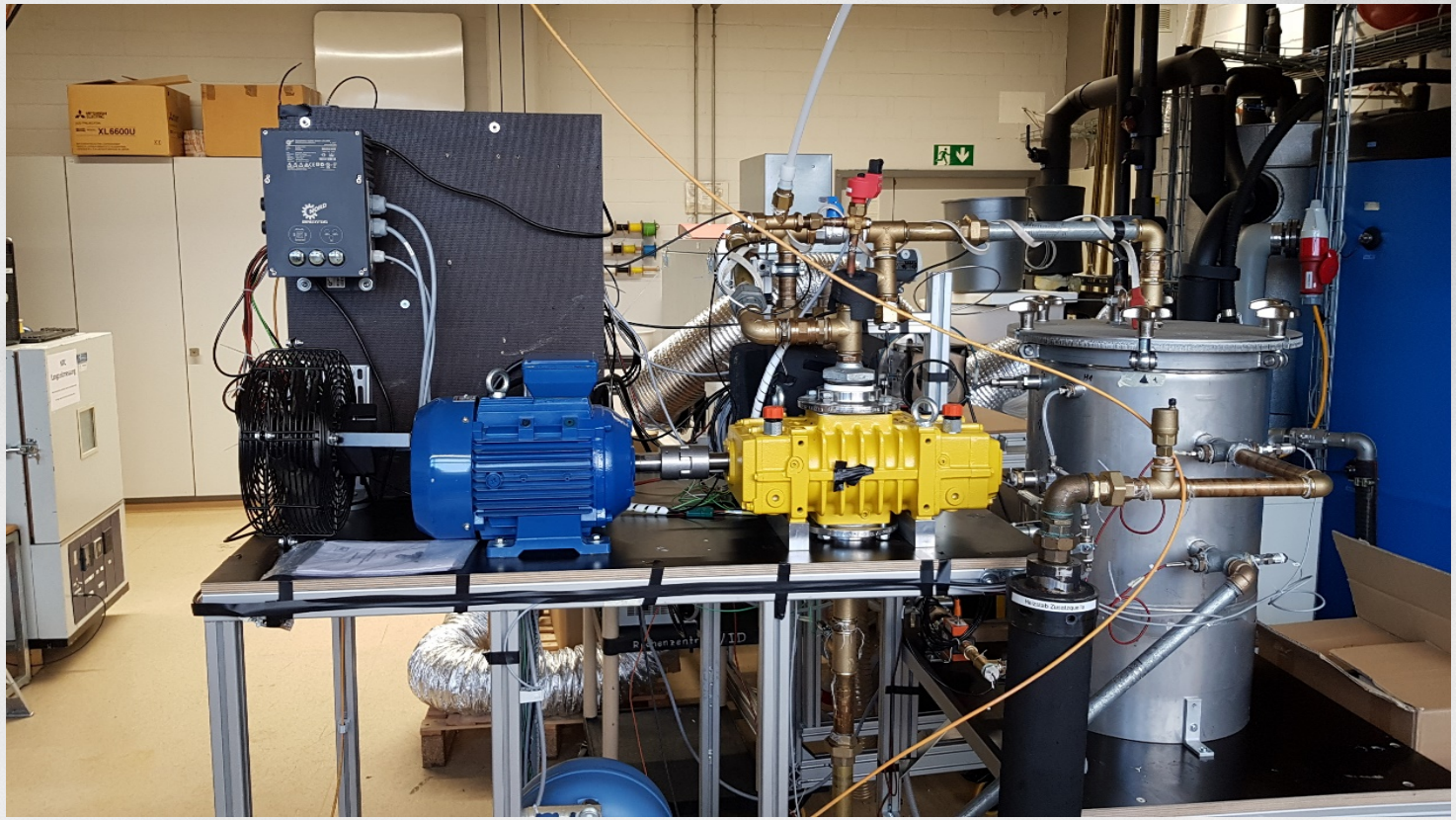


Laboratory HP produces steam at NTB

115°C Steam flow:

38.8 kg/h simulated

34.2 kg/h achieved



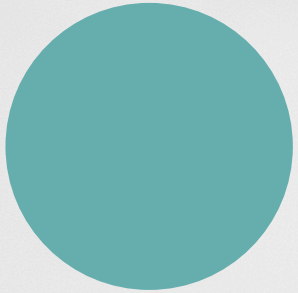
Laboratory HP produces steam at NTB

115°C Steam production efficiency:

Laboratory HP produces steam at NTB

115°C Steam production efficiency:

Ref.

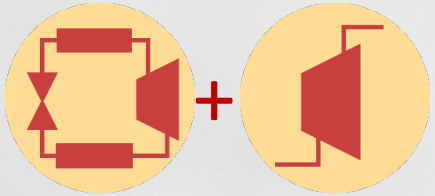


1

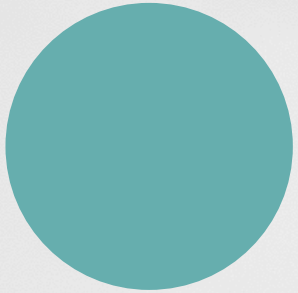
Laboratory HP produces steam at NTB

115°C Steam production efficiency:

Ref.



Source: 40°C



1

2/3

Laboratory HP produces steam at NTB

115°C Steam production efficiency:

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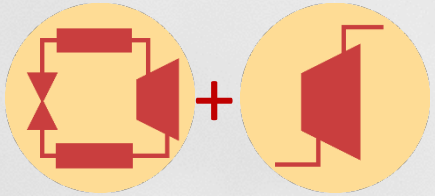
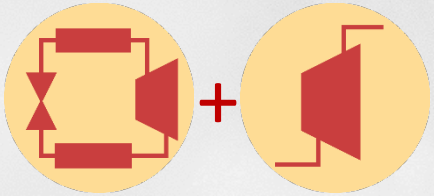
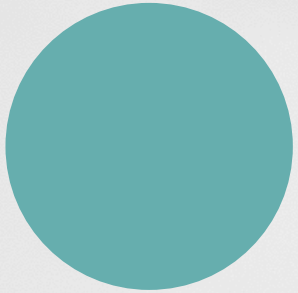


Source: 40°C



Source: 60°C



1

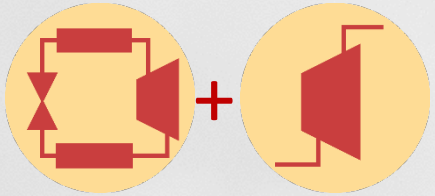
2/3

1/2

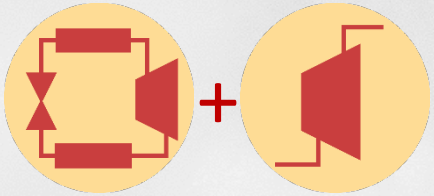
Laboratory HP produces steam at NTB

115°C Steam production efficiency:

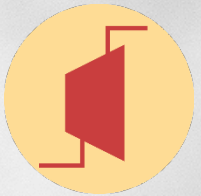
Ref.



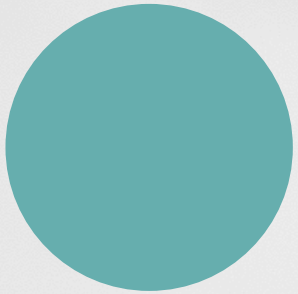
Source: 40°C



Source: 60°C



Source: 105°C



1

2/3

1/2

1/5

Compressor is the weakest link

There is a lack of steam compressors.

