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CSDENGINEERS INGENIOUS BY NATURE

HEIG VD

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HIGH TEMPERATURE HEAT PUMPS

24 MARCH 2023 | ITTIGEN

«Overview of HTHP technologies»

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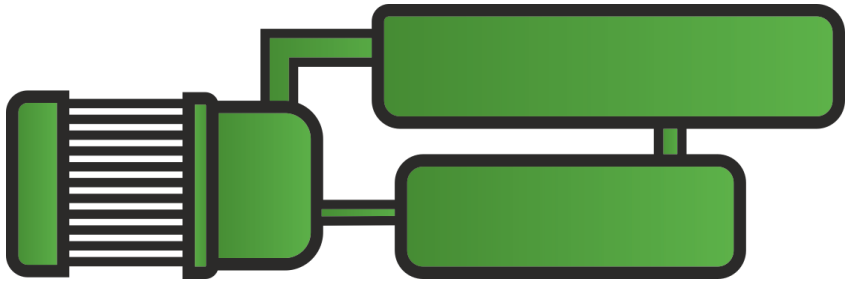
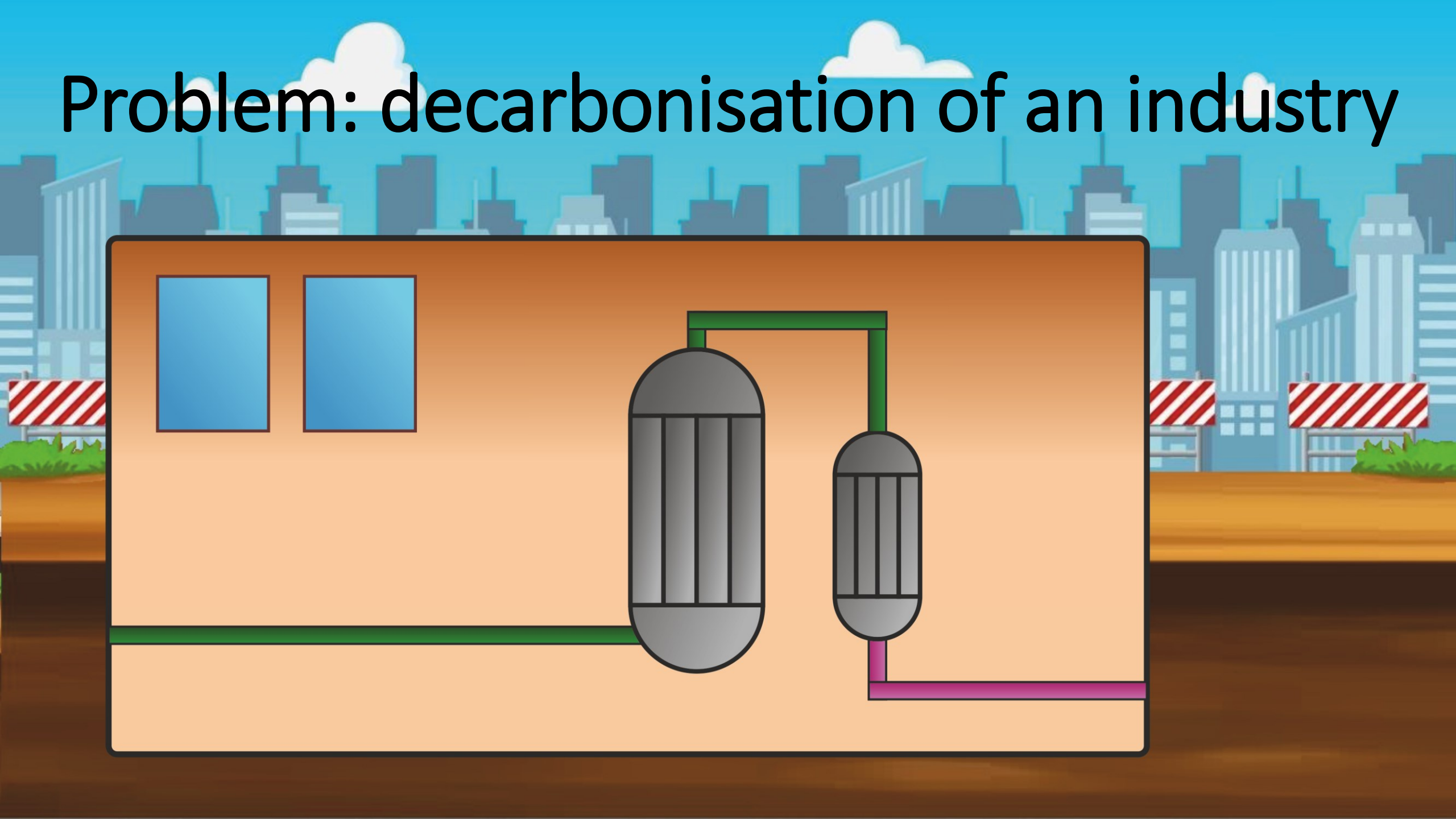
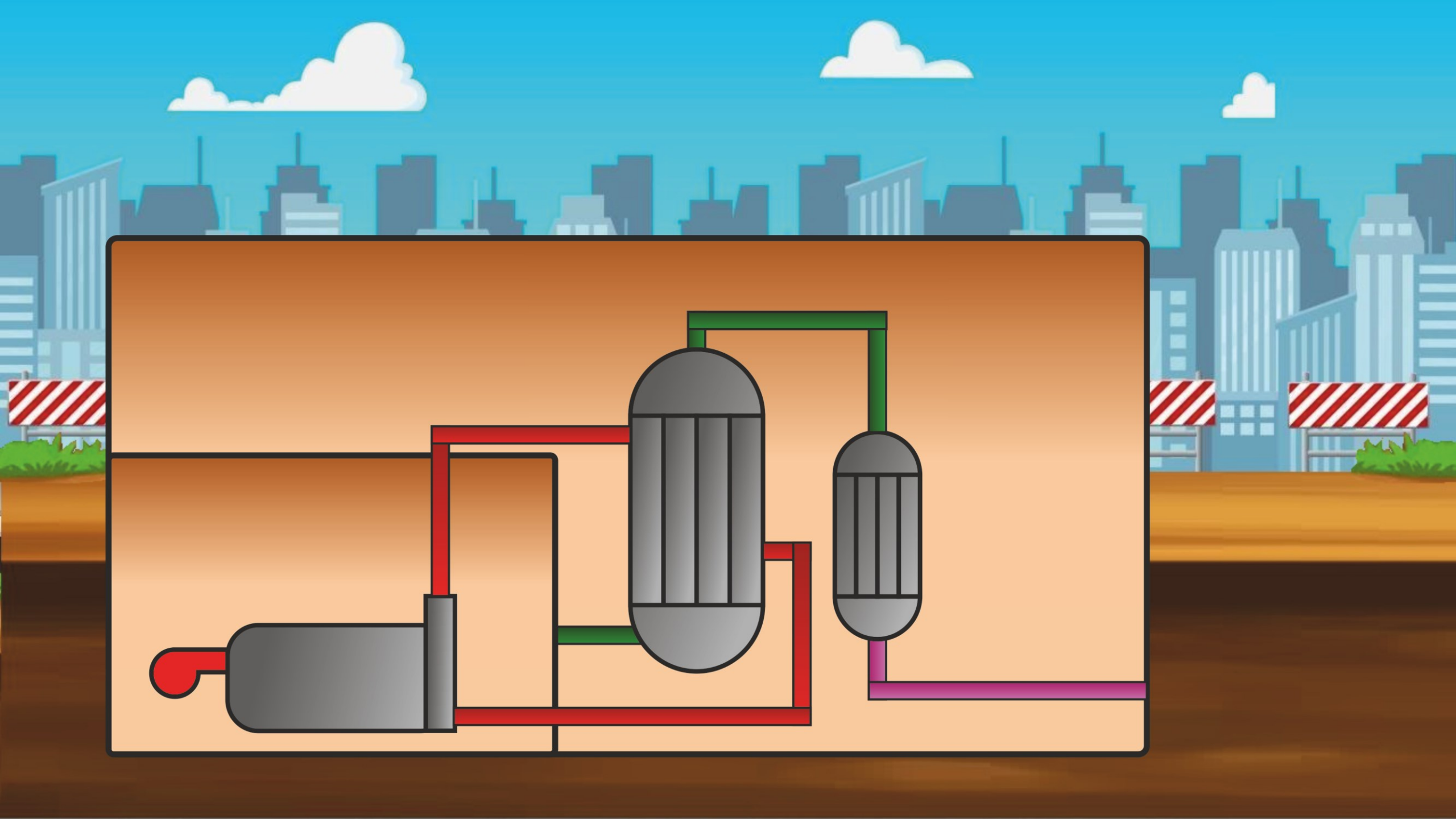
Nicole Calame, CSD Ingénieurs SA

