



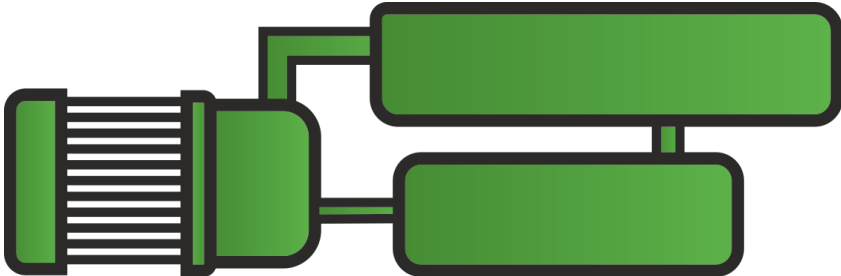
HIGH TEMPERATURE HEAT PUMPS

24 MARCH 2023 | ITTIGEN

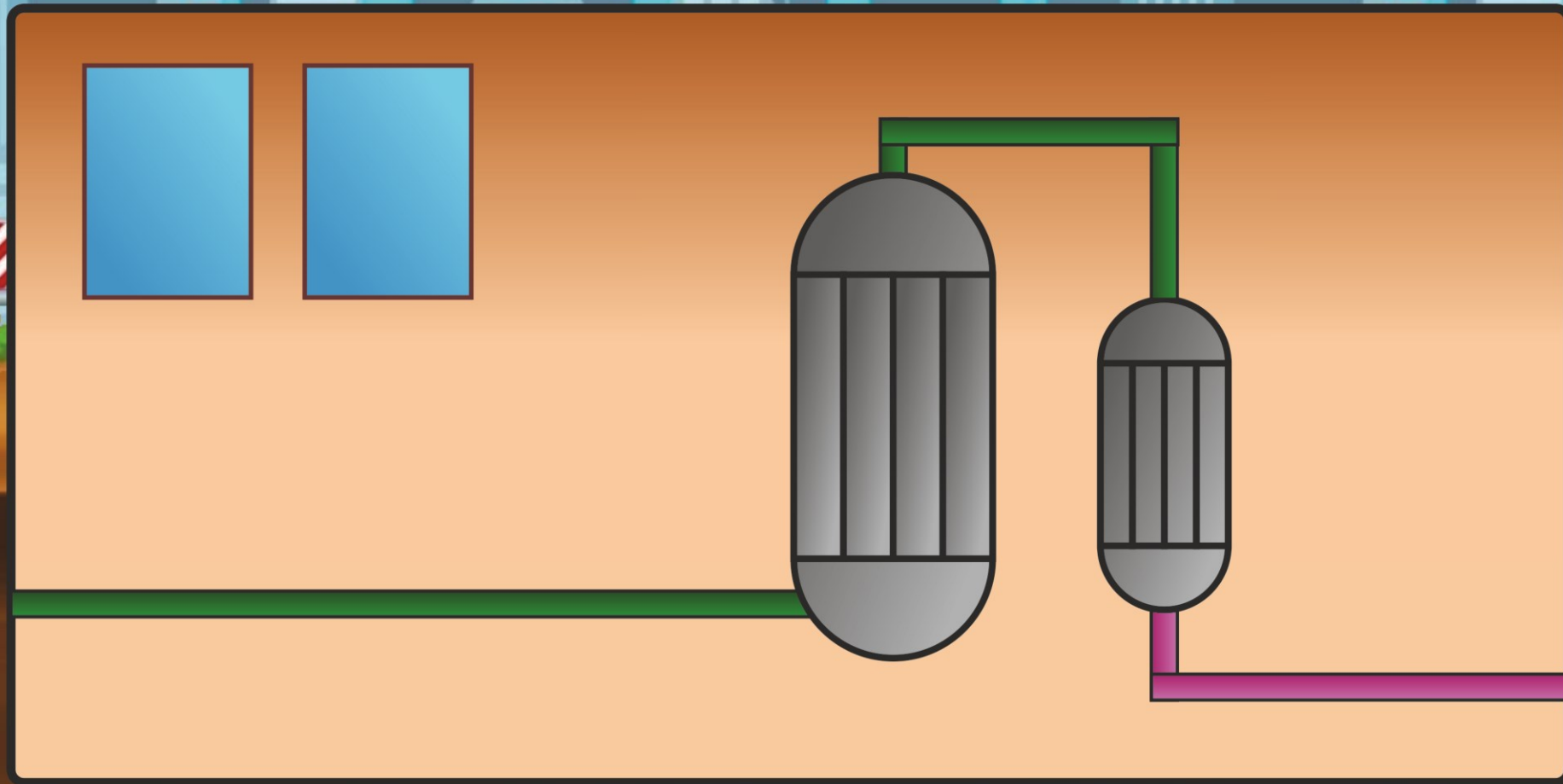
«Overview of HTHP technologies»

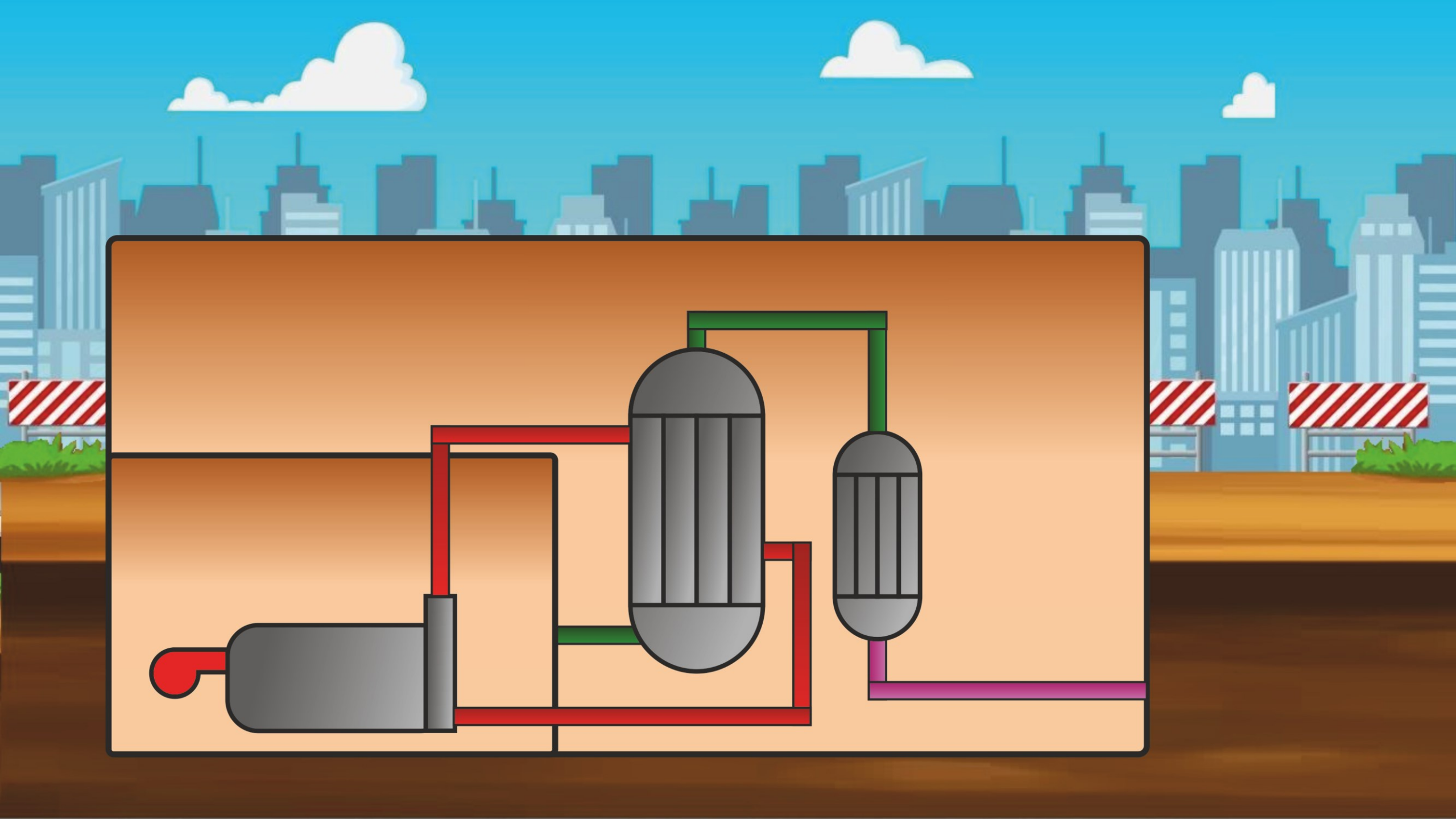
Frédéric Bless, OST
Nicole Calame, CSD Ingénieurs SA