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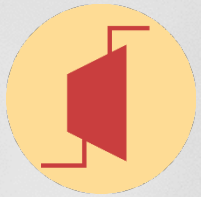
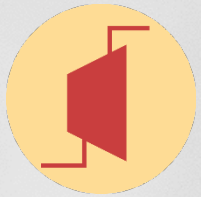
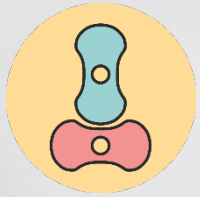


V_F [Nm^3/h]
$\prod_P$ [-]
E_E [kWh/t]

Compressor is the weakest link

KAESER KOMPRESSOREN





V_F

Π_P

E_E

Compressor is the weakest link

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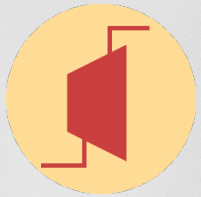
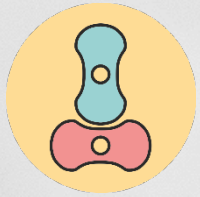


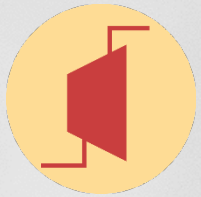


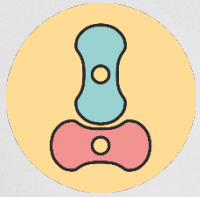
V_F	>5000
$\prod_P$	2
E_E	80

Compressor is the weakest link

KAESER KOMPRESSOREN

eDF





V_F	>5000
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E_E	80

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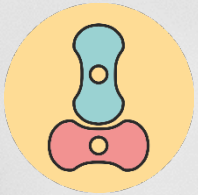
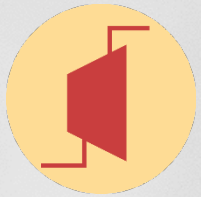
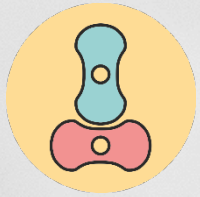
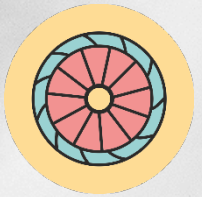


V_F	>5000	~2000
$\prod_P$	2	4.5
E_E	80	120

Compressor is the weakest link

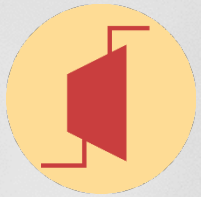


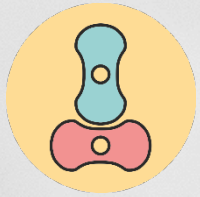


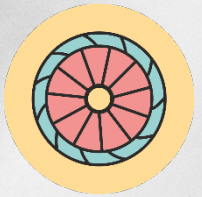


V_F	>5000	~2000
$\prod_P$	2	4.5
E_E	80	120

Compressor is the weakest link



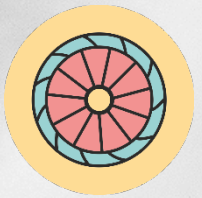




V_F	>5000	~2000	<1000
$\prod_P$	2	4.5	2
E_E	80	120	50

Compressor is the weakest link

There is a lack of steam compressors.

	KAESER KOMPRESSOREN	EDF	DBS DYNAMIC BOOSTING SYSTEMS
			
V_F	>5K	~2K	<1K
Π_P	2	4.5	2
E_E	80	120	50

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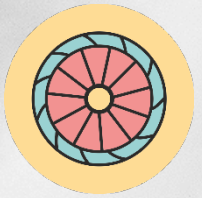
			
V_F	>5K	~2K	<1K
Π_P	2	4.5	2
E_E^*	1.53	1.04	1

Technologies works but the lack of steam compressor is slowing this progression

To increase our competence in steam production

H2020 application in progress

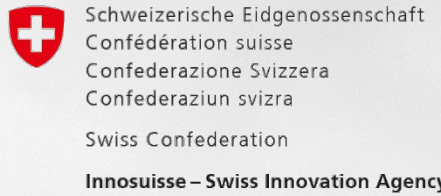
To increase our competence in steam production

H2020 application in progress

Eurostars application in progress

To increase our competence in steam production

H2020 application in progress
Eurostars application in progress
InnoSuisse project planned



To increase our competence in steam production

Were a doing an study on cycles comparaison

To increase our competence in steam production

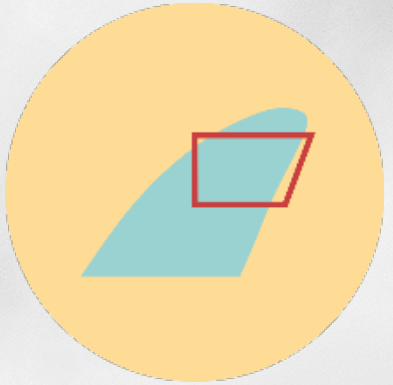
Were a doing an study on cycles comparaison

Goal is 150°C steam production.

To increase our competence in steam production

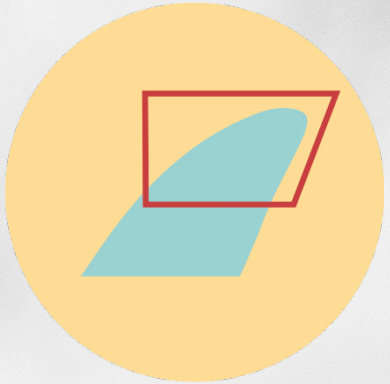
Were a doing an study on cycles comparaison

1) High-temperature HP



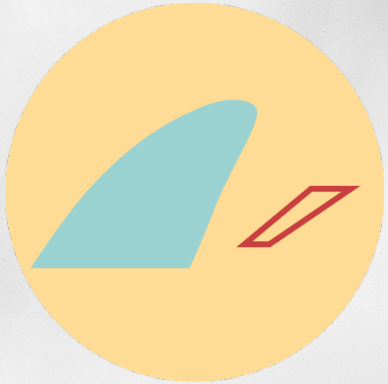
To increase our competence in steam production

2) Transcritial HP



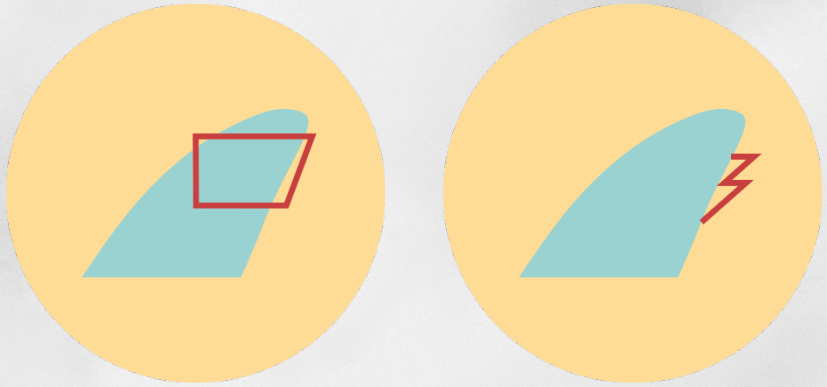
To increase our competence in steam production

3) Reversed Brayton HP



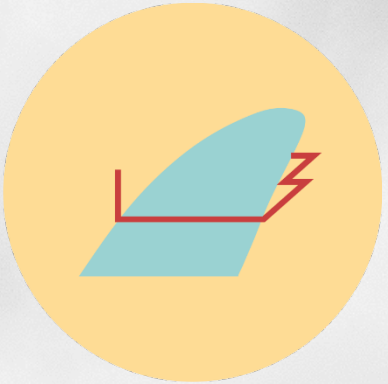
To increase our competence in steam production

