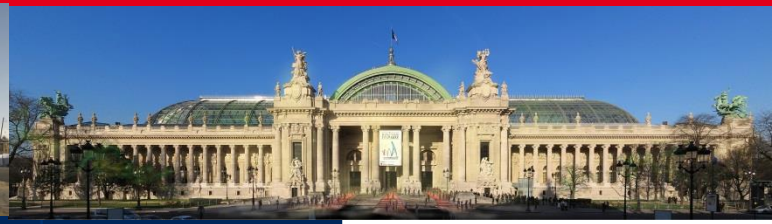
26th World Gas Conference

1 – 5 June 2015, Paris, France



Industrial Gas Utilization – SG 5.1: High temperature gas heat pumps to recover industrial waste heat

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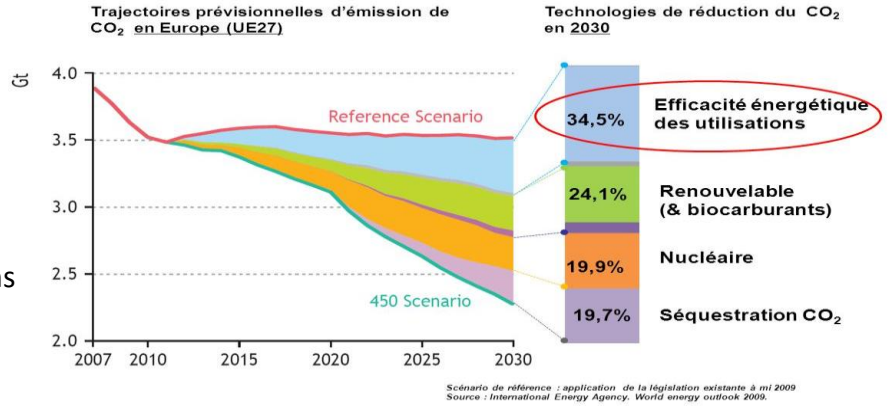
WORLD GAS CONFERENCE

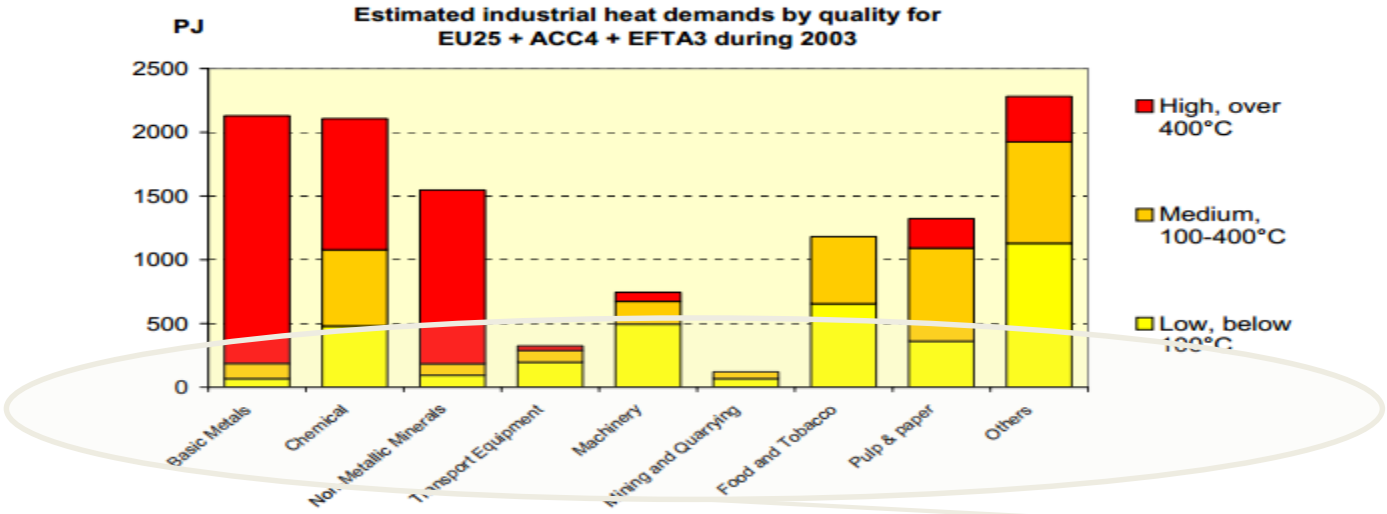
Industrial world Context: Main priorities focused on Energy efficiency & Heat recovery

- Energy and environmental context
  - ✓ Factor 4 – 450 ppm CO2
  - ✓ European Energy- Climate targets: 3 x 20%
  - ✓ **Today's trend ➔ < 50 % of the EC 2020 target**
- Regulation Context
  - ✓ Energy management standards - ISO 50001
  - ✓ New operating permitting for industrial plants
  - ✓ National quotas CO2 or White certificate allocations
  - ✓ New pollutants emissions values (NOx, SOx …cf EC BREF)
- Profitability of UE industries or ind. Plate-forms (Steel ind. Chemical ind. ….)
  - ✓ Energy prices ➔ Reduction of energy consumption
  - ✓ Sustainability of EC industries
  - ✓ Re-engineering of the energy master plans
- Strategic context – "Technology boosting"
  - ✓ Advanced technologies in energy (NTE)
  - ✓ Eco-design concept
  - ✓ « **Low carbon-foot print** » factories or Smart Energy Factories (ex: Candmet CND)



- **Energy efficiency & Heat recovery are complementary to renewable**
- **Implementation needs specific Systems & territory approaches**
- **Trends : Innovative concept of « Eco-design plants or Smart Energy Factories»**