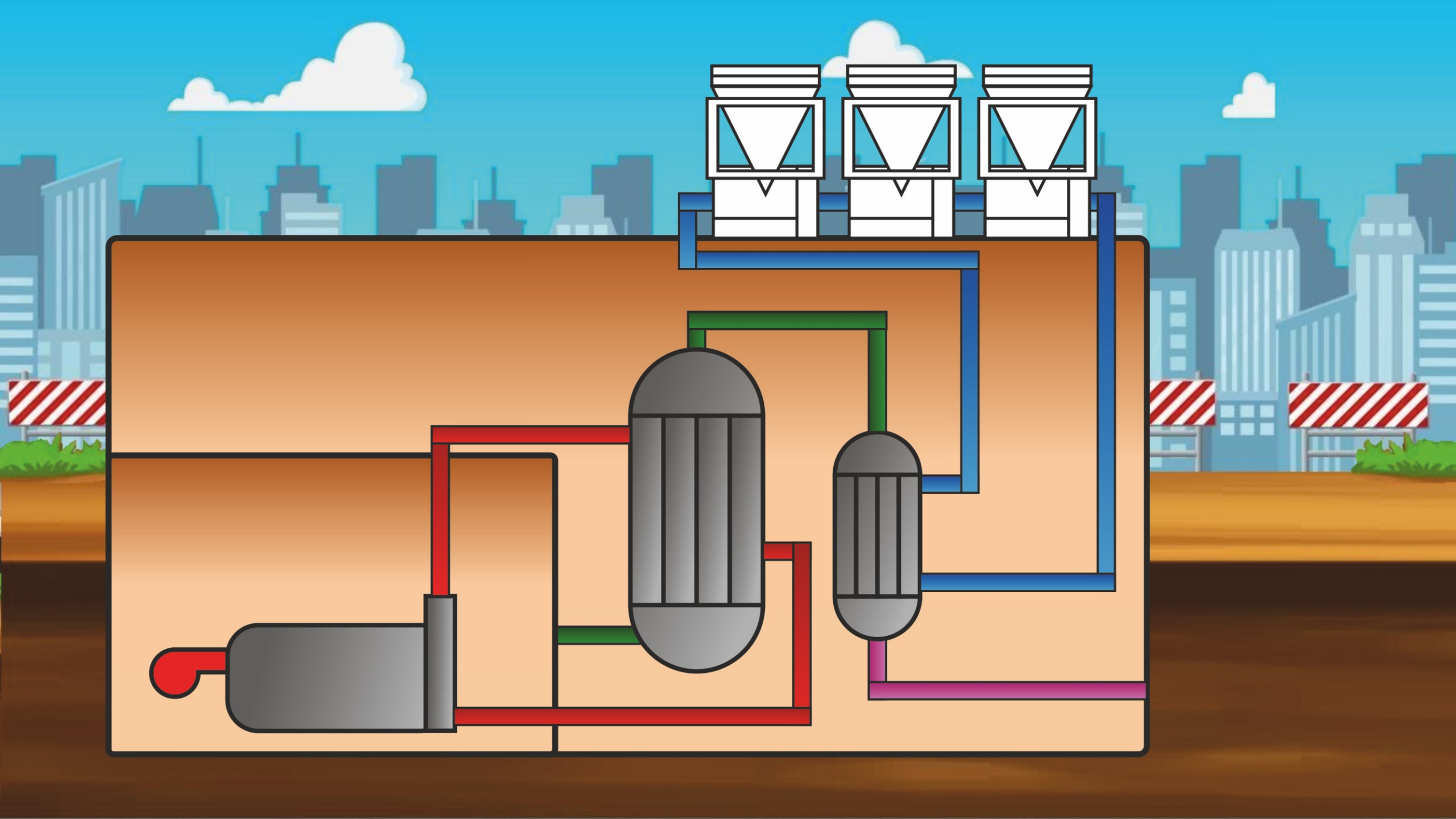
What to think when integrating an heat pump