4) HTHP + MVR

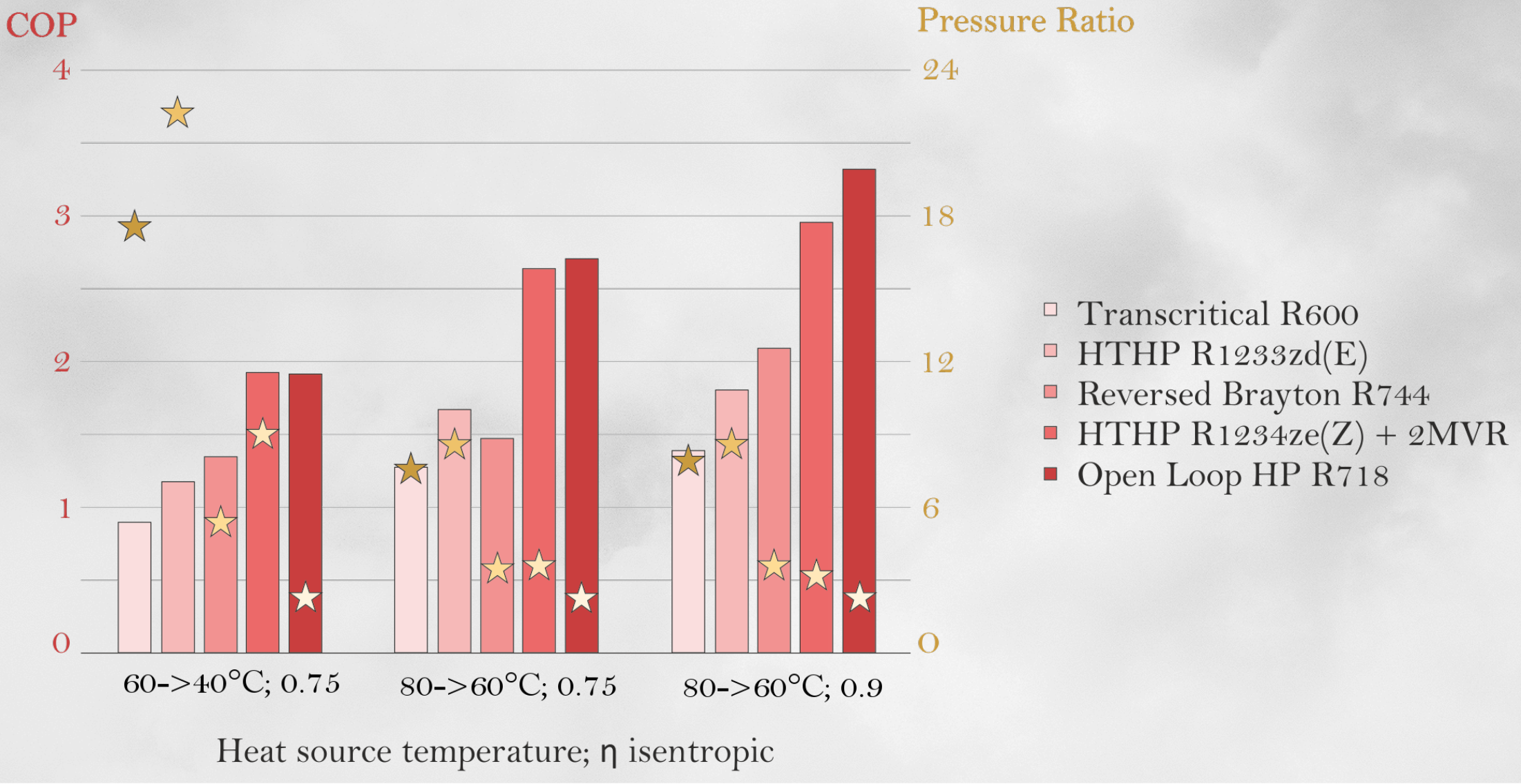


To increase our competence in steam production

5) Open-loop HP



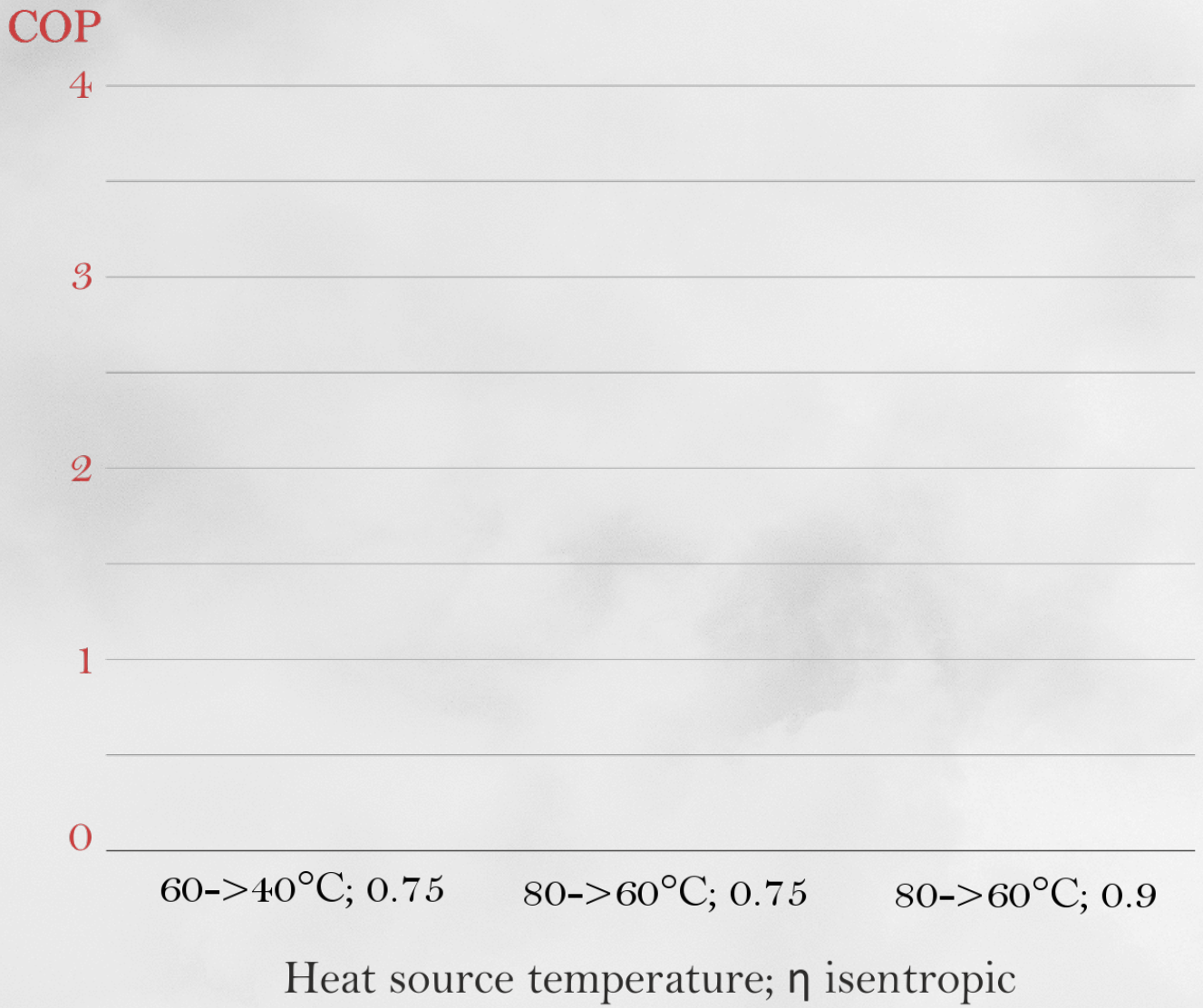
COP is higher when MVR is used



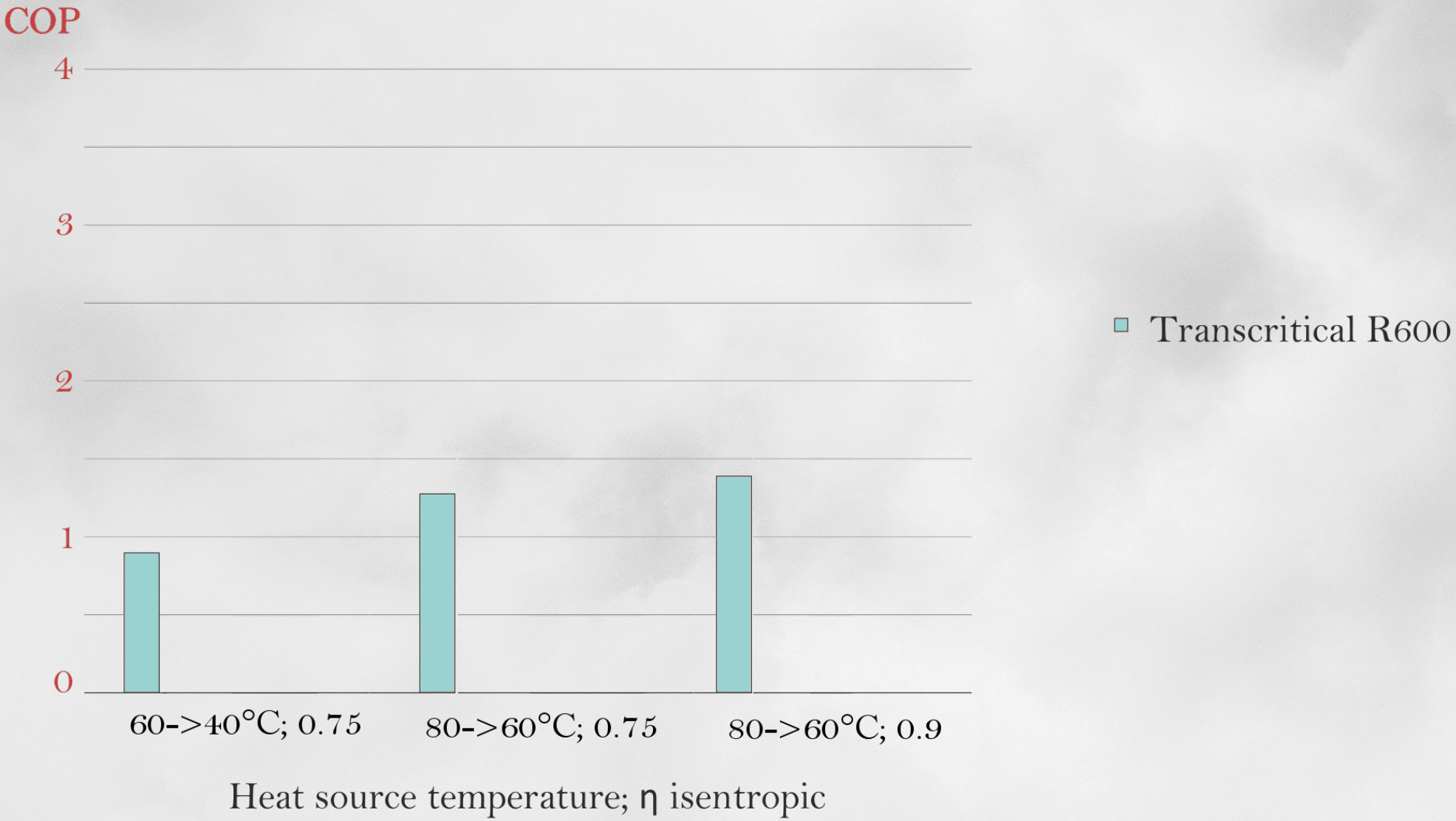
COP for different cycle to produce 150°C Steam