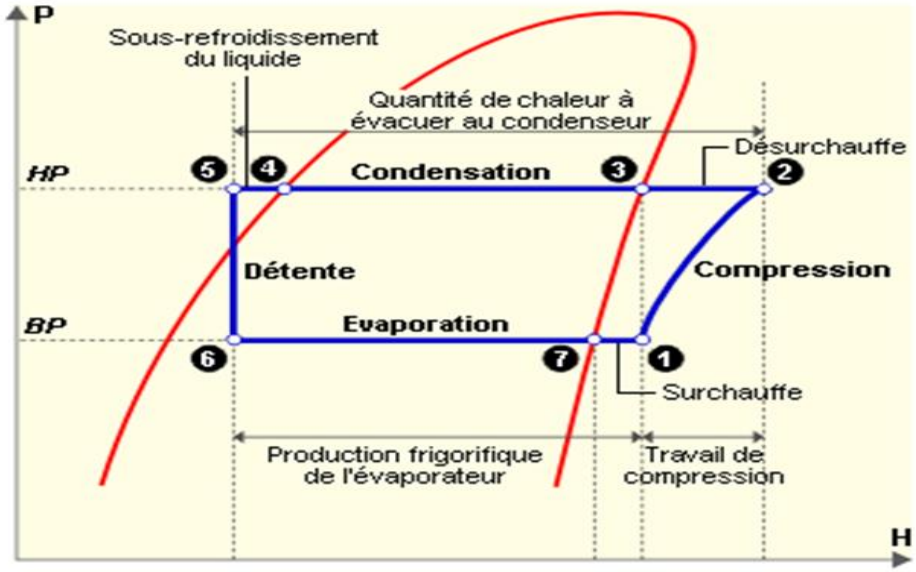
Industrial Heat demand in Europe



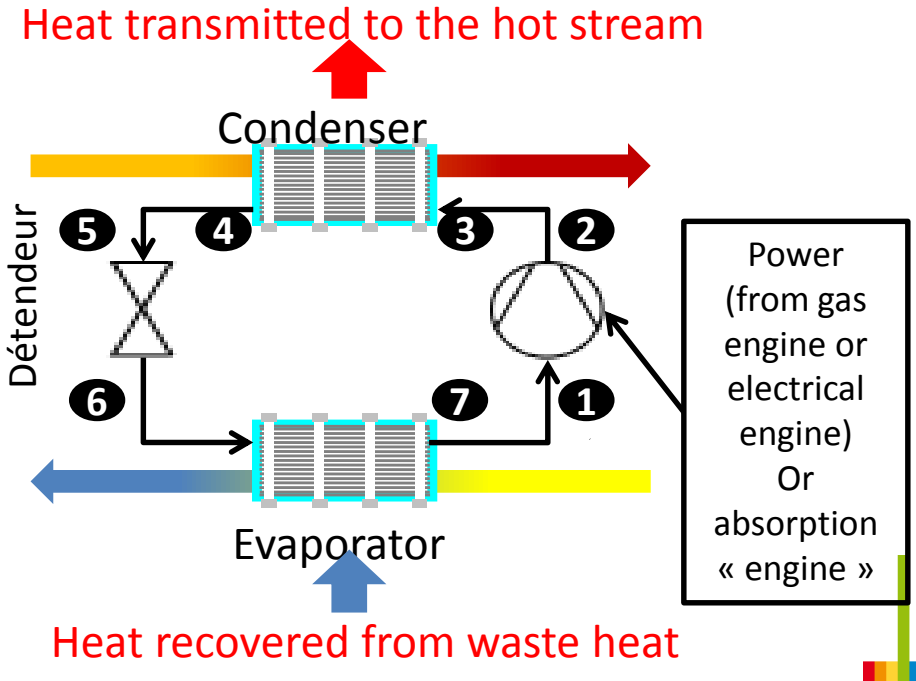
Source: EcoHeatCool project

Temperature around 100°C represents a large ratio of the whole industry demand

Industrial Heat pump principle: A good way for heat Recovery

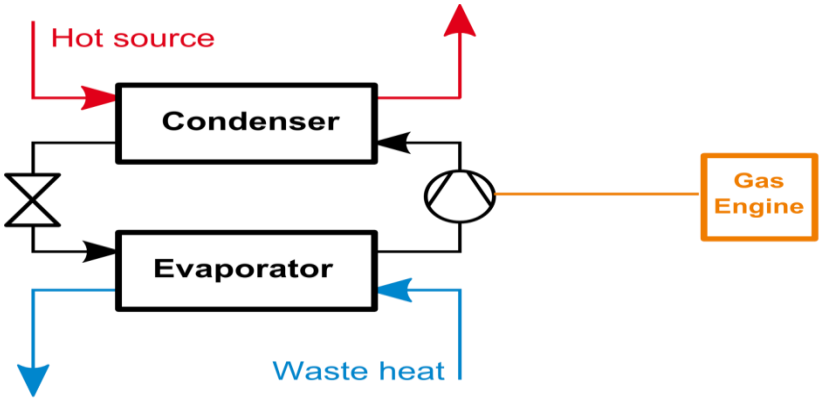


Mollier diagram (Heat pump cycle)