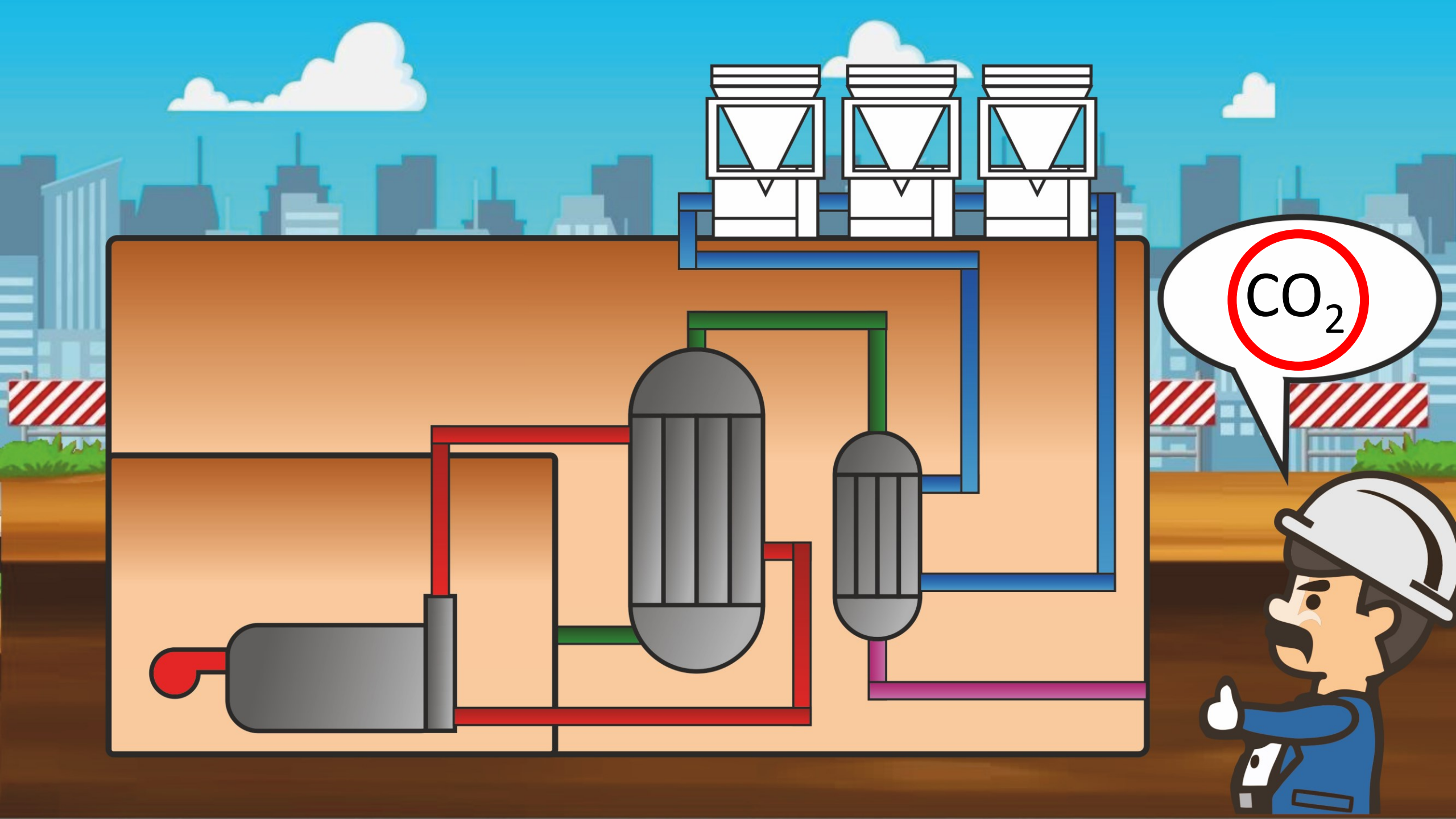


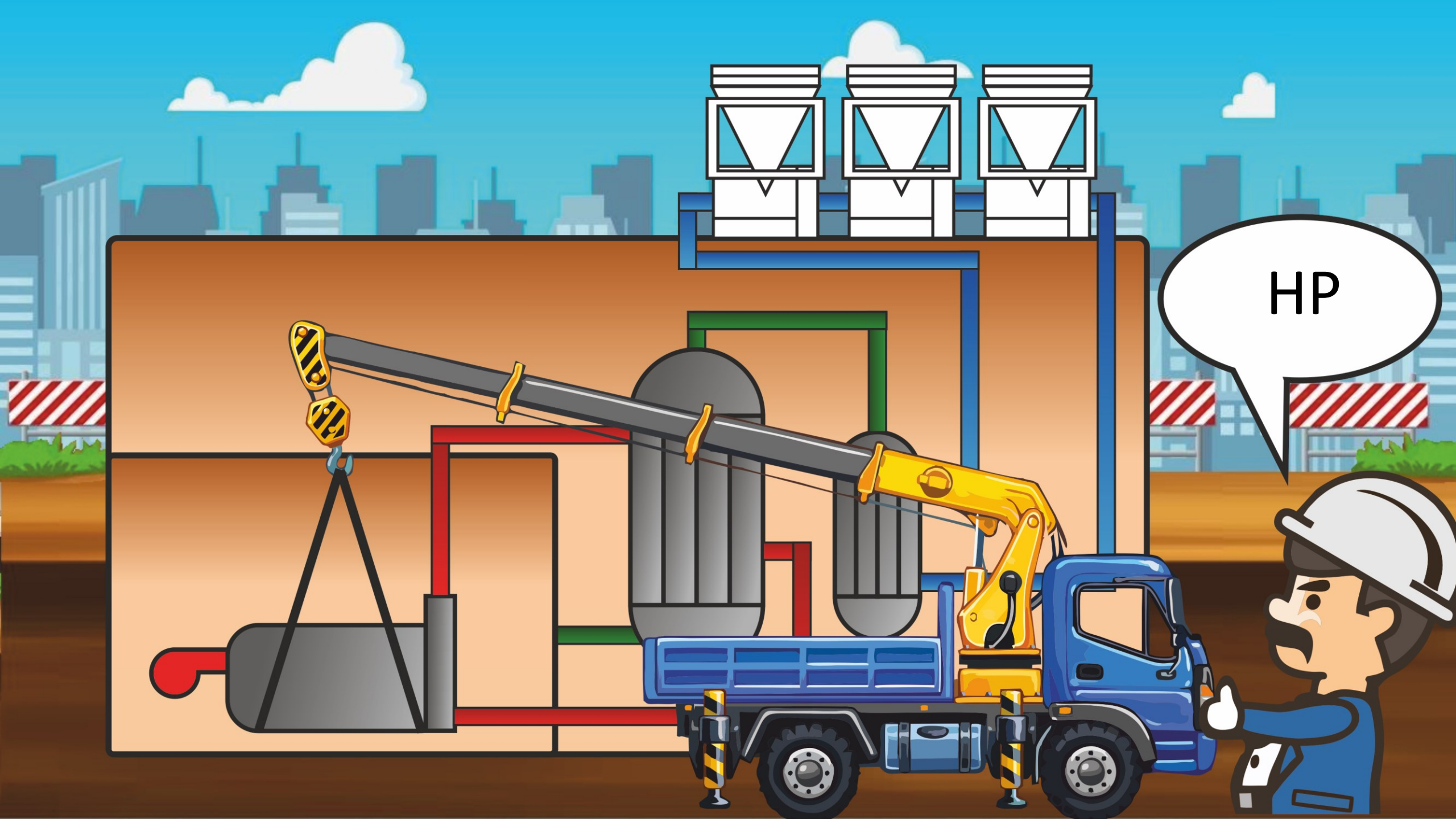
Problem: decarbonisation of an industry



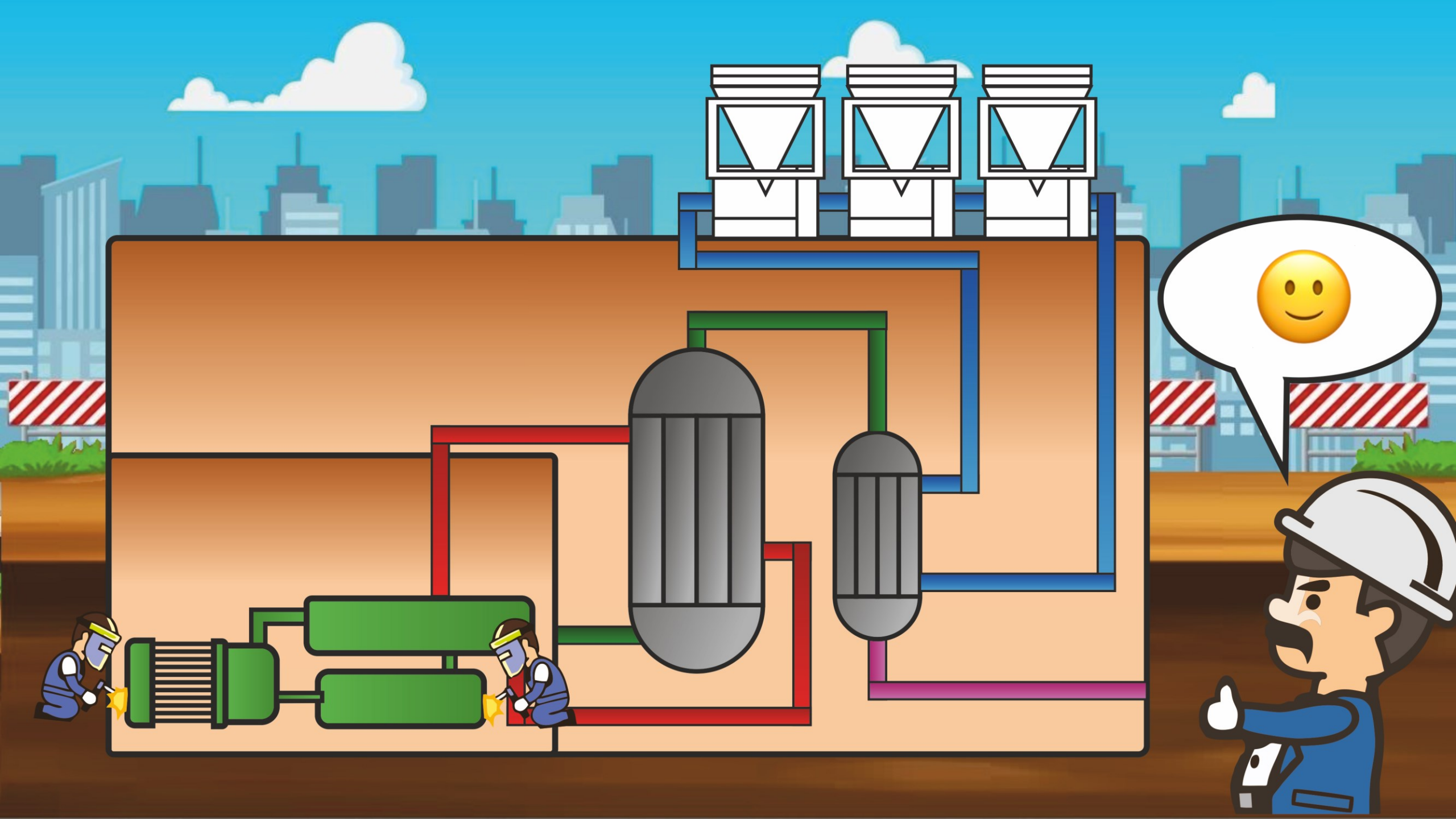




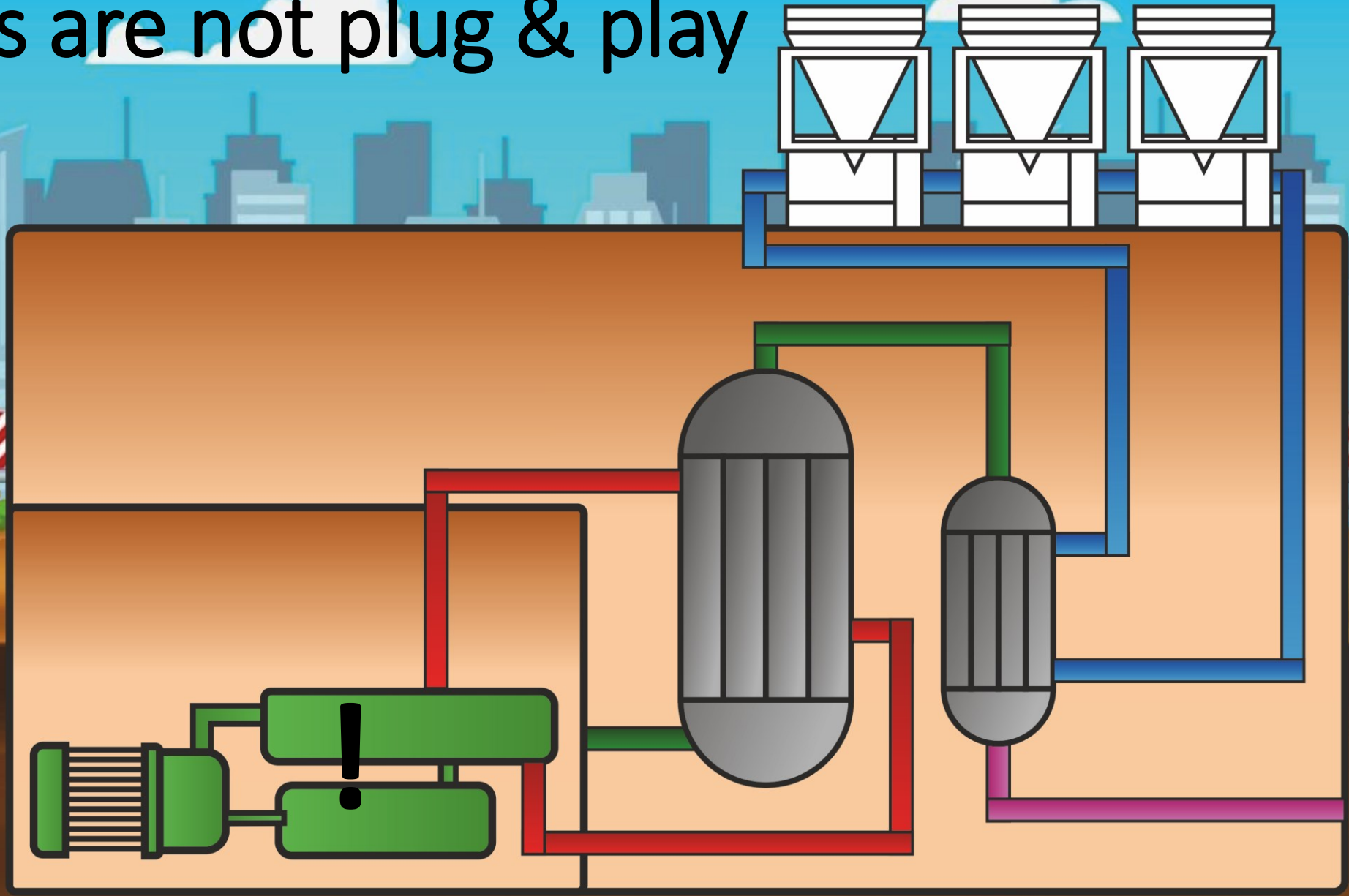




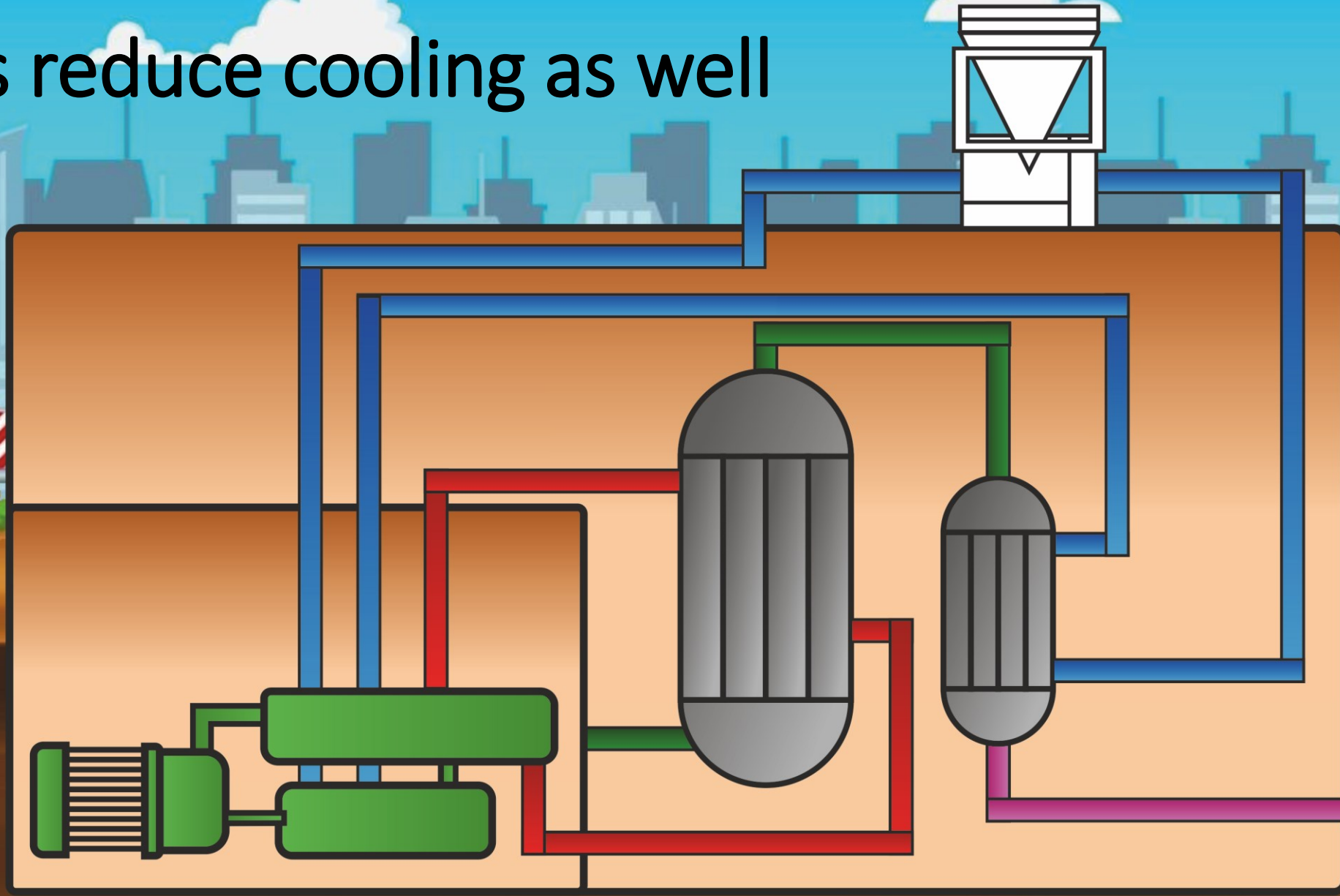
HP

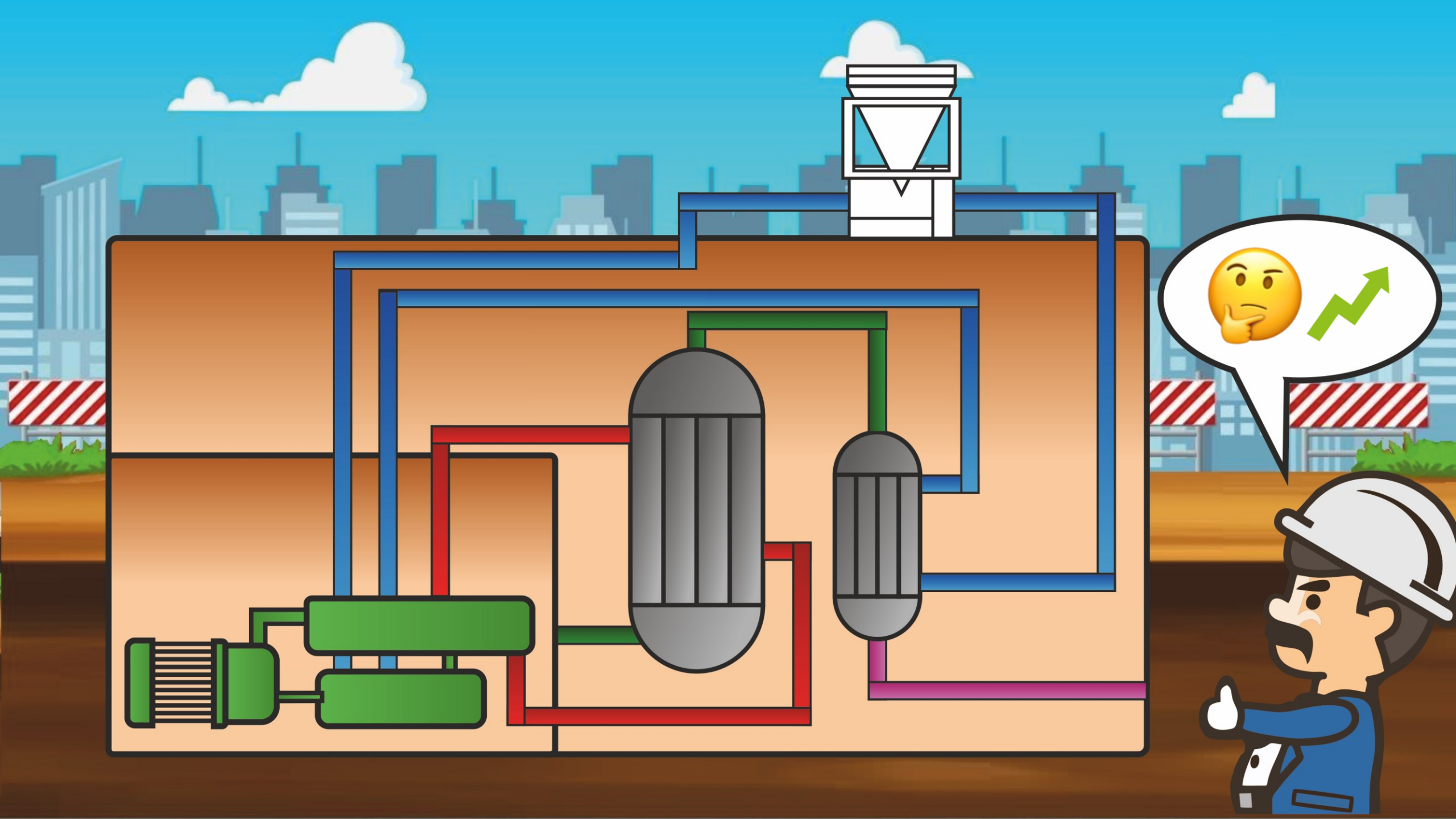