Heat source temperature; η isentropic

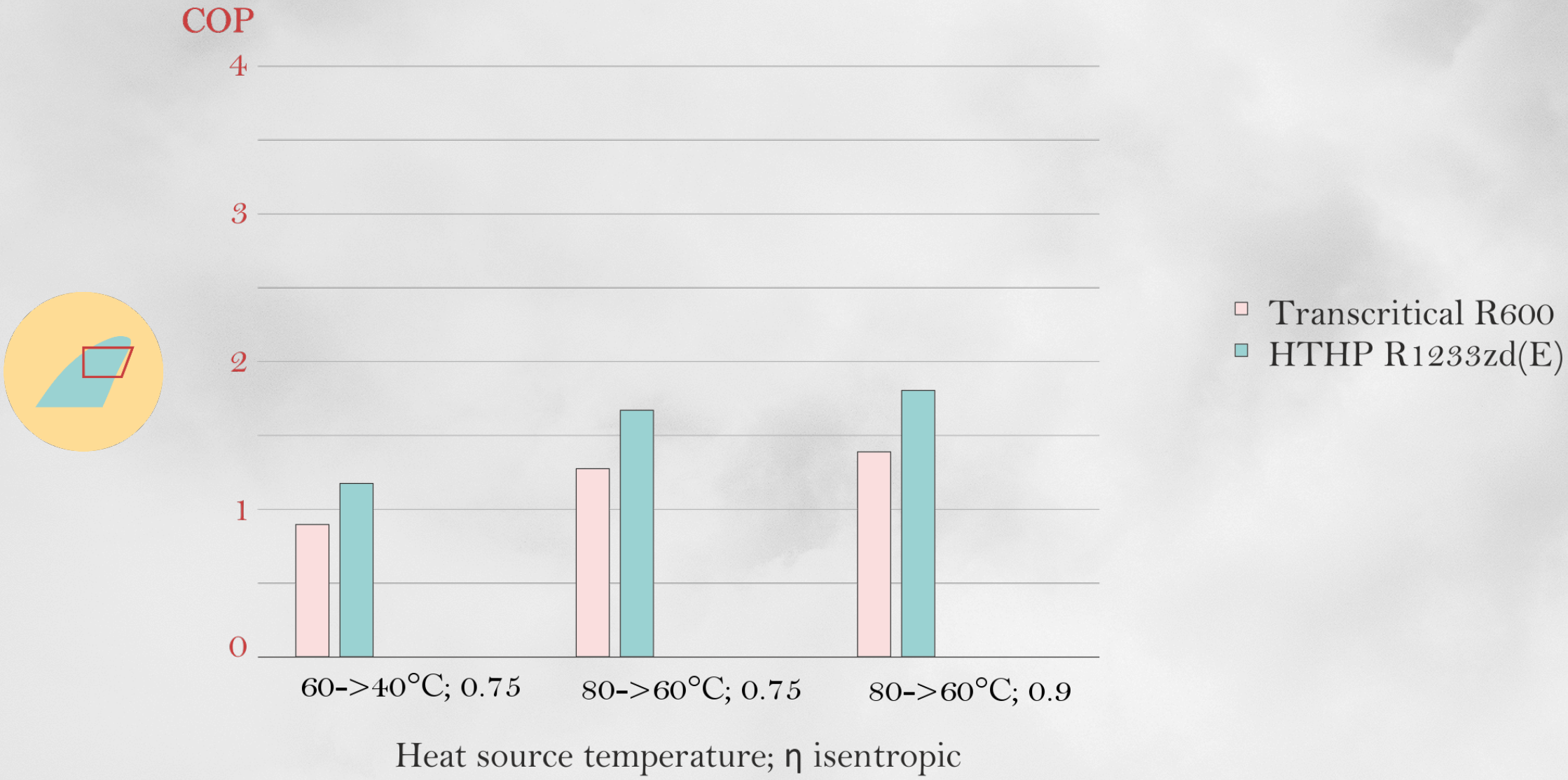
COP at different state to produce 150°C Steam



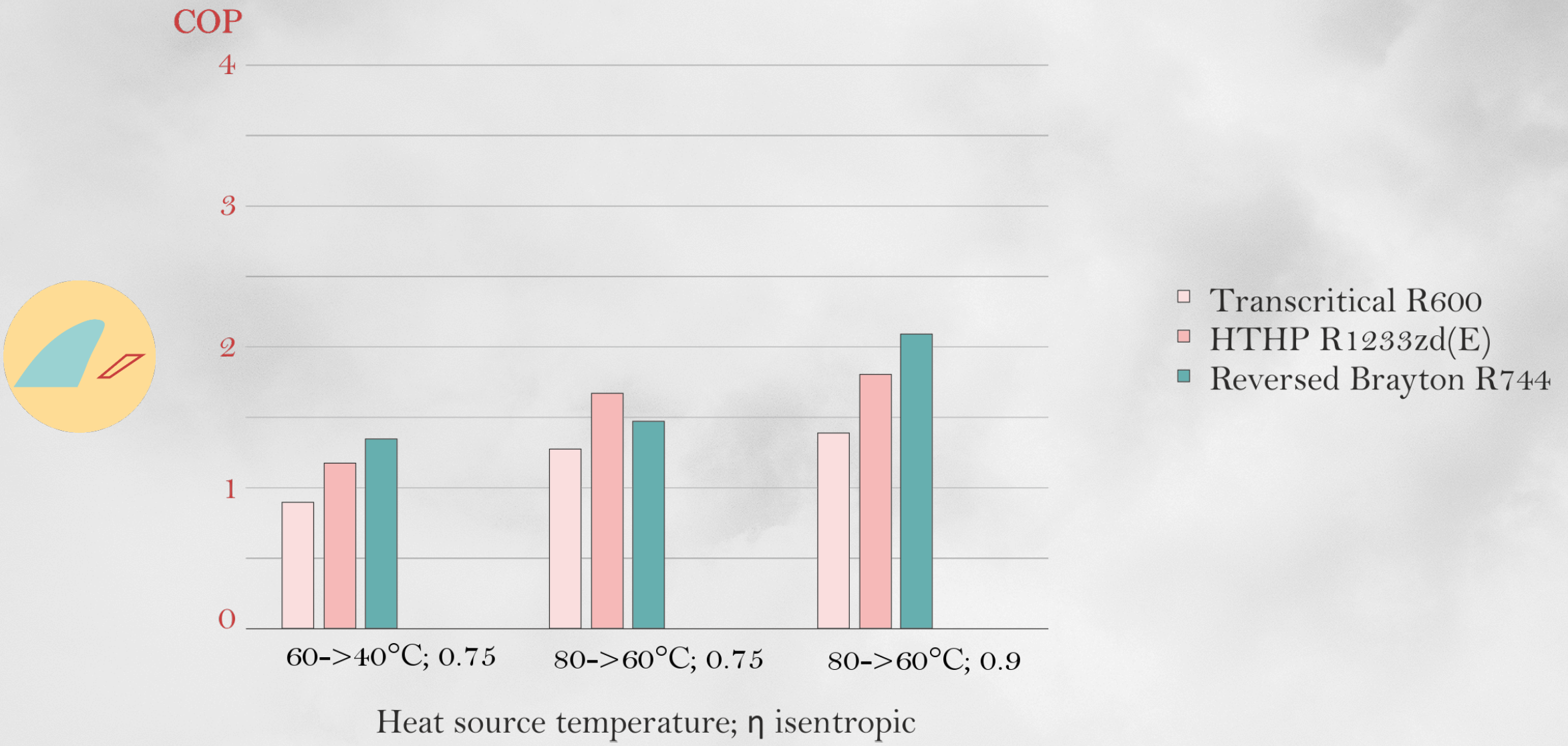
COP at different state using transcritical R600 HP



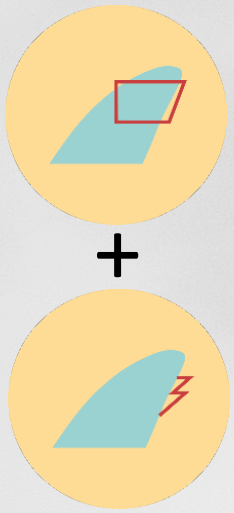
COP at different state using R1233zd(E) HTHP