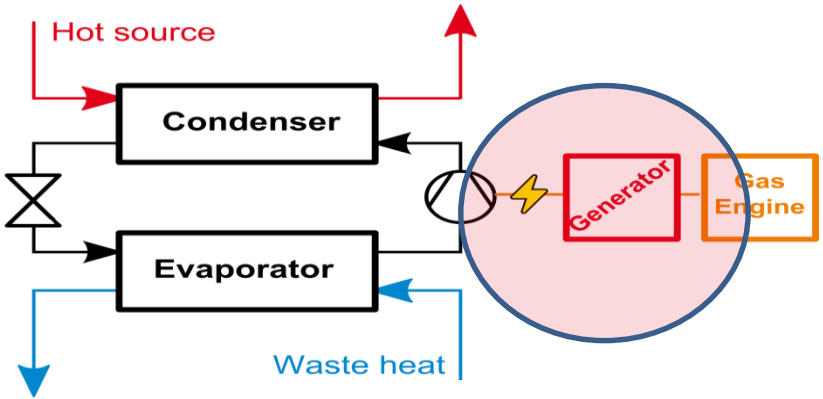


Designing a natural gas heat pump

Two configurations



Direct (= mechanical) coupling

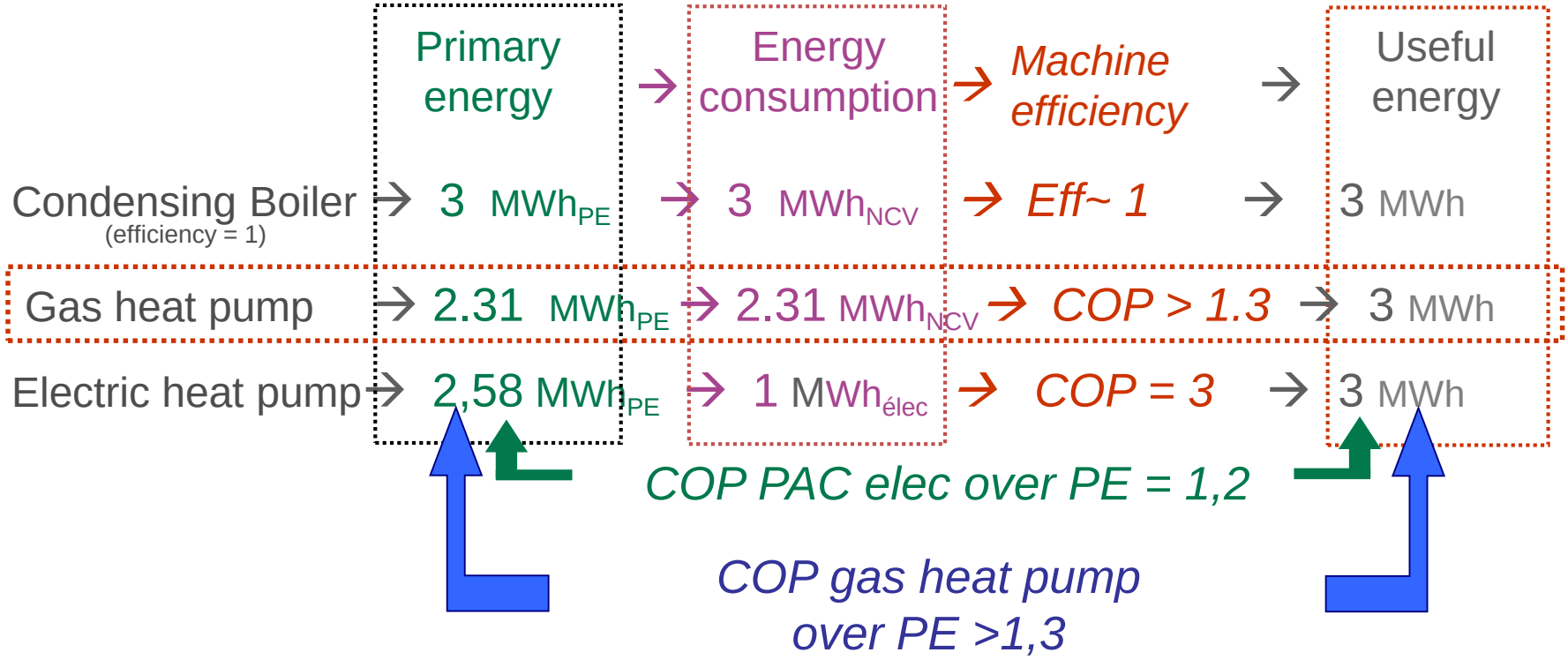


Generator system

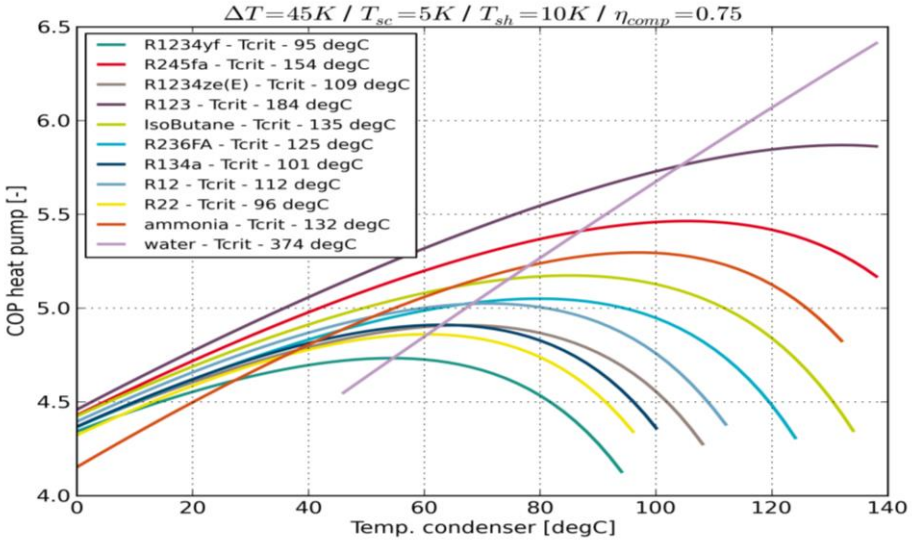
Requires an open compressor
HP power > 2MWth

Half-open compressor, magnetic bearing engine can also be used
0.5MWth< HP power< 2MWth

Primary energy consumption of industrial gas heat pumps



1st point -Mechanical COP vs various refrigerent fluids

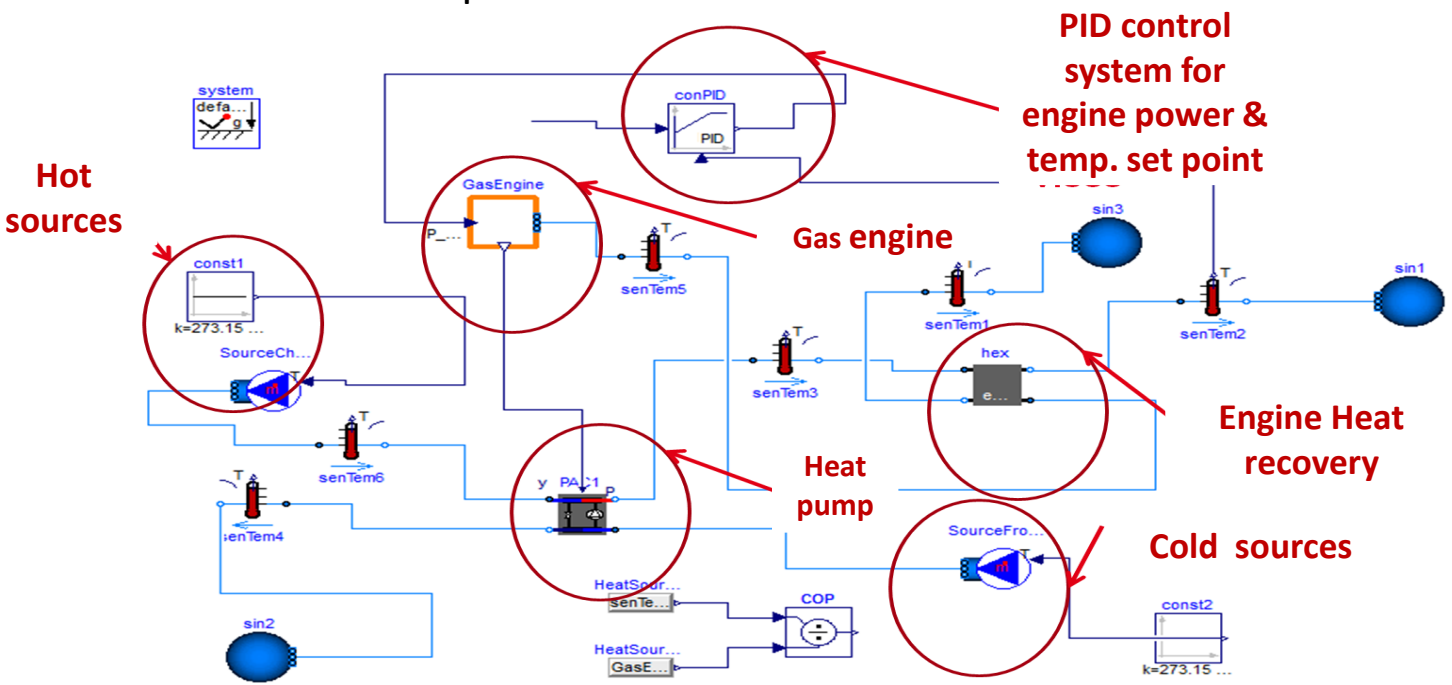


ENGIE - CRIGEN calculations

- The refrigerant has to offer the best energy performance, the lowest cost, the lowest impact on environment (GWP index) and to guarantee the safety of the machines
- Optimal COP is obtained for a condensation temperature of the fluid lower than around 30°C of the critical temperature