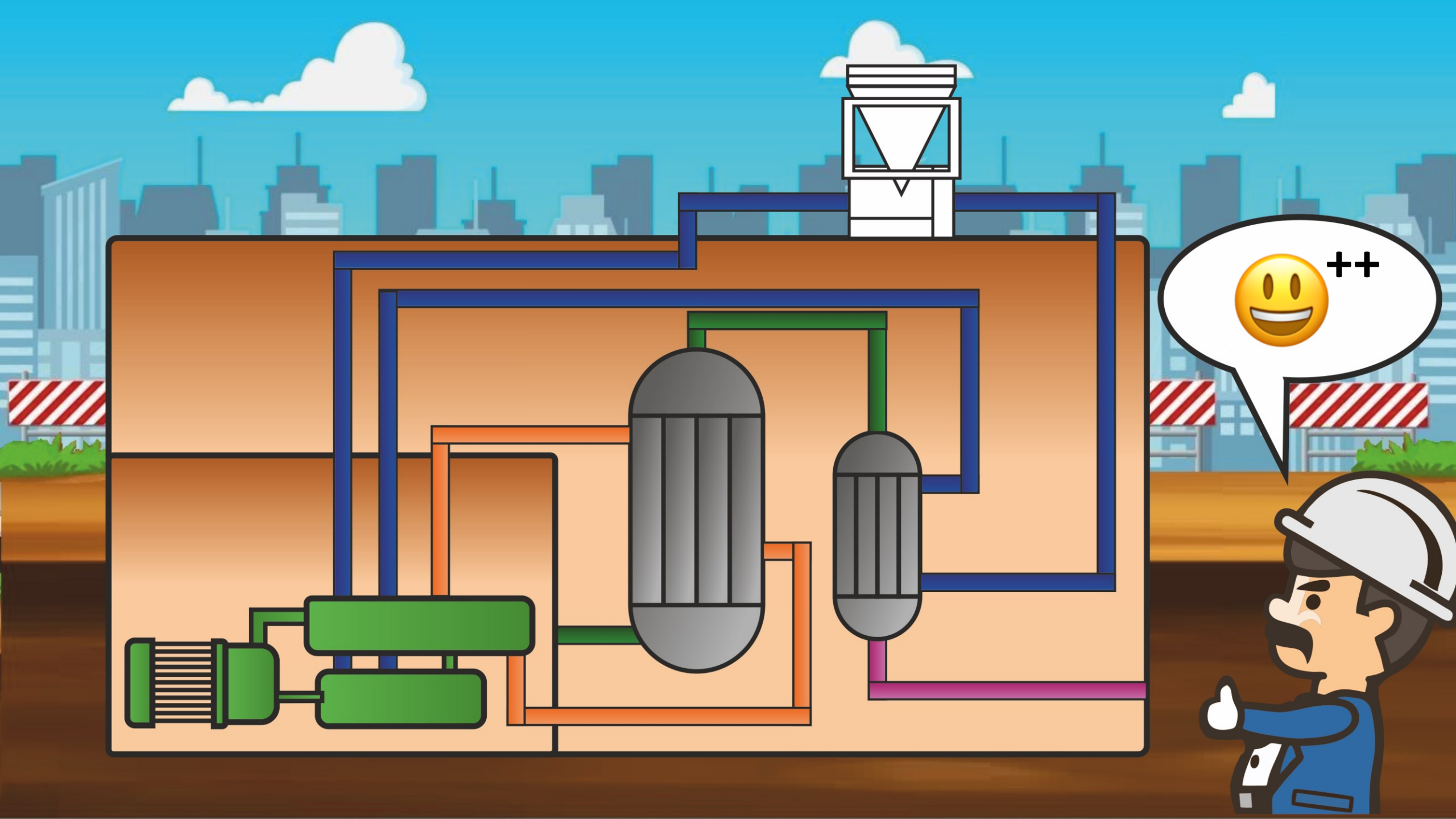
HPs are not plug & play



HPs reduce cooling as well



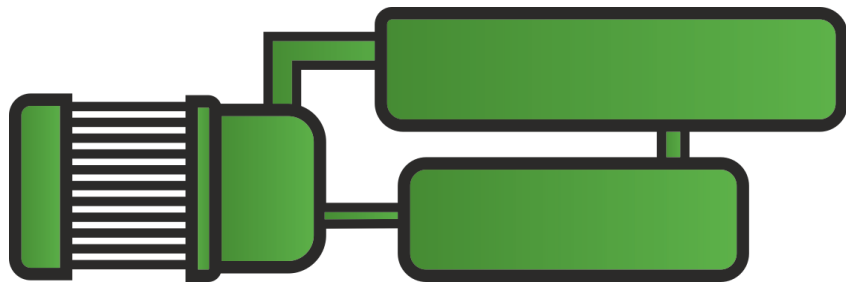




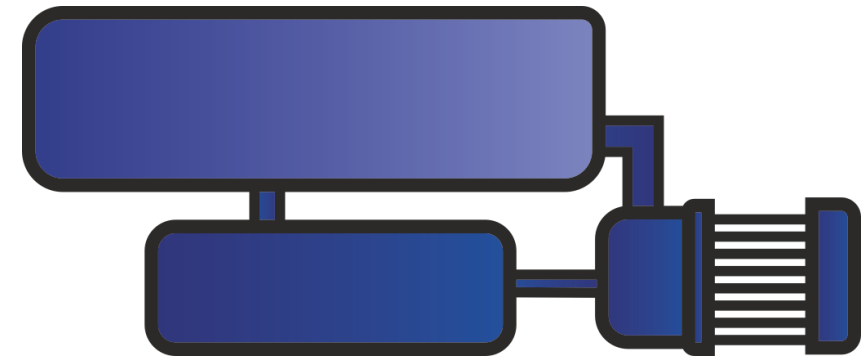
Heat pumps are not a plug & play

- HPs integration required a broad approach.
- HPs reduce cooling demand.
- HPs are very diverse => great variability