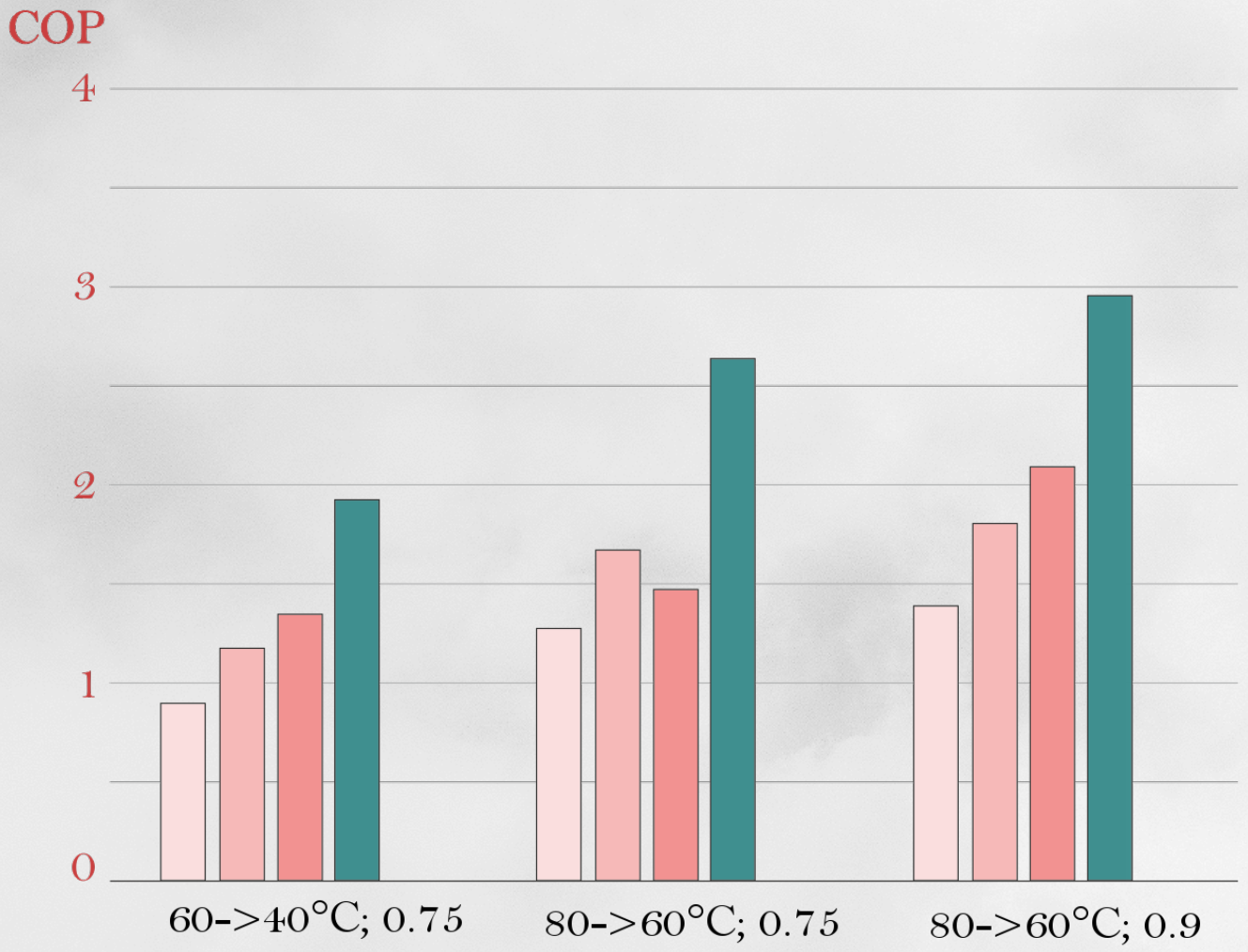


COP at different state using reversed Brayton CO_2



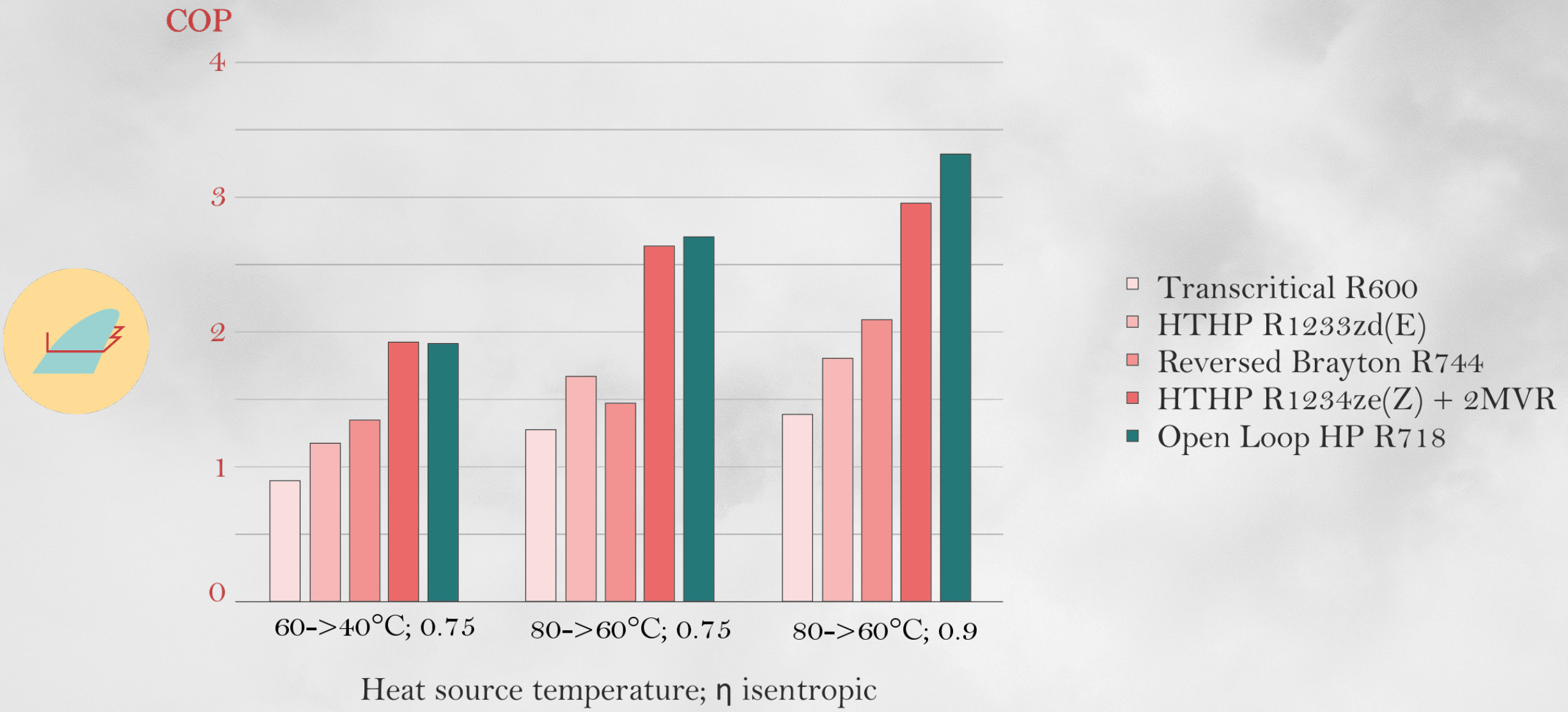
COP at different state using HTHP + 2 MVR