2st point – Optimize thermal Integration of a Gas HP into industrial process

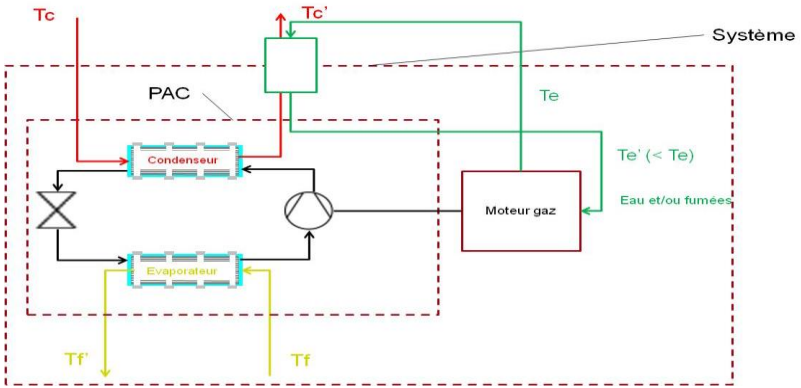
A new model to calculate performances has been developped



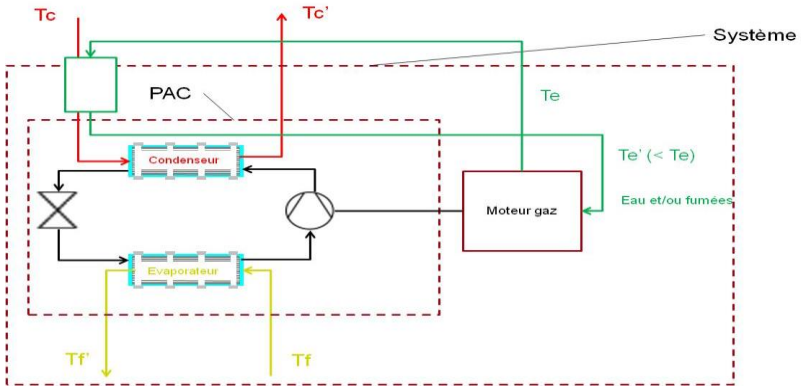
➔ The model helps to determine the best configuration between various gas engine heat pumps