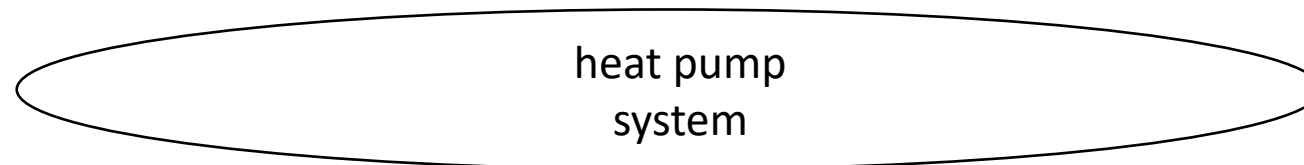
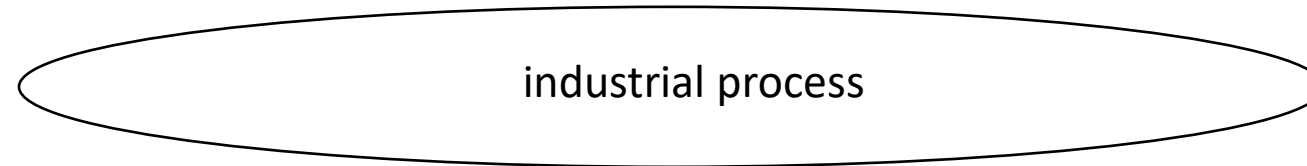
Variability is a chance



≠



Variability allows to optimize the system to any application



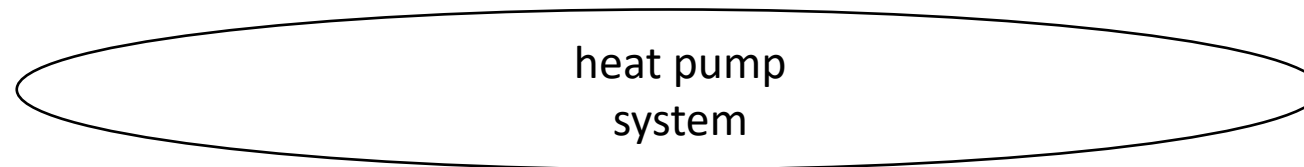
Variability allows to optimize the system to any application