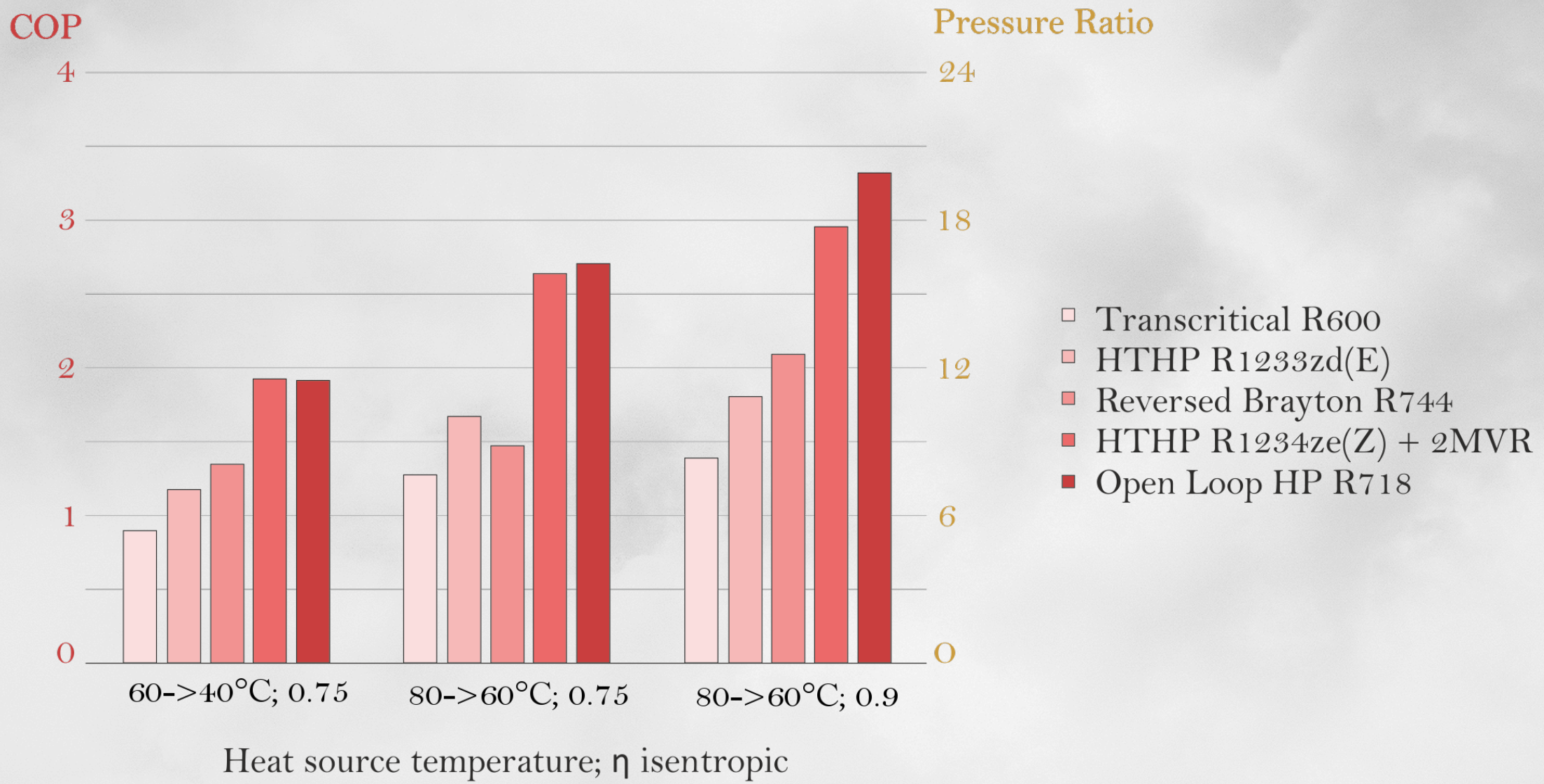


- Transcritical R600
- HTHP R1233zd(E)
- Reversed Brayton R744
- HTHP R1234ze(Z) + 2MVR

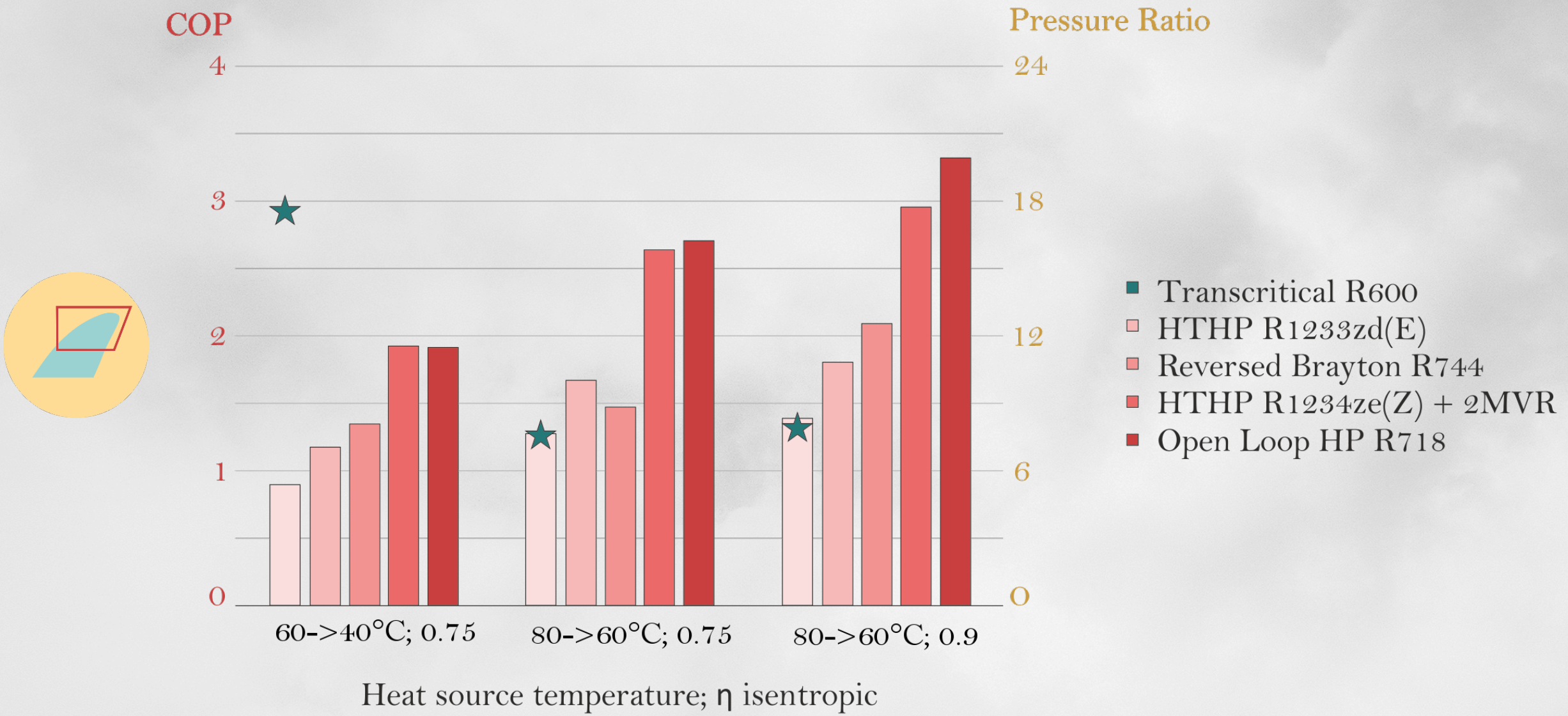
COP at different state using open loop R718 HP



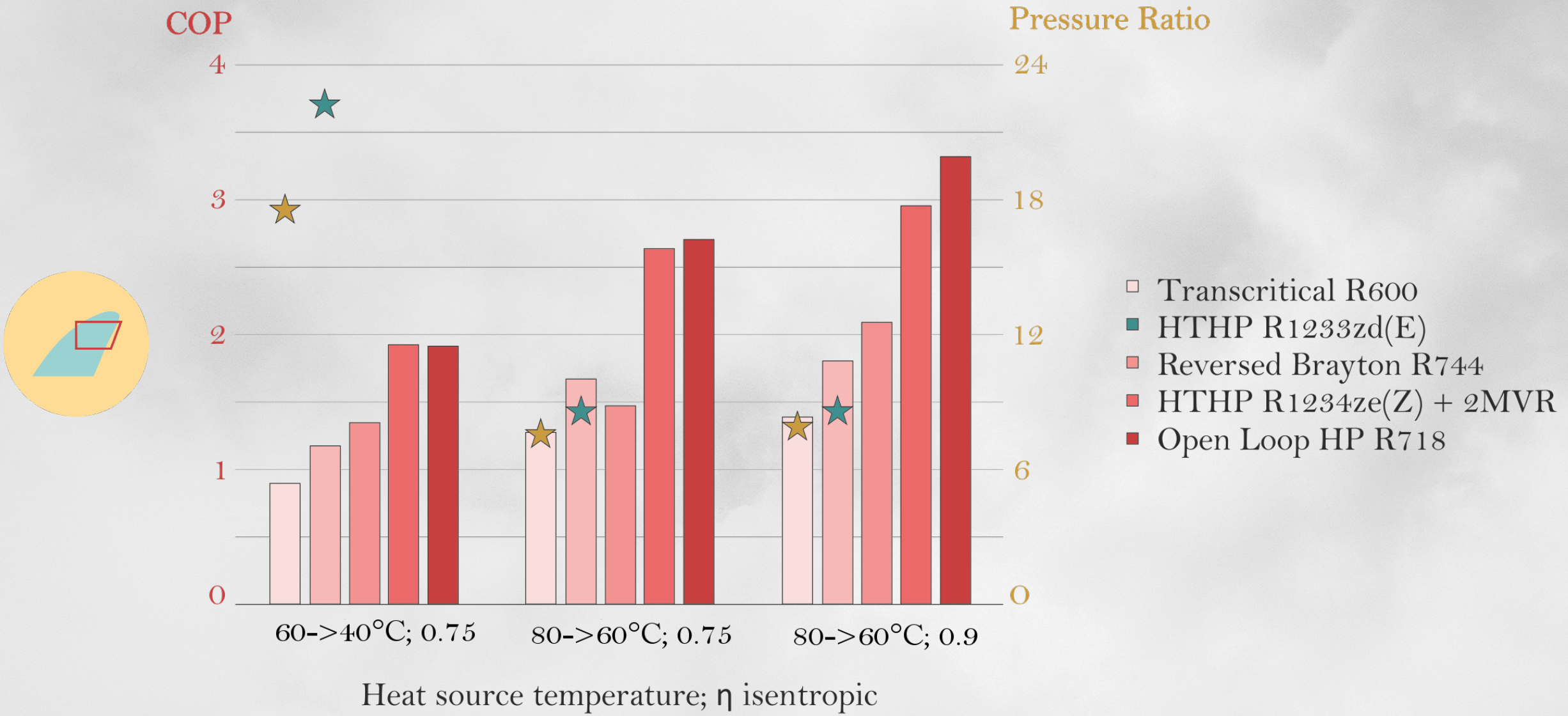
Pressure difference for the different cycles