3st point- Choose the right option to recover heat energy from the engine

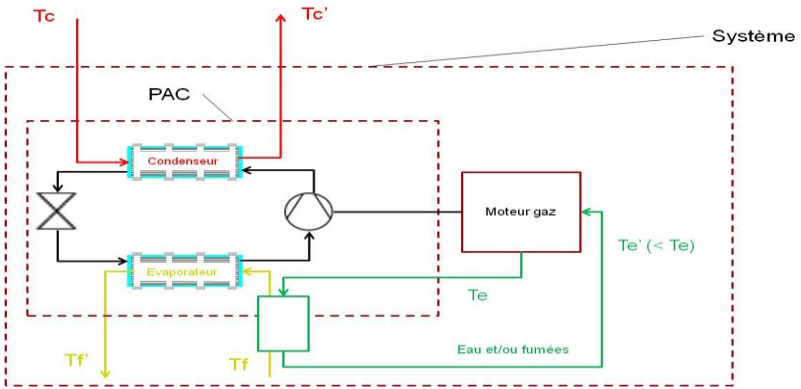
Config 2 (direct) – option 1



Config 2 (direct) – option 2

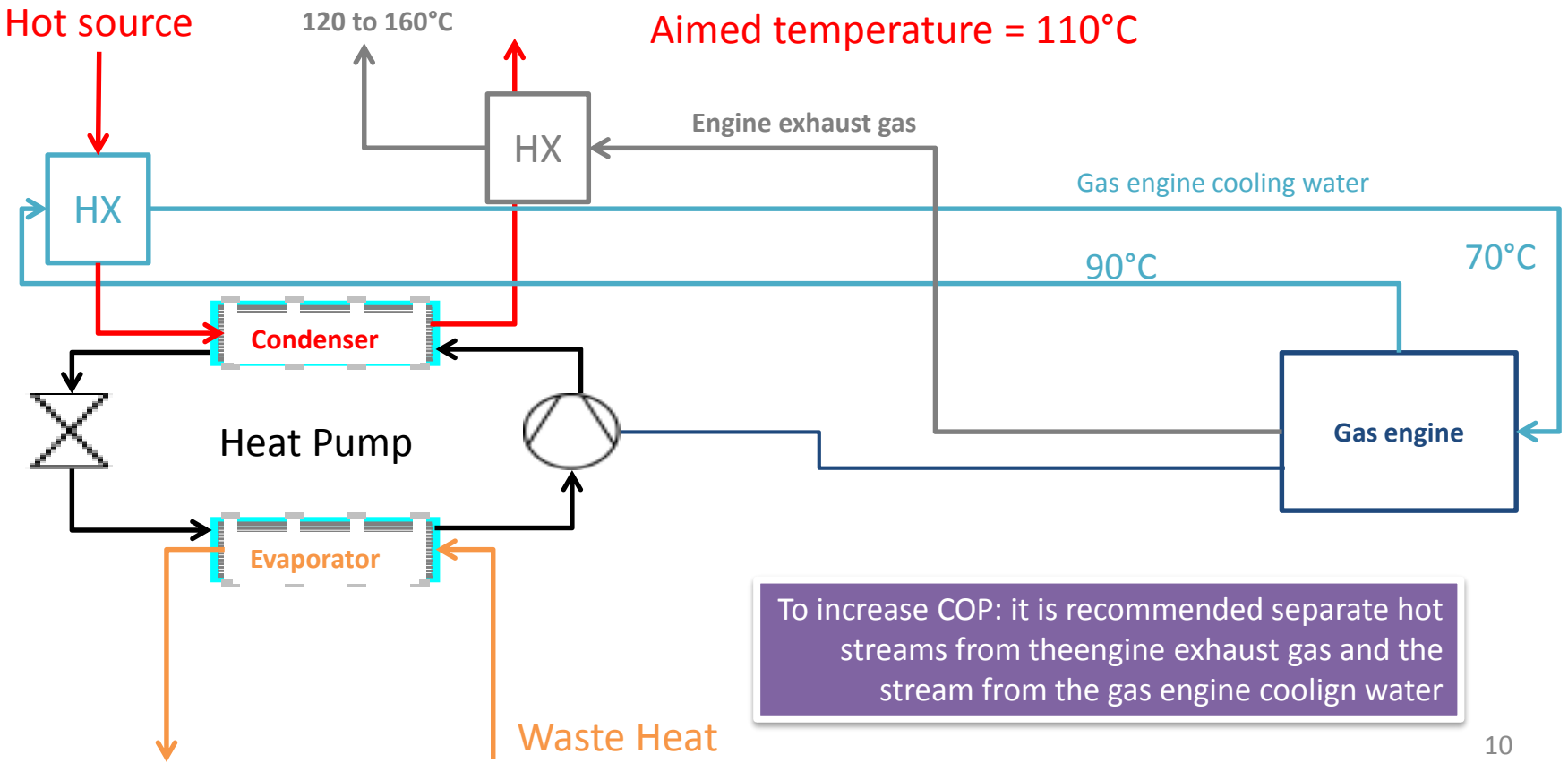


Config 2 (direct) – option 3



➔ The best option strongly depends on the process

3st point- Choose the right option to recover heat energy from the engine one of Best option

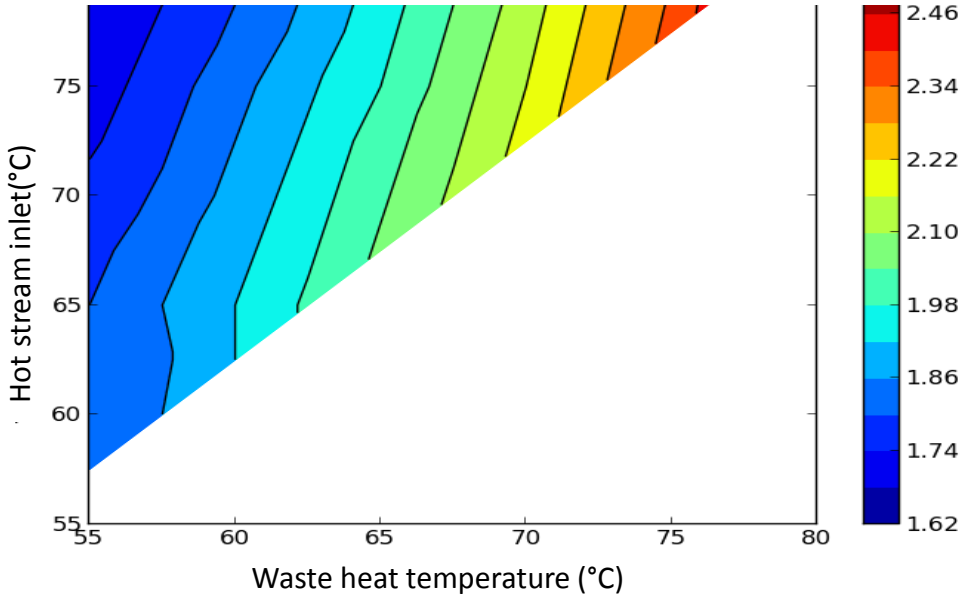


To increase COP: it is recommended separate hot streams from theengine exhaust gas and the stream from the gas engine coolign water

3st point- Choose the right option to recover heat energy from the engine
Performance chart

Integration of a gas heat pump into industrial process
Performance charts

COP obtained to reach 110°C temperature



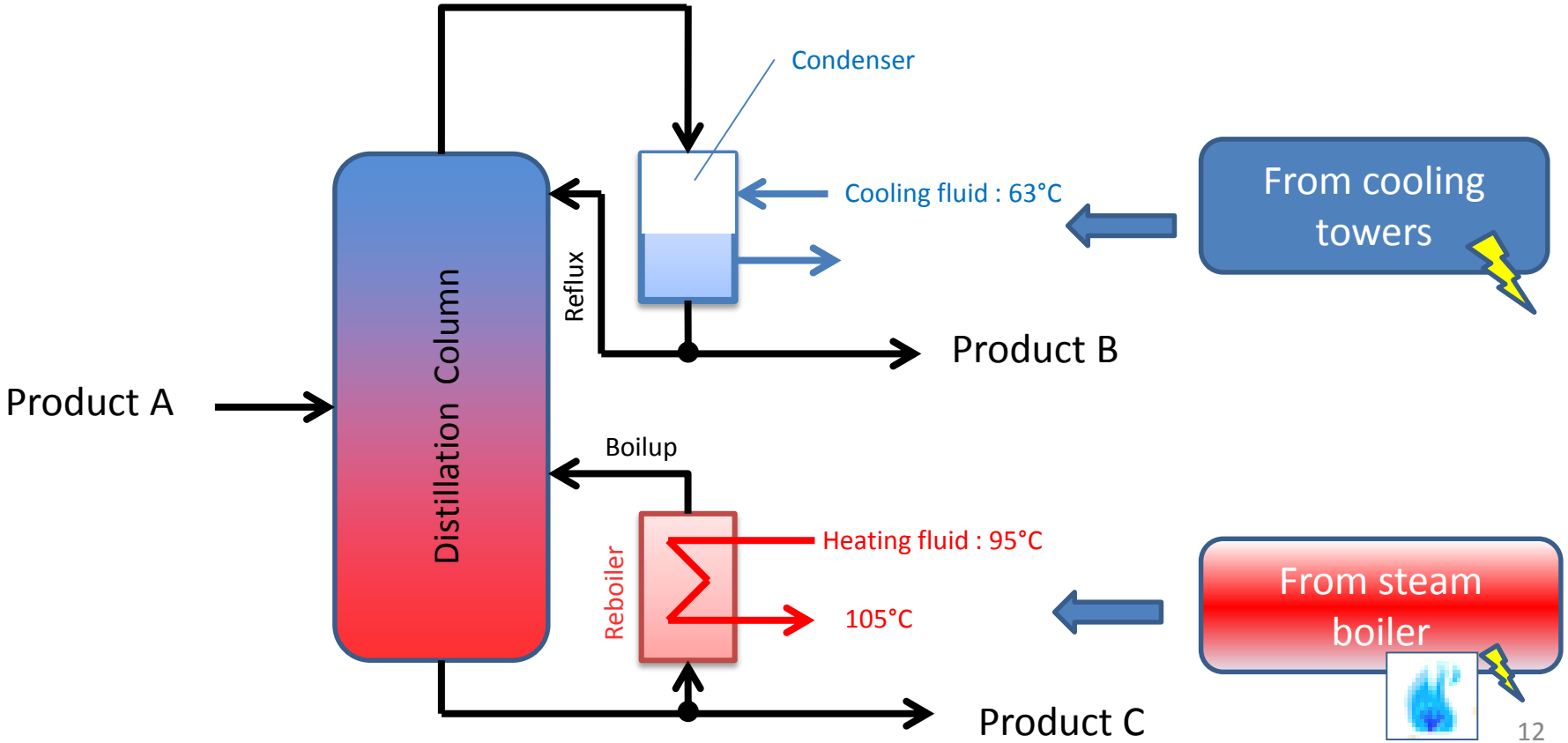
➔ **Assumptions:**

- ➔ targed temperature = 110°C
- ➔ Useful power = 1 MW
- ➔ Cold stream flow rate / hot stream flow rate = 10

$$COP = \frac{\Delta P_{hot\_source}}{P_{gas}} = \frac{(P_{condenser} + P_{water\_hx} + P_{fumes\_hx})}{P_{gas}}$$