process
heat

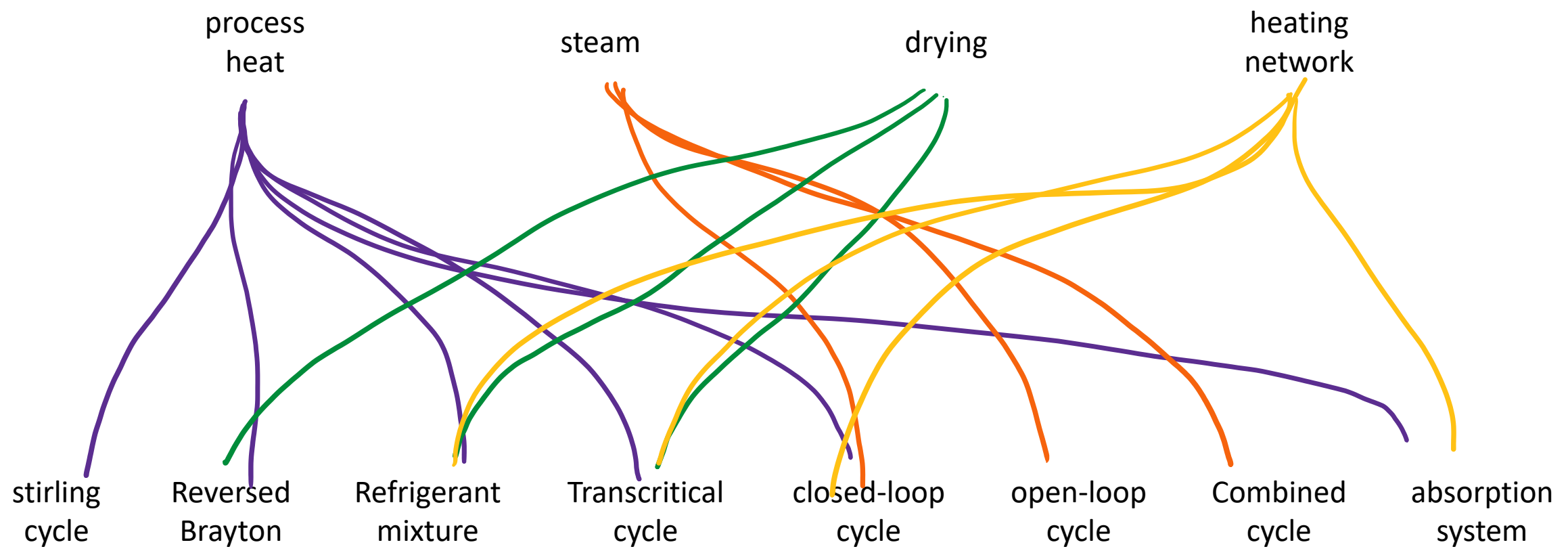
steam

drying

heating
network

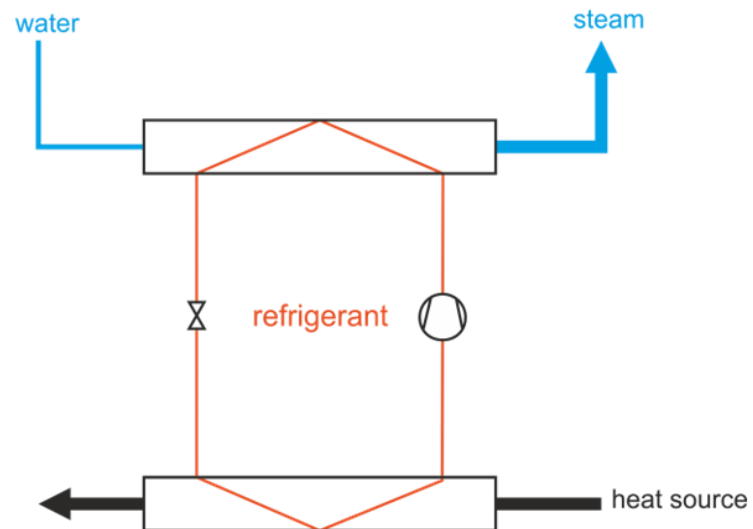


Variability allows to optimize the system to any application



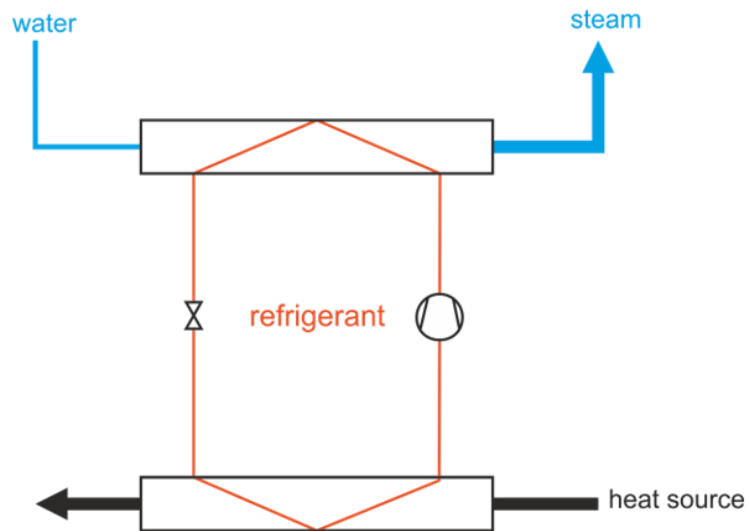
Many heat pump cycles to create steam

HP closed-loop

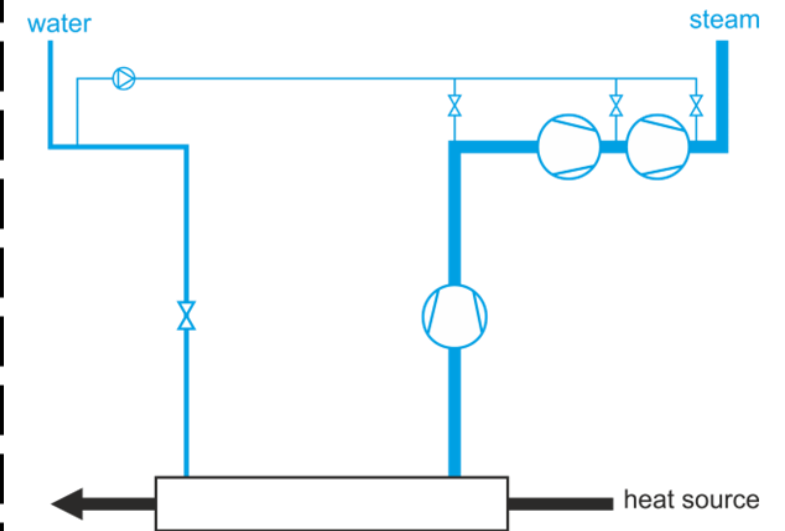


Many heat pump cycles to create steam

HP closed-loop

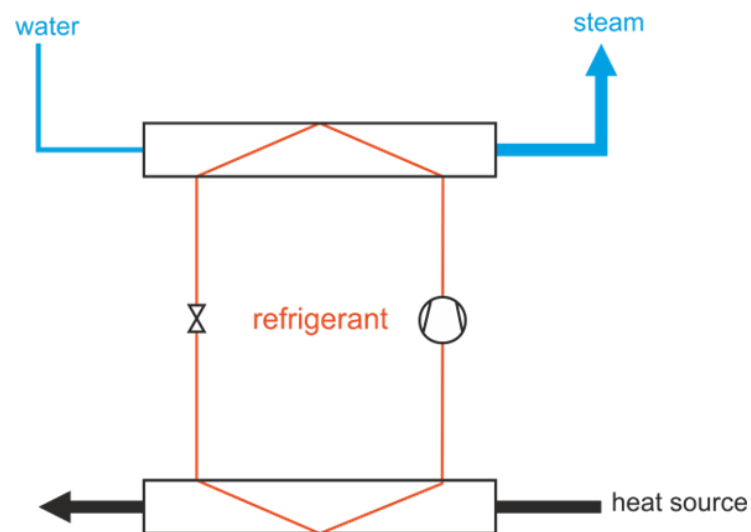


MVR

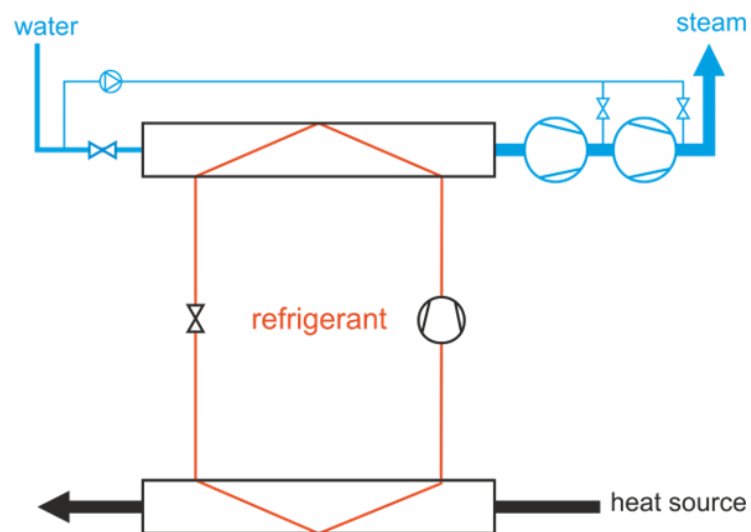


Many heat pump cycles to create steam

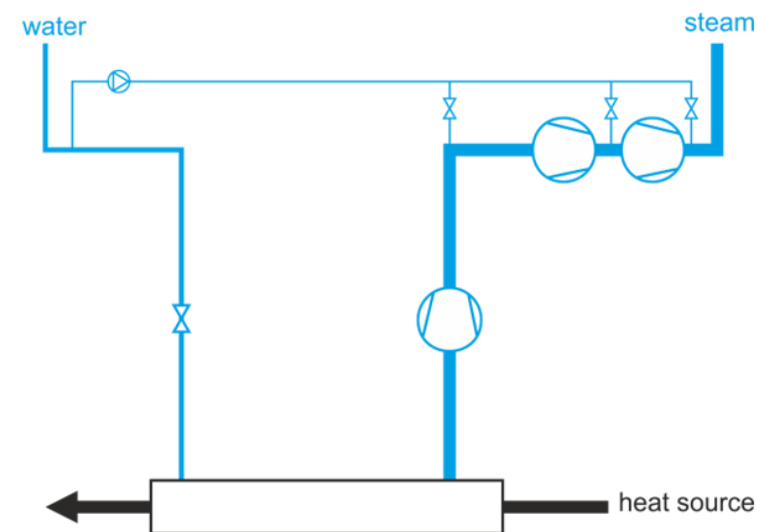
HP closed-loop



Combined cycle

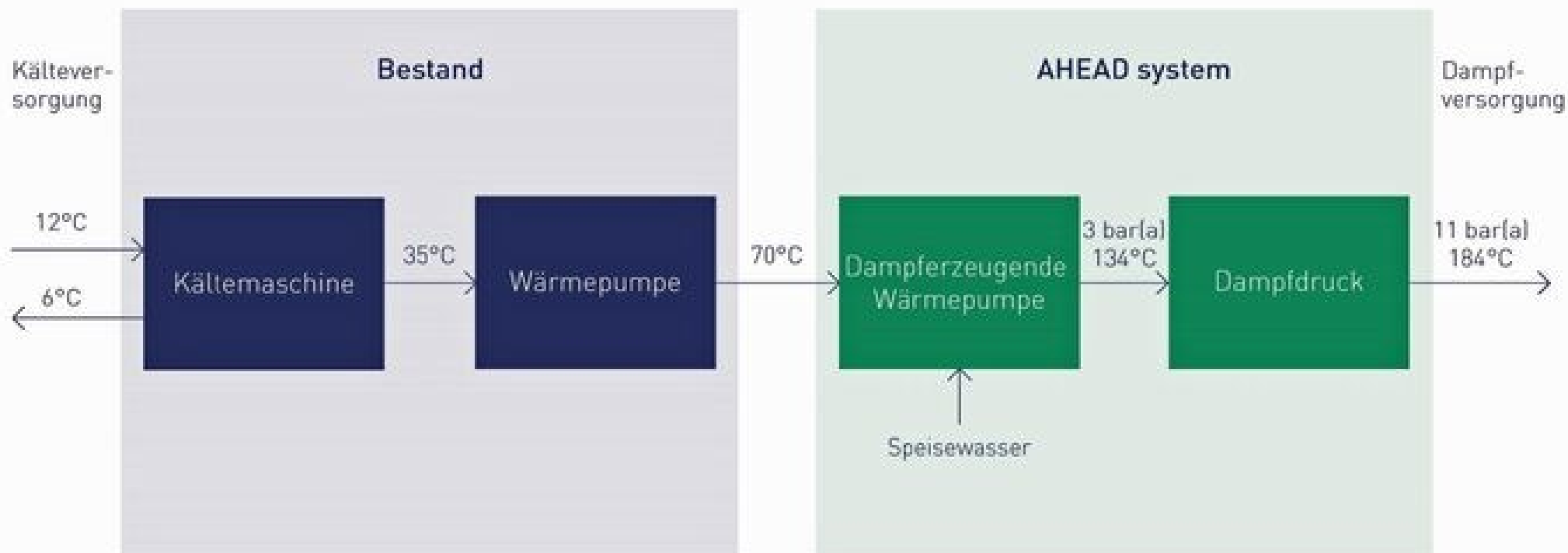


MVR



Example of heat pump cycle to create steam

New Energy for Industry (NEFI)-Projects



→ Heizleistung der AHEAD-Anlage
2,5 to Dampf / Stunde

→ 4000 Stunden wissenschaftliche
messtechnische Begleitung

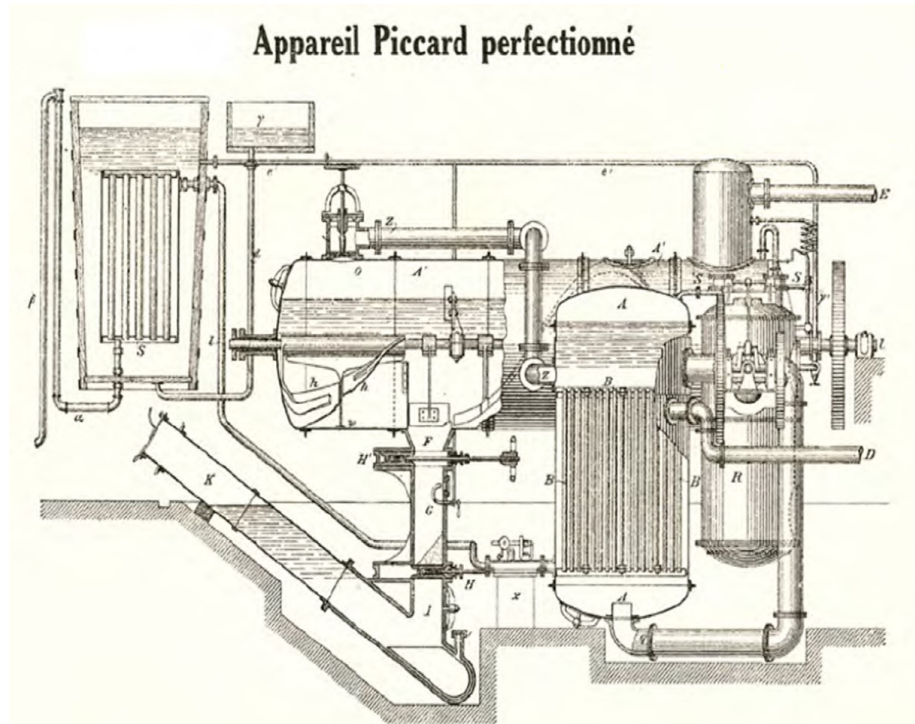
→ Dampf mit 11 bar(a) und einer
Kondensationstemperatur von 184°C

Example of heat pump cycle to create steam



New Energy for Industry (NEFI)-Projects

From origins to latest developments



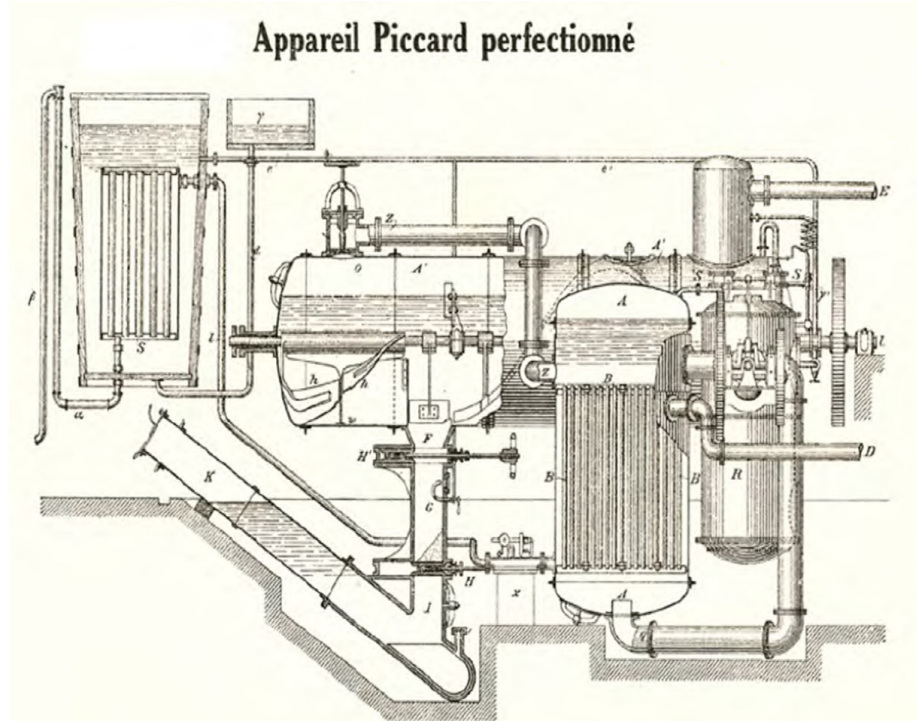
1877 – 1st (steam driven) heat pump ...

From origins to latest developments



IEA Annex 58 on High Temperature Heat Pumps

13 participating countries: Austria, Belgium, China, Canada, Denmark, France, Germany, Netherlands, Japan, Norway, South Korea, Switzerland, US



1877 – 1st (steam driven) heat pump ...

2023 – Heat pumps allowing steam production

Heat pumps supplying heat over 100°C



- Characteristics :

- Compressor types
- Working fluids
- Capacity range
- Maximum temperature
- Temperature lift
- Thermodynamical cycle
- Heat carrier media
- ... & TRL !



Overview of HTHP technologies

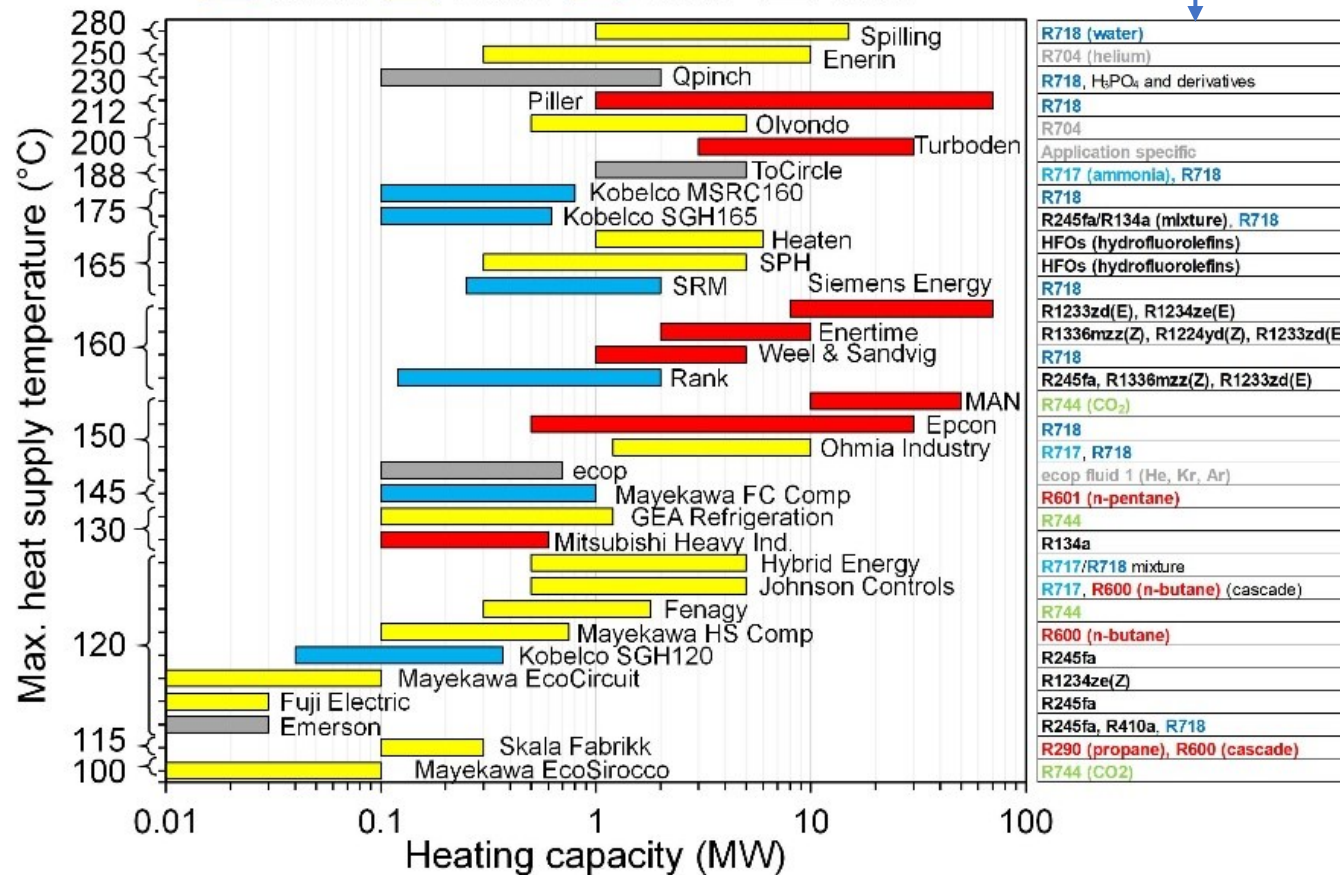


- High temperature achievable ! ...from what source ?

Compressor technology

■ Screw
 ■ Piston
 ■ Turbo
 ■ Other

Refrigerant fluid

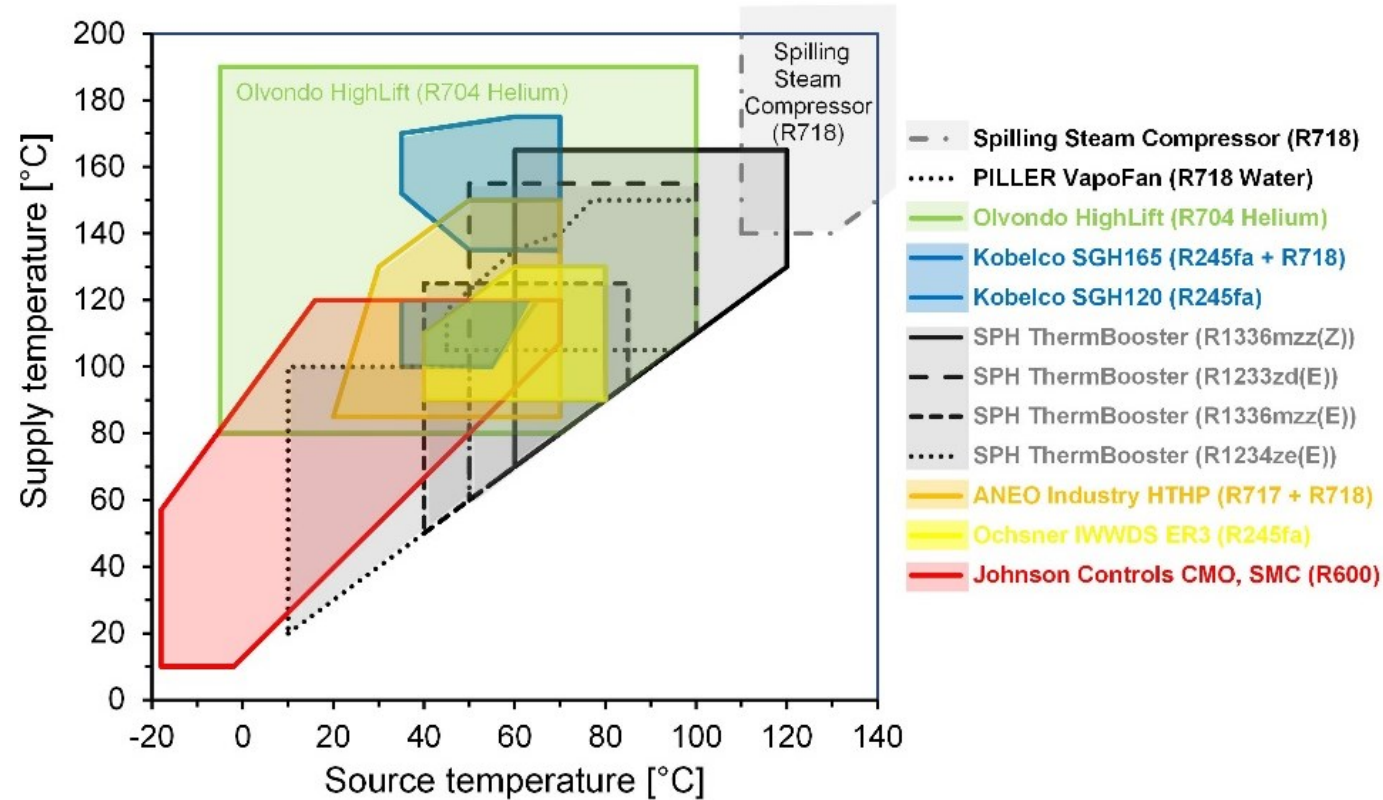


Information provided by technology suppliers without 3rd party validation

Adequacy between HP and project conditions



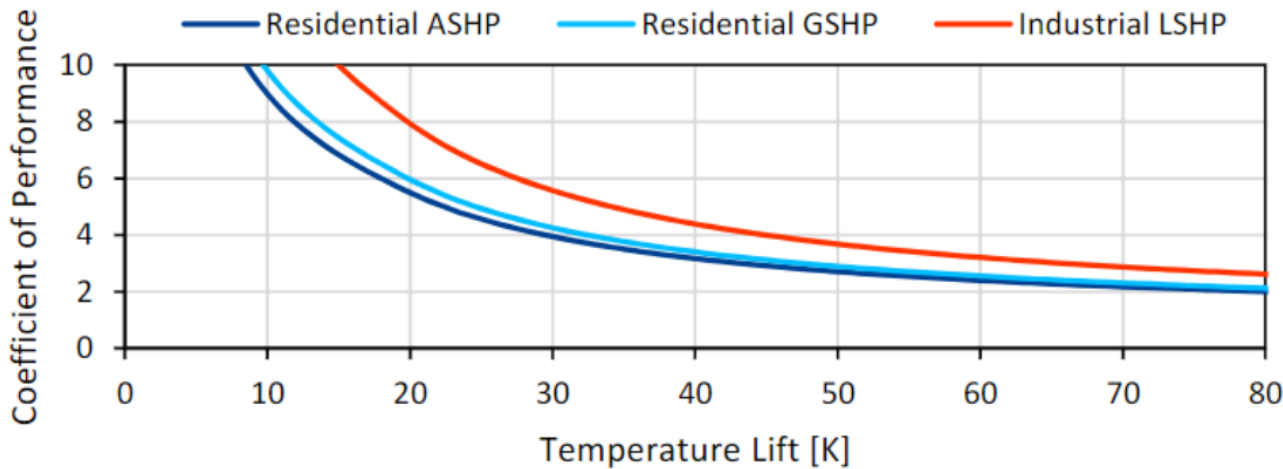
- Operating range = physical limits of the components
- The best heat pump ?



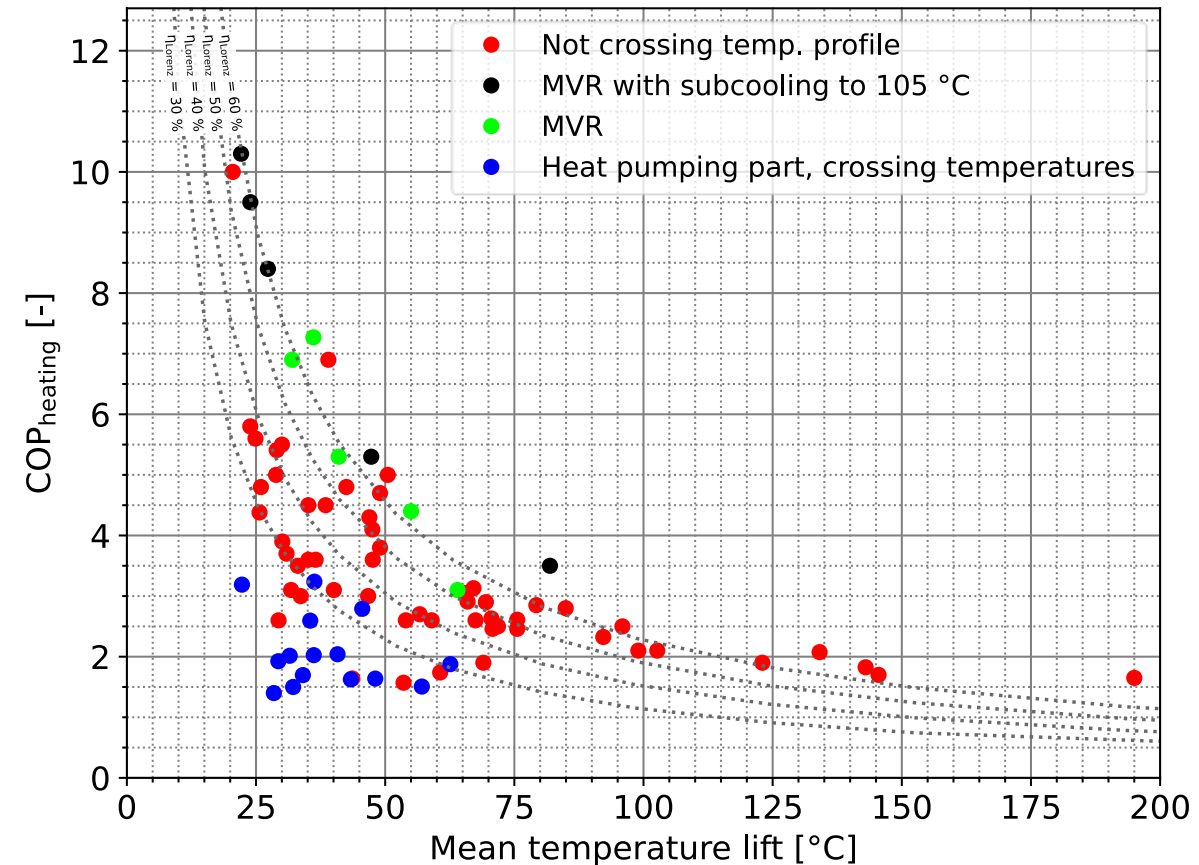
Overview of HTHP efficiency



- $COP = \text{Produced heat} / \text{power needed for compression}$
- Larger scale & industrial context = better efficiency
- Temperature lift is key for COP



Source : Wolf and IEA Annex 35, 2014

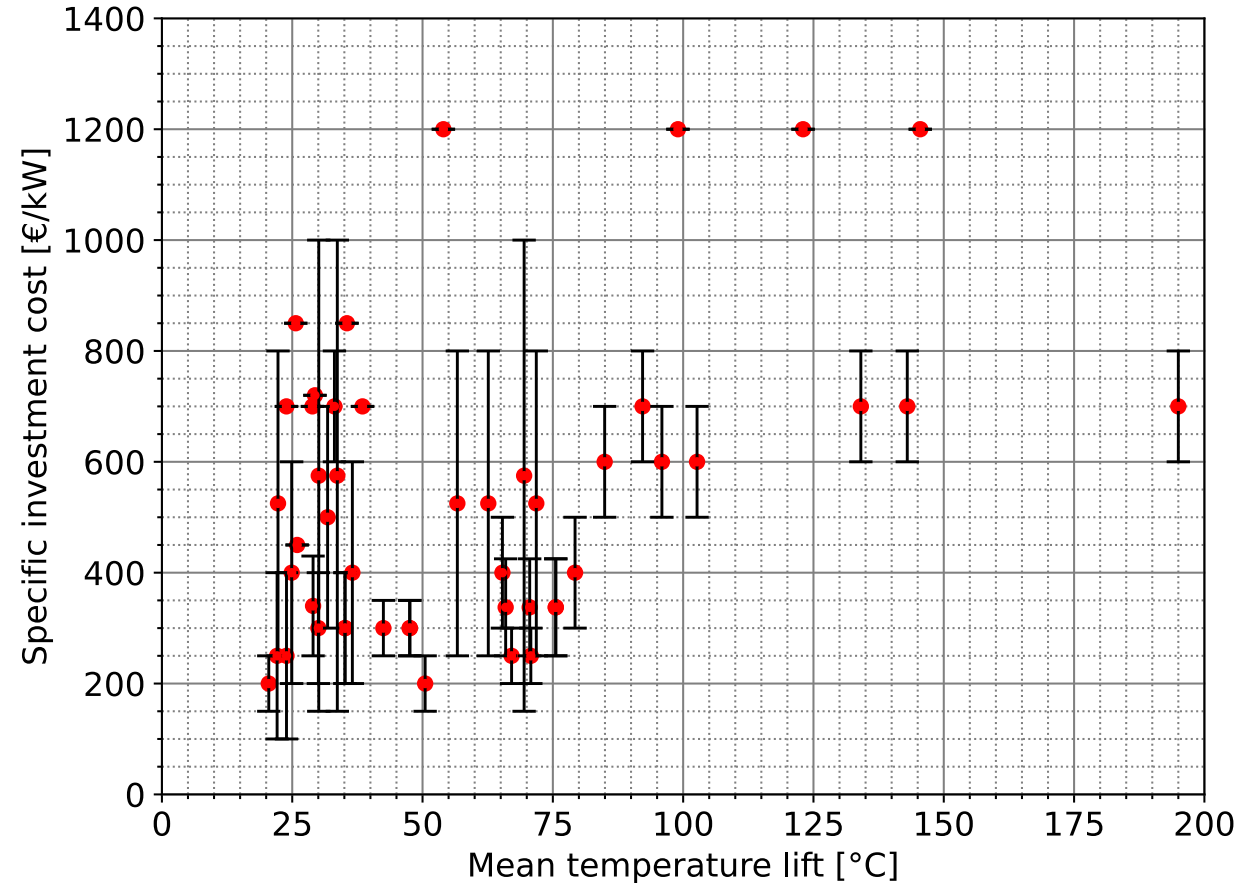


High Temperature Heat Pumps | 24 March 2023

Source : IEA Annex 58, 2022

Specific cost

- Specific investment cost (disregarding installation and integration cost)
- Costs, savings and payback
- Including TRL 4 - 9



Discussion on HTHP systems



- Compressor technology :
 - From the process industry
 - Modified compressors based on proven technology
 - New concepts or deeply adapted
 - Oil-free systems
- Importance of a good integration : within the processes, hydraulic, regulation
- Dynamic behaviour
- Availability on market

Further information sources on HTHP



- Collected information from IEA Annex 58
 - Data sheets from worldwide suppliers
 - Description of demonstration case studies
 - <https://heatpumpingtechnologies.org/annex58/task1/>

Annex 58 High-Temperature Heat Pumps

Screw compressor high-temperature heat pump Rank®

Figure 1: Rank® HTHP and compressor

Summary of technology

Rank® is a worldwide recognized company in the design and manufacture of Organic Rankine Cycles for different capacities and applications. Now, Rank® is using this valuable experience in extreme conditions to develop high-temperature heat pumps (HTHP) that can produce renewable heat up to 160 °C.

New Rank® HTHP systems are based on a single-stage cycle with an internal heat exchanger (IHE). However, a two-stage cascade cycle with IHEs can be assembled for covering larger temperature lifts.

The compressor is electrically driven, is based on a screw technology with a frequency inverter to be adapted to the customer's actual operation. The compressor is based on direct drive, avoiding gears or pulleys, minimizing the maintenance, and increasing electrical efficiency. Moreover, magnetic coupling ensures tightness and avoids the possibility of leakage.

Lubrication used for the proper operation of the compressor is polyester oil (POE) oil of a specific viscosity, fully compatible with organic working fluids and able to work at high temperatures while keeping the optimum properties.

Rank® HTHP systems since we have adapted to the field sized using our applications. The industrial process or district heating.

Our HTHP prototype and small lab-scale prototype on the temp designed for.

The development but our cost installing of applications.

Compact H technology a thermal heat comes uses as it coils, am

Figure 2: Rank® modular solution

Our machines operate through an automatic, efficient managing system without human intervention. Real-time data transmission via the internet allows predictive maintenance by server data analysis, online supervision (PC, mobile phone, tablet, etc.), and remote configuration of working parameters.

Table 1: Performance for the single-stage cycle with IHE HTHP prototype (experimentally measured in lab, prototype, not fully optimized for specific purpose)

Tem _{in} [°C]	Tem _{out} [°C]	Tem _{out} [°C]	COP _{heating} []
88	70	103	5.9
101	70	122	4.6
115	70	130	4.0
100	80	150	3.7
116	95	160	3.0
		160	2.8

Table 2: Case study for production of thermal oil.

Tem _{in} [°C]	Tem _{out} [°C]	Tem _{out} [°C]	Tem _{out} [°C]	COP _{heating} []
100	70	130	110	3.6
100	80	130	110	4.5

Project example

A perfect application for our HTHP systems is district heating networks (DHN).

DHN are present in urban and industrial environments where each user is connected and uses heat at a given temperature. Heat is distributed at a particular temperature, but users' needs can differ.

FACTS ABOUT THE TECHNOLOGY

Heat supply capacity: 120 kW to 2000 kW
 Temperature range: useful heat inlet 80 °C to 120 °C and outlet 100 °C to 160 °C / heat source inlet 60 °C to 100 °C and outlet 40 °C to 80 °C
 Working fluid: adaptable to the application (R245fa, R1336mz(Z), R1233zd(E))
 Compressor technology: Screw
 Specific investment cost for installed system without integrations: 200-400 € per kW, but it varies between temperature levels and applications
 TRL level: TRL 7 - prototype demonstration
 Expected lifetime: 20 years (with the possibility of hiring Services to extend lifetime and ensure the highest energy performance)
 Size: weight 5.5 to 8 tons / surface required 5.2 to 13 m² / height 2.2 to 2.5 m

Contact information

Rank ORC S.L.
 83 info@rank-orc.com / sales@rank-orc.com
 +34 964 69 68 99

All information were provided by the supplier without third-party validation. The information was provided as an indicative basis and may be different in final installations depending on application specific parameters.

IEA Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)

- Video content
 - Webinar on steam HP & Video on Industrial HP (C. Arpagaus)
 - www.sweet-decarb.ch YouTube Channel (footer) or <https://www.youtube.com/@sweetdecarbch>

Conclusion on High Temperature Heat Pumps

- Solution to drive the decarbonisation & improve energy efficiency in the industrial sector
- Available products and strong ongoing developments
- Aim for lowest possible heat use temperature