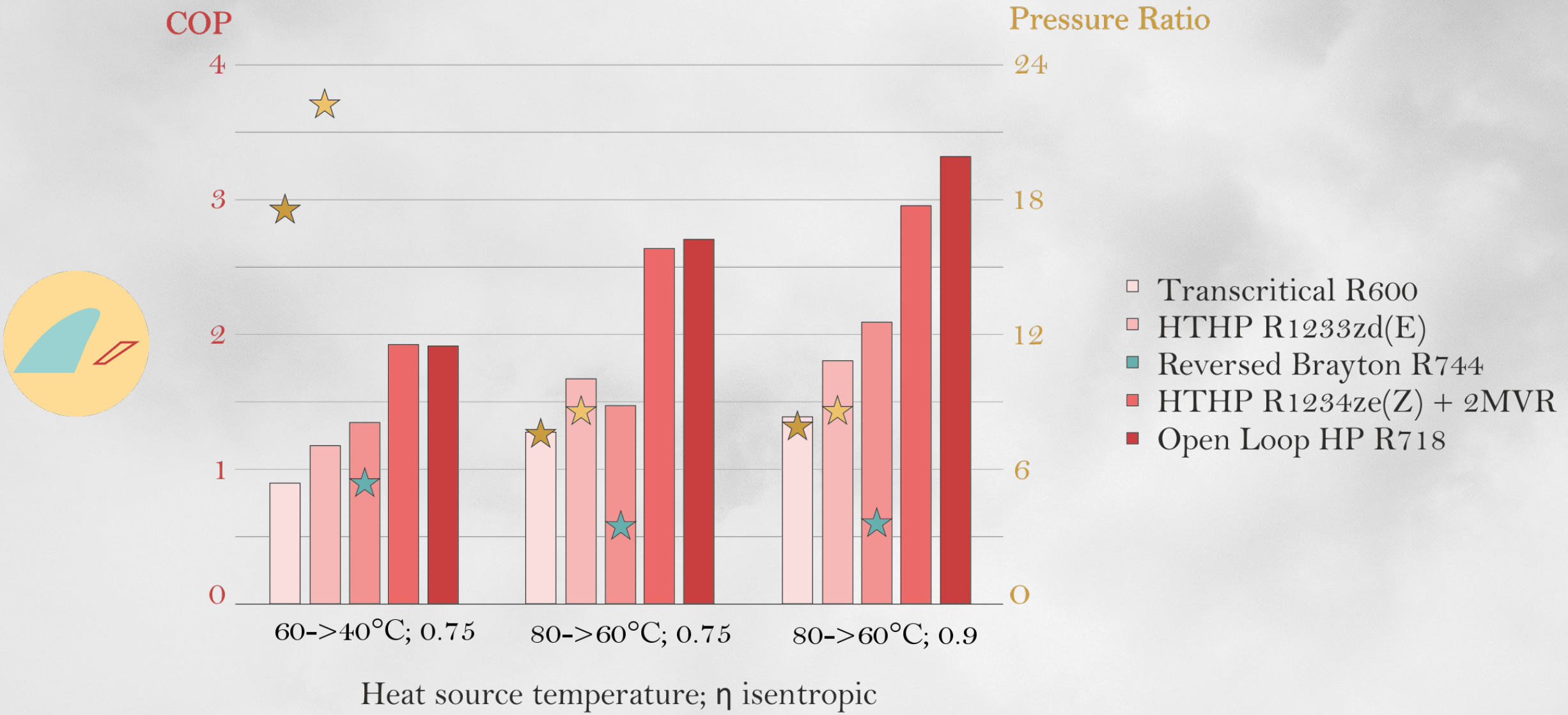
Pressure difference using transcritical R600 HP



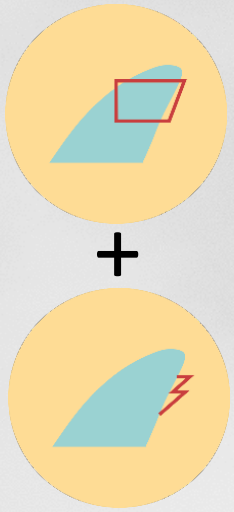
Pressure difference using R1233zd(E) HTHP