➔ **It's possible to obtain up to a 2.5 COP with a gas heat pump**

Appliance example: Chemical process-distillation tower

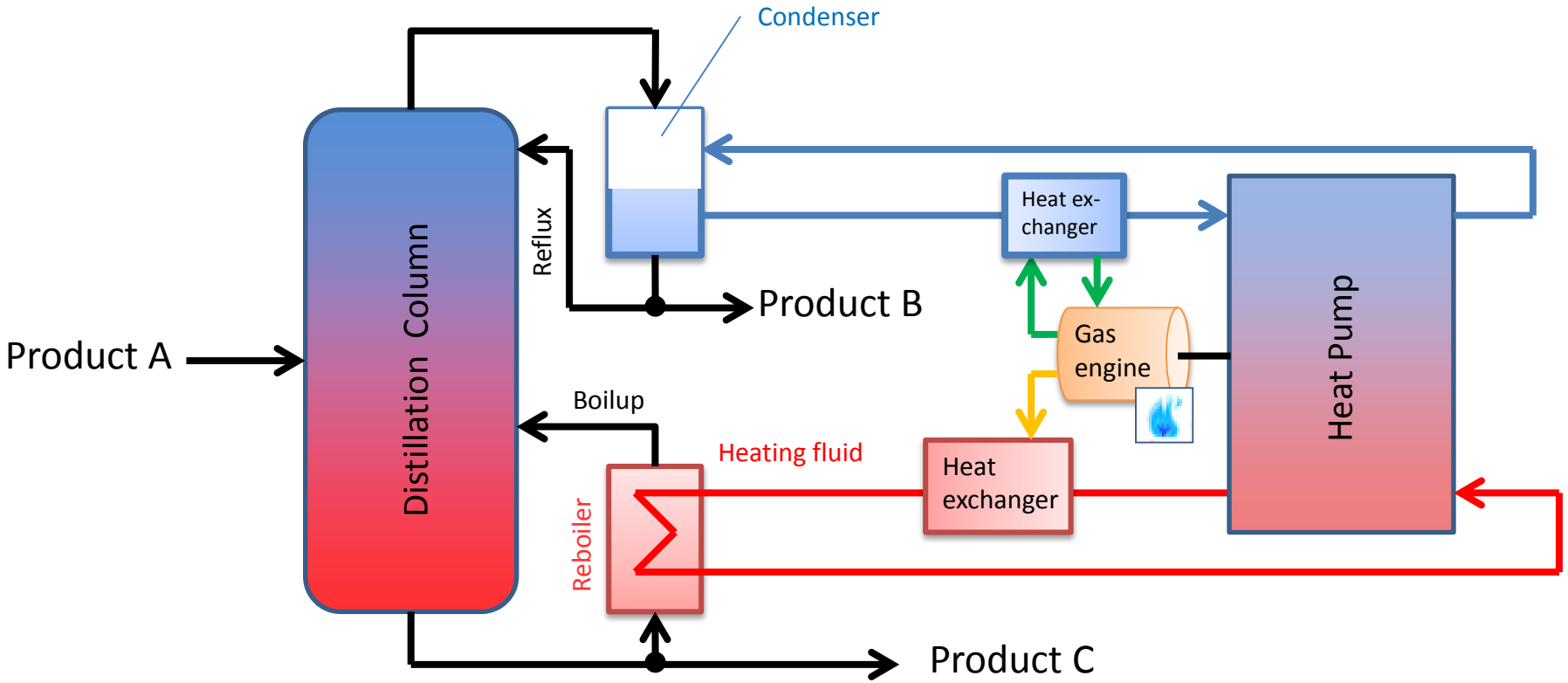


Appliance example: Chemical process-distillation tower

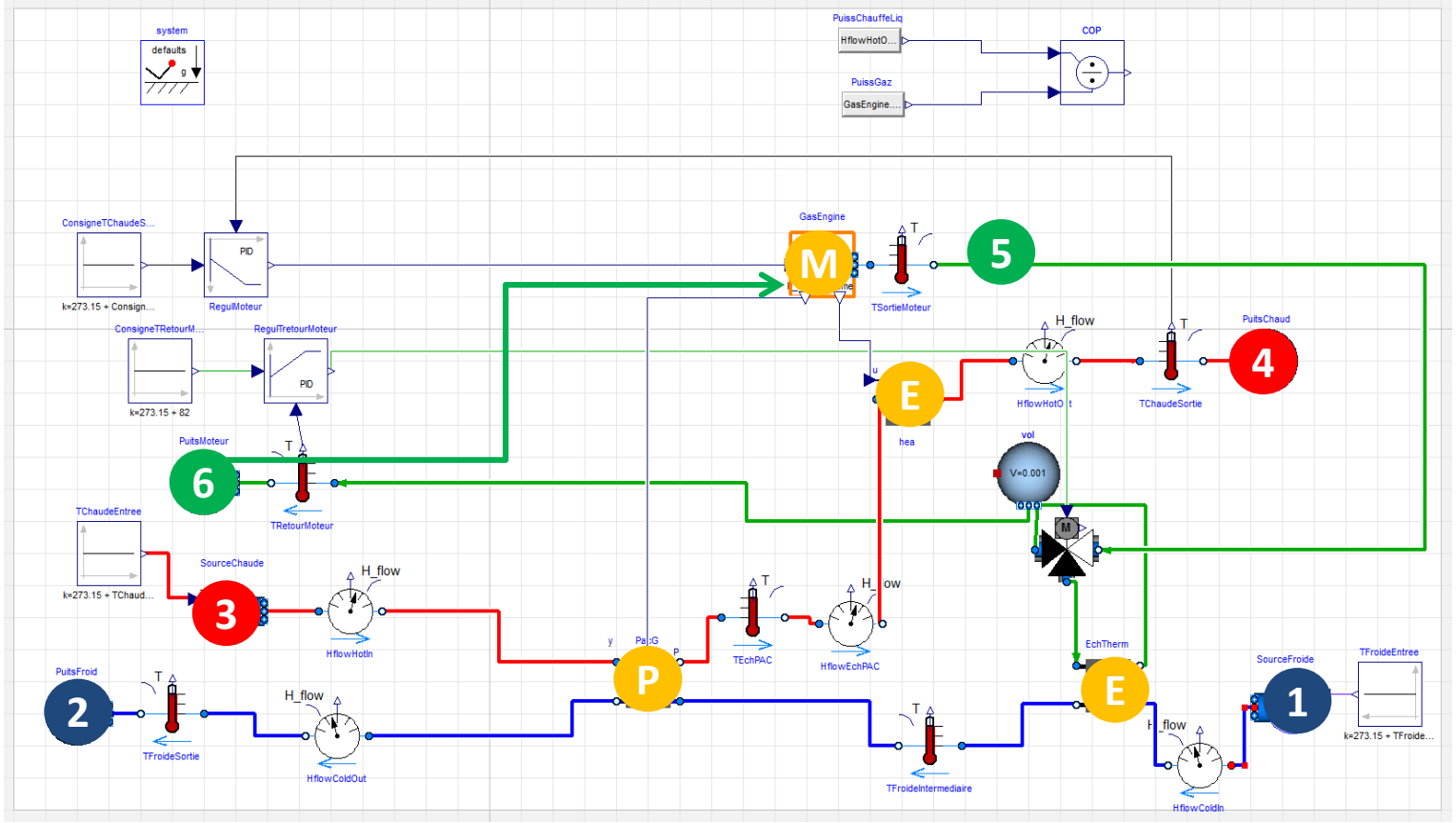
- Gas engine performances collected from several manufacturers
- Gas engine performances for this case:
  - Gas input power: 561kW
  - Electric efficiency: 41%
  - Heat production (burnt gases cooled down to 120°C): 26%
  - Engine cooling system:
    - 16%
    - In/out water temperature: 82/90°C
      - The heat exchanger of the engine cooling system can't be used on the « hot » circuit (95°C/105°C)
      - It's used on the « cold » circuit to increase the COP of the heat pump