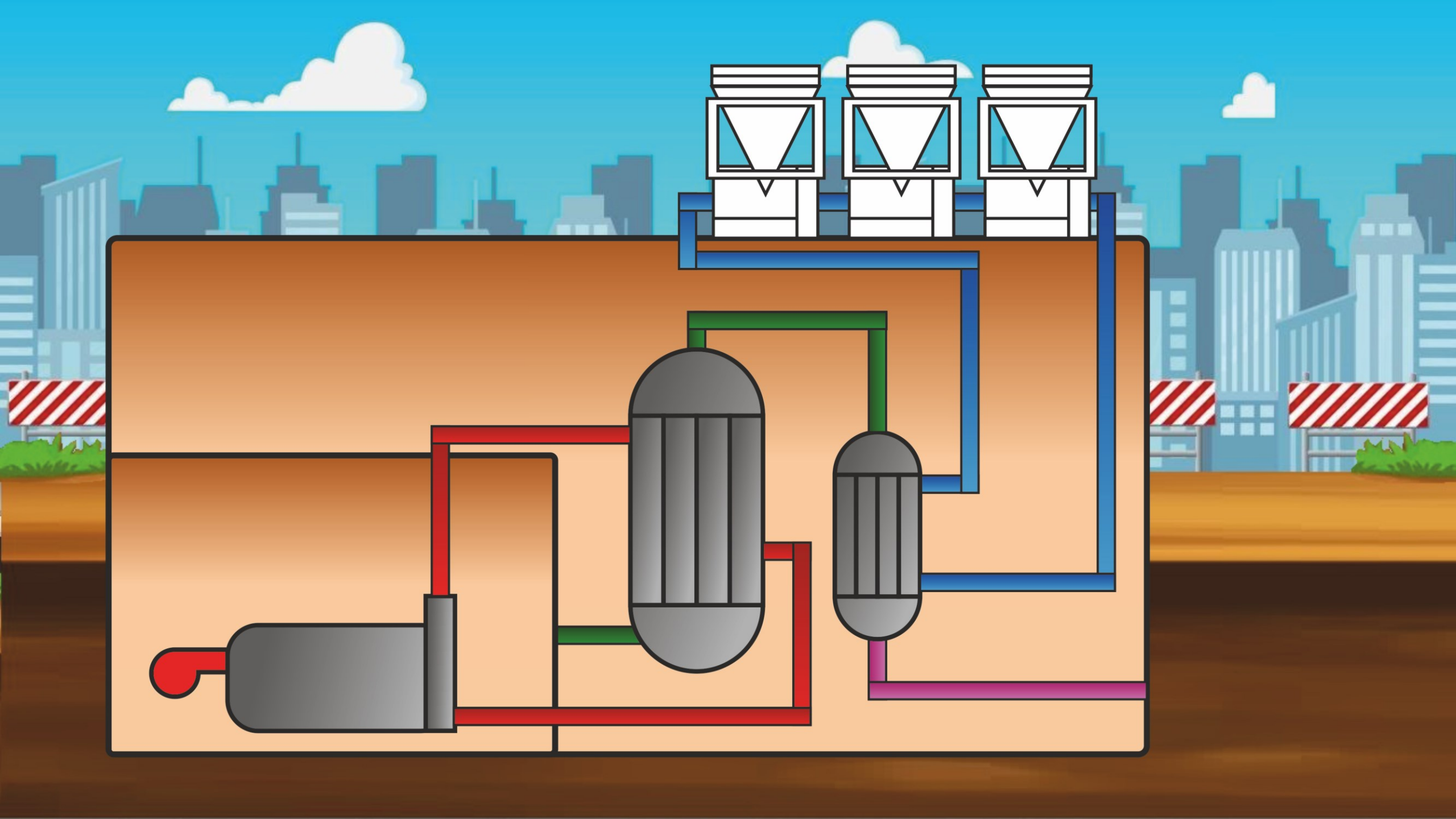
What to think when integrating an heat pump

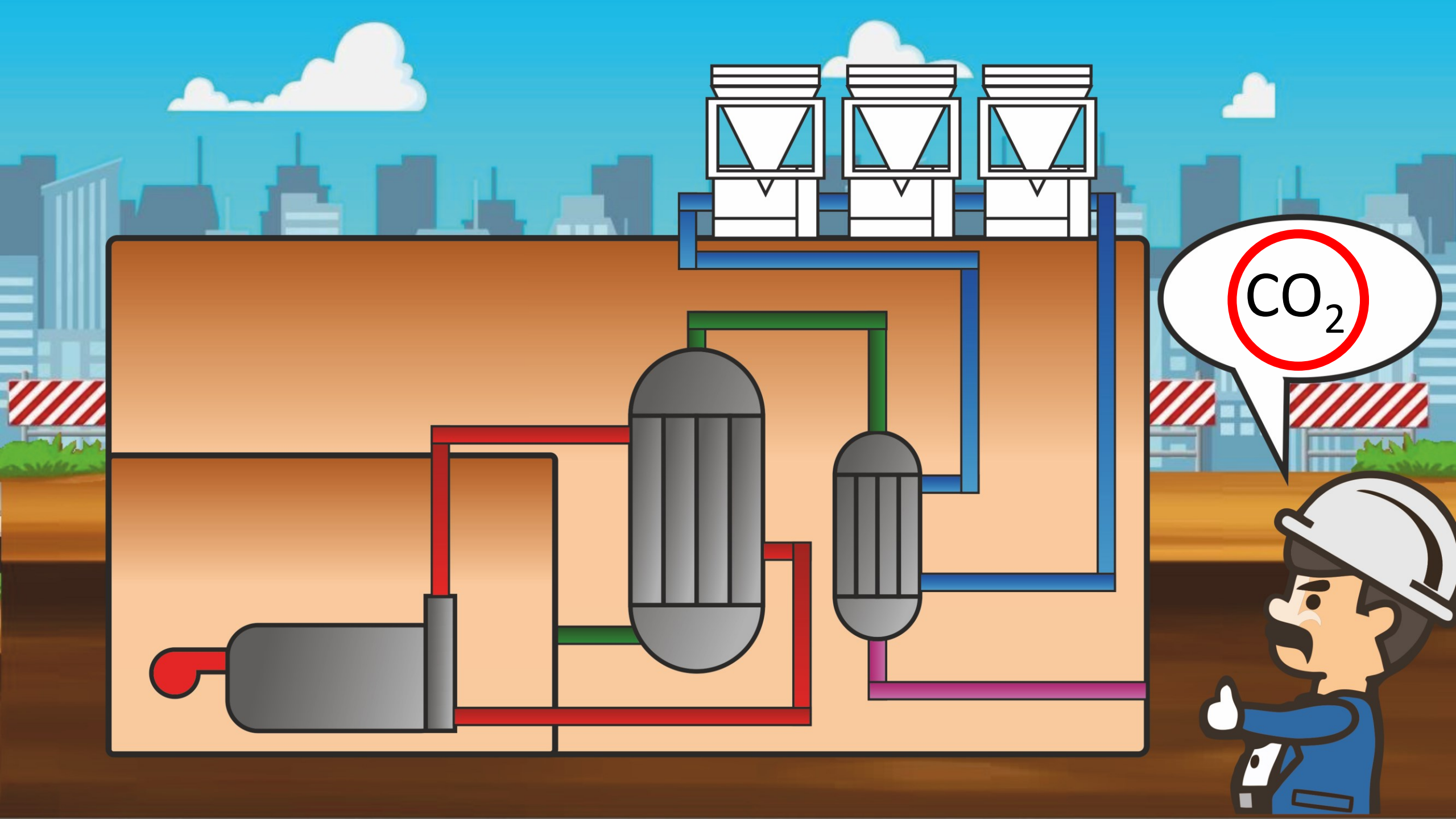