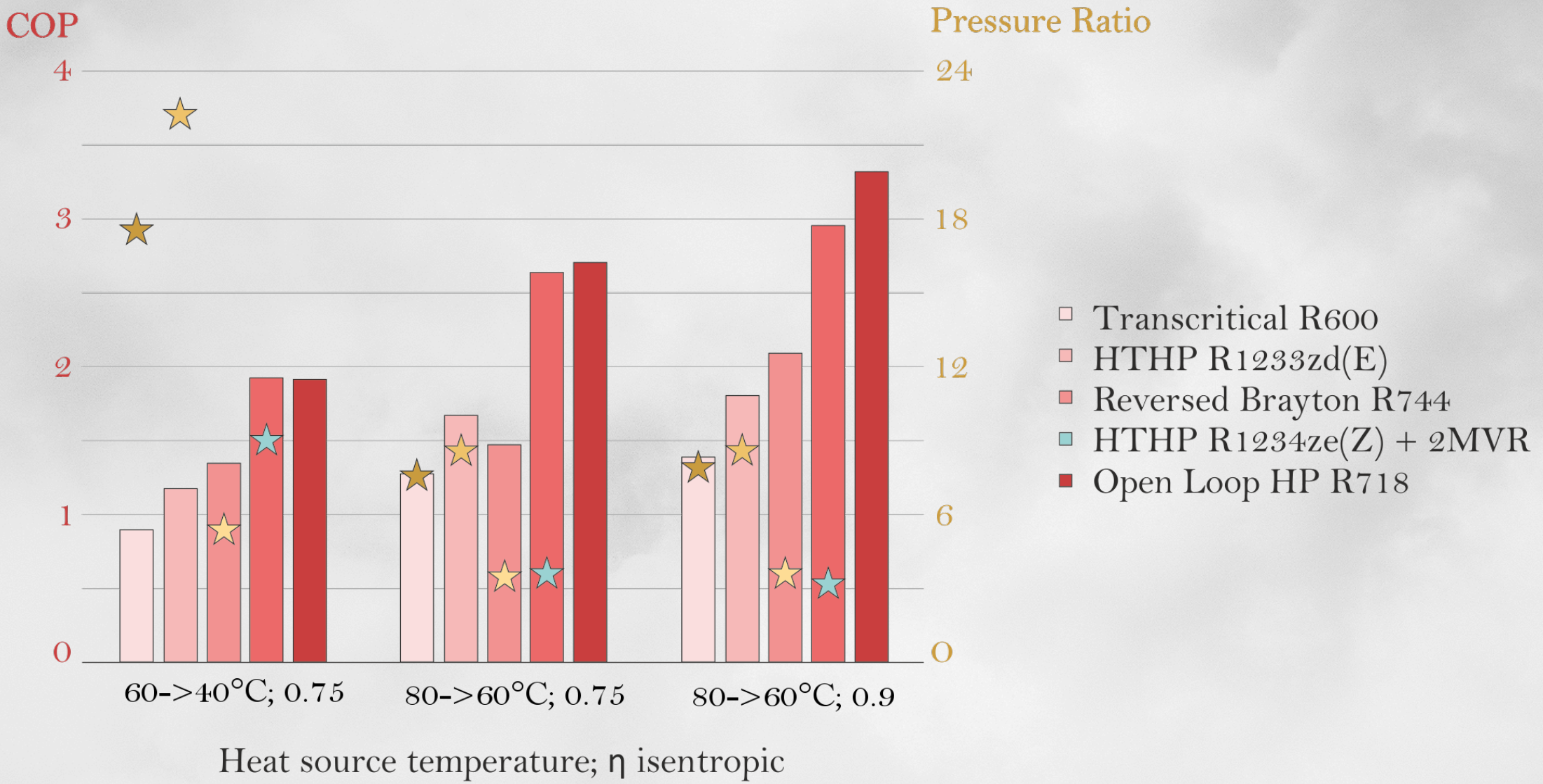


Pressure difference using reversed Brayton CO_2

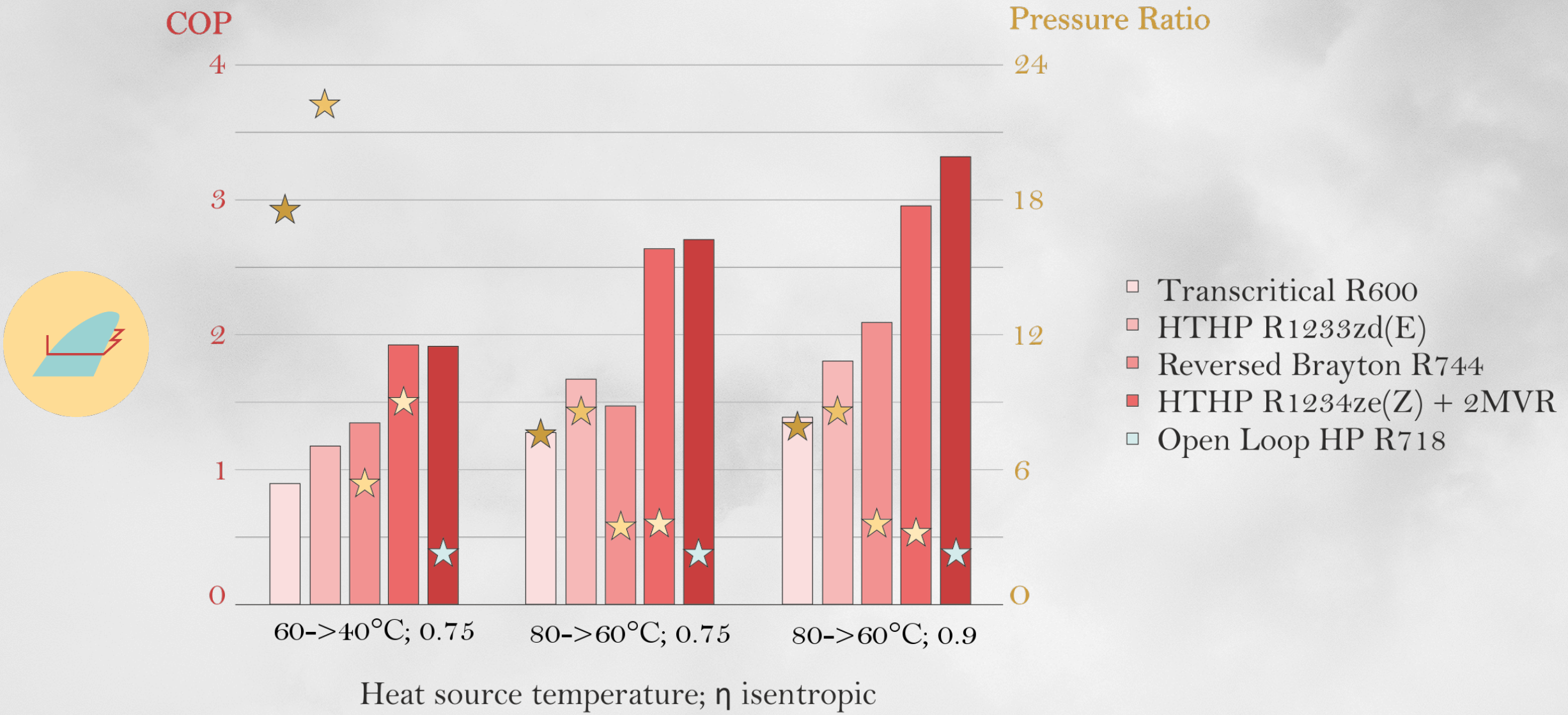


Pressure difference using HTHP + 2 MVR

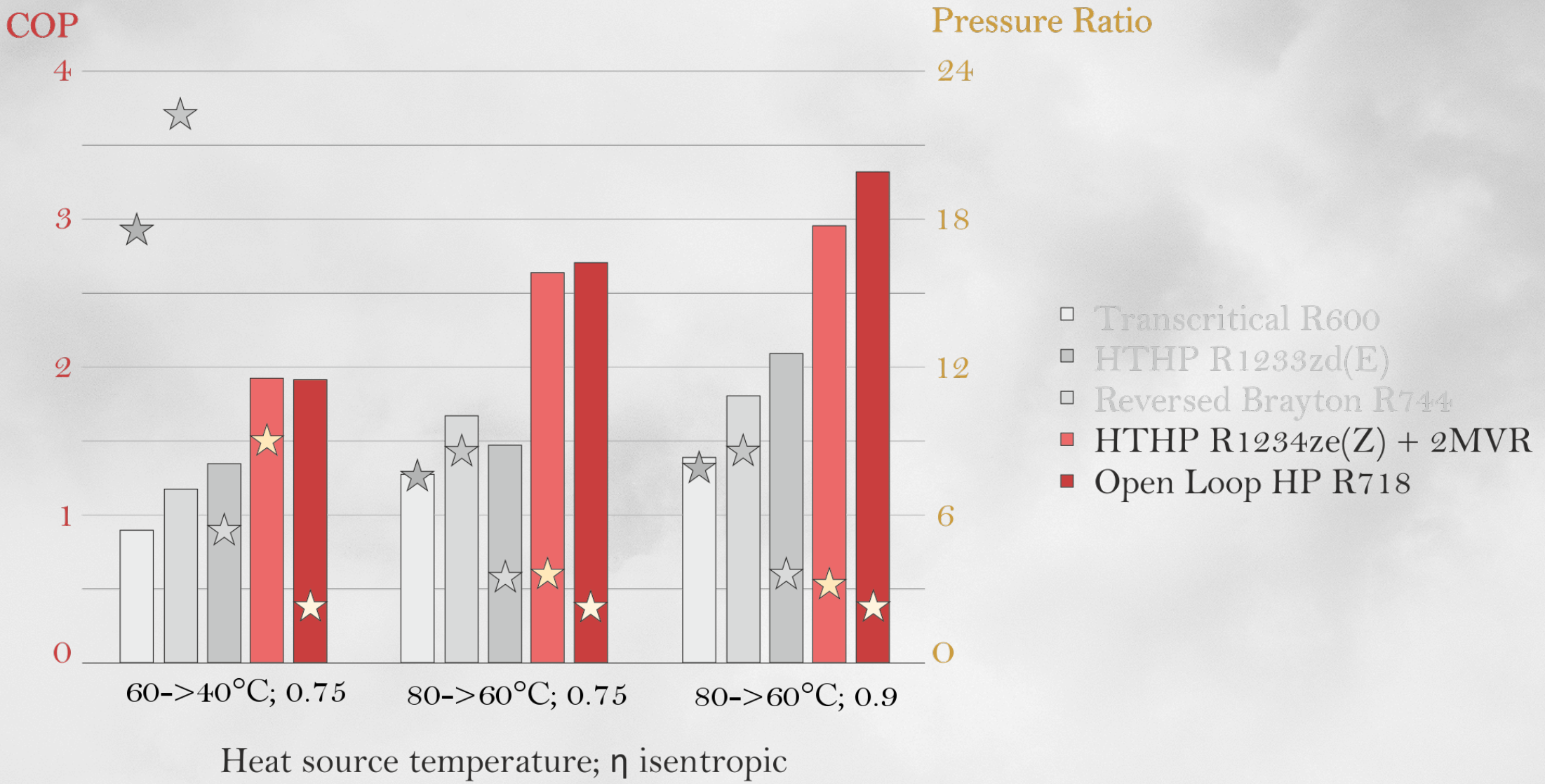




Pressure difference using open loop R718 HP



COP and Pressure difference is best with MVR



Steam production from heat pump technologies is coming

Technologies works but the lack of steam compressor is slowing this progression

Study of different steam production cycles is ongoing

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Handhout:

Background Photo by Eberhard Grossgasteiger on Unsplash