$$COP_{heating} = \frac{T_{hot}}{T_{hot} - T_{cold}}$$

Appliance example: Chemical process-distillation tower



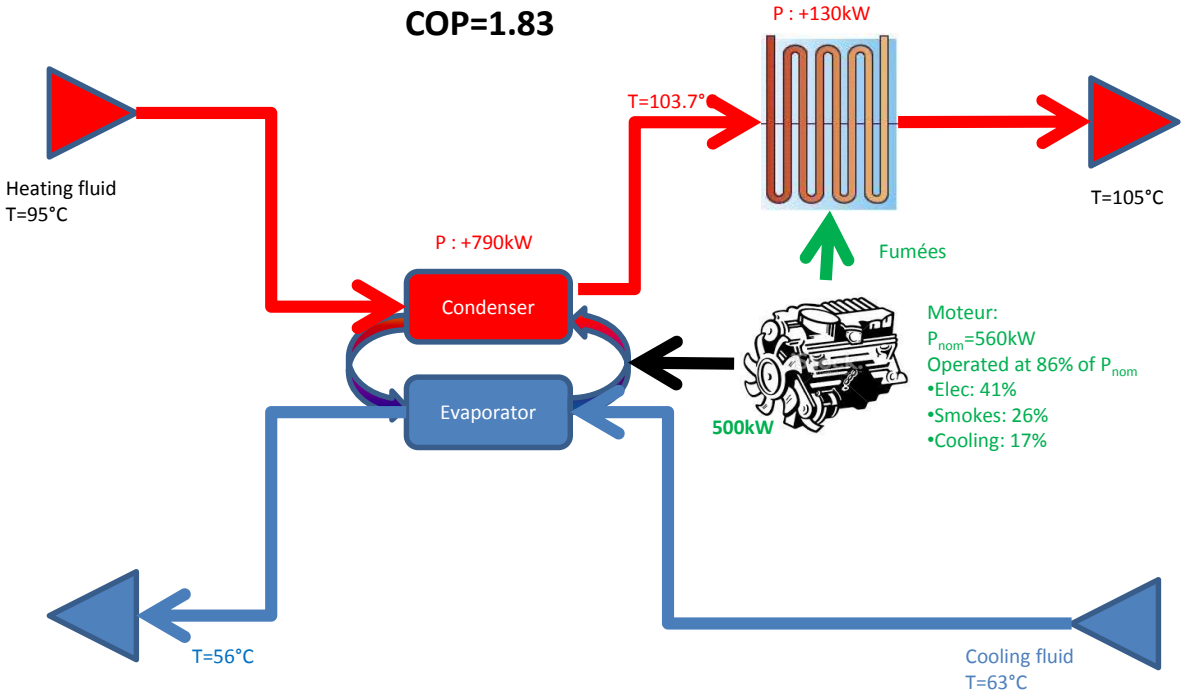
Appliance example: Chemical process-distillation tower



Legend:

(1) Cooling fluid inlet
(2) Cooling fluid outlet
(3) Heating fluid inlet
(4) Heating fluid outlet
(5) Gas engine cooling system outlet (T=90°C)
(6) Gas engine cooling system inlet (82°C)
(M) Gas engine
(P) Heat Pump
(E) Heat exchanger

Appliance example: Chemical process-distillation tower/ Results



First level of engine heat recovery : exhaust flue gas

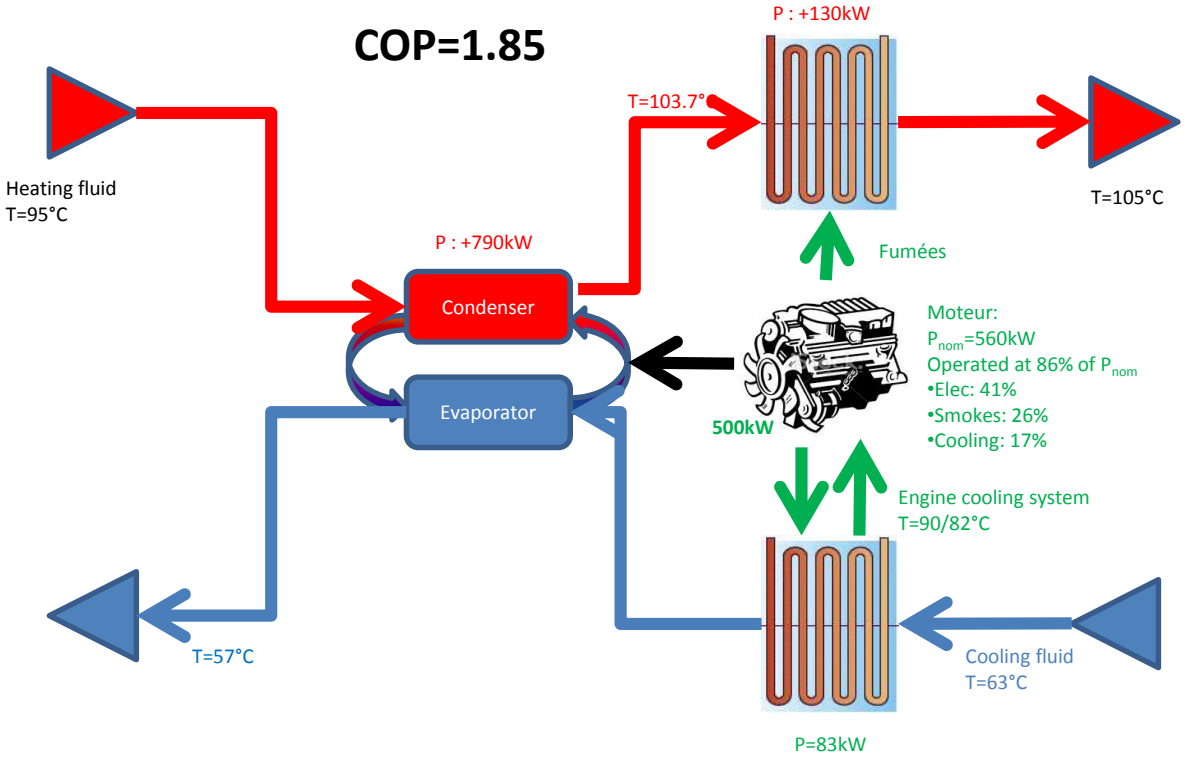
Global COP ~1.83

→Cooling engine heat should be used elsewhere in the process.

Note :

Without the « hot » heat exchanger, COP drops down to 1.52 → Its role is essential to the gas heat pump performances

Appliance example: Chemical process-distillation tower/ Results



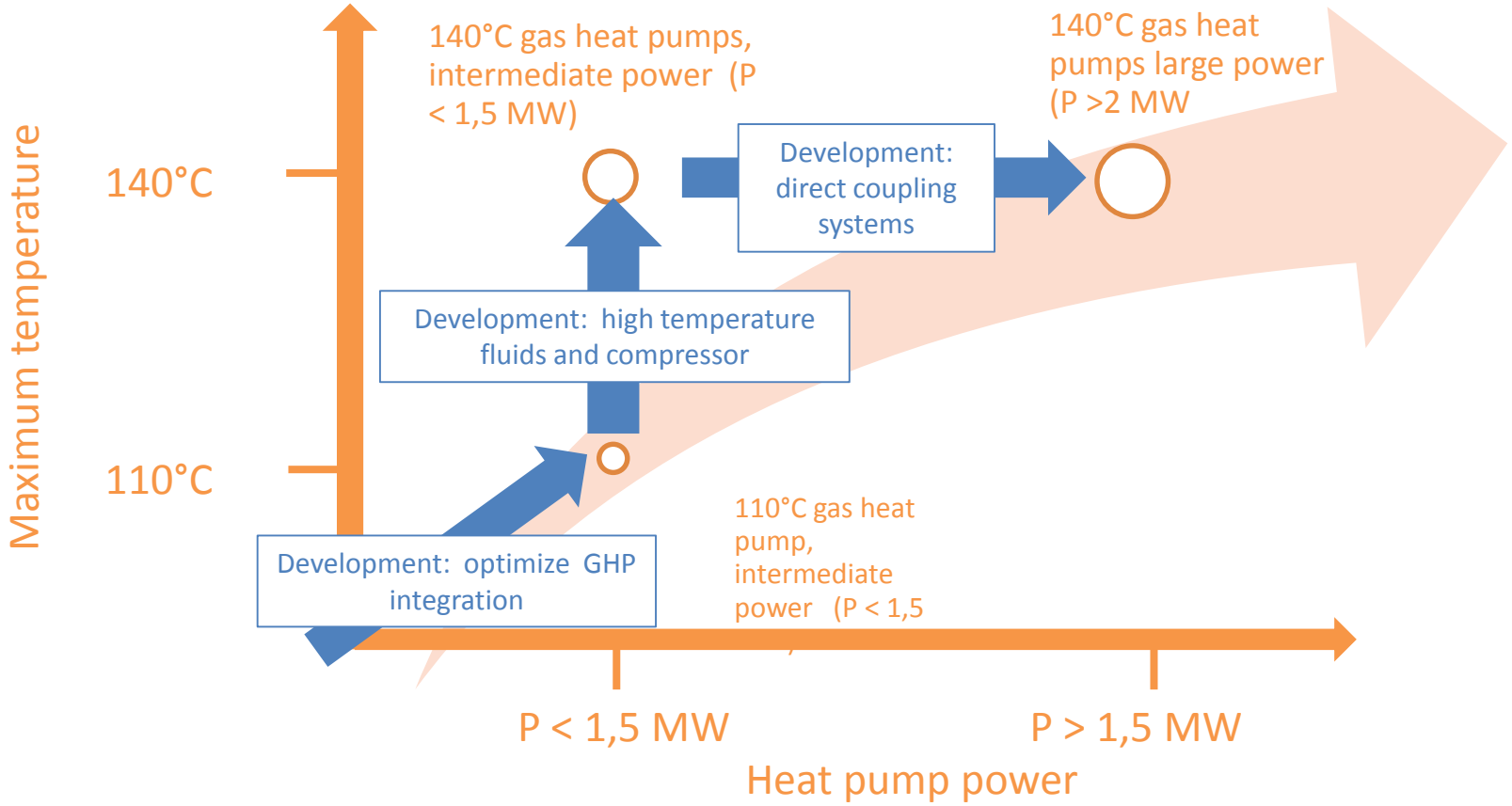
Best configuration:

Global COP =1.85

= Reduction of gas consumption by at least 55%

Heat recovery on engine cooling system is essential for gas heat pump to increase COP

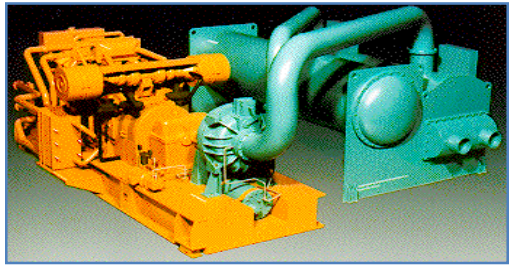
Industrial heat pumps : Roadmap for development



ENGIE -VALENTHIN project

VALENTHIN
FILIERE DE VALORISATION ENERGETIQUE DES REJETS THERMIQUES INDUSTRIELS

➔ **We are building a new sector for energy recovery from industrial waste heat**



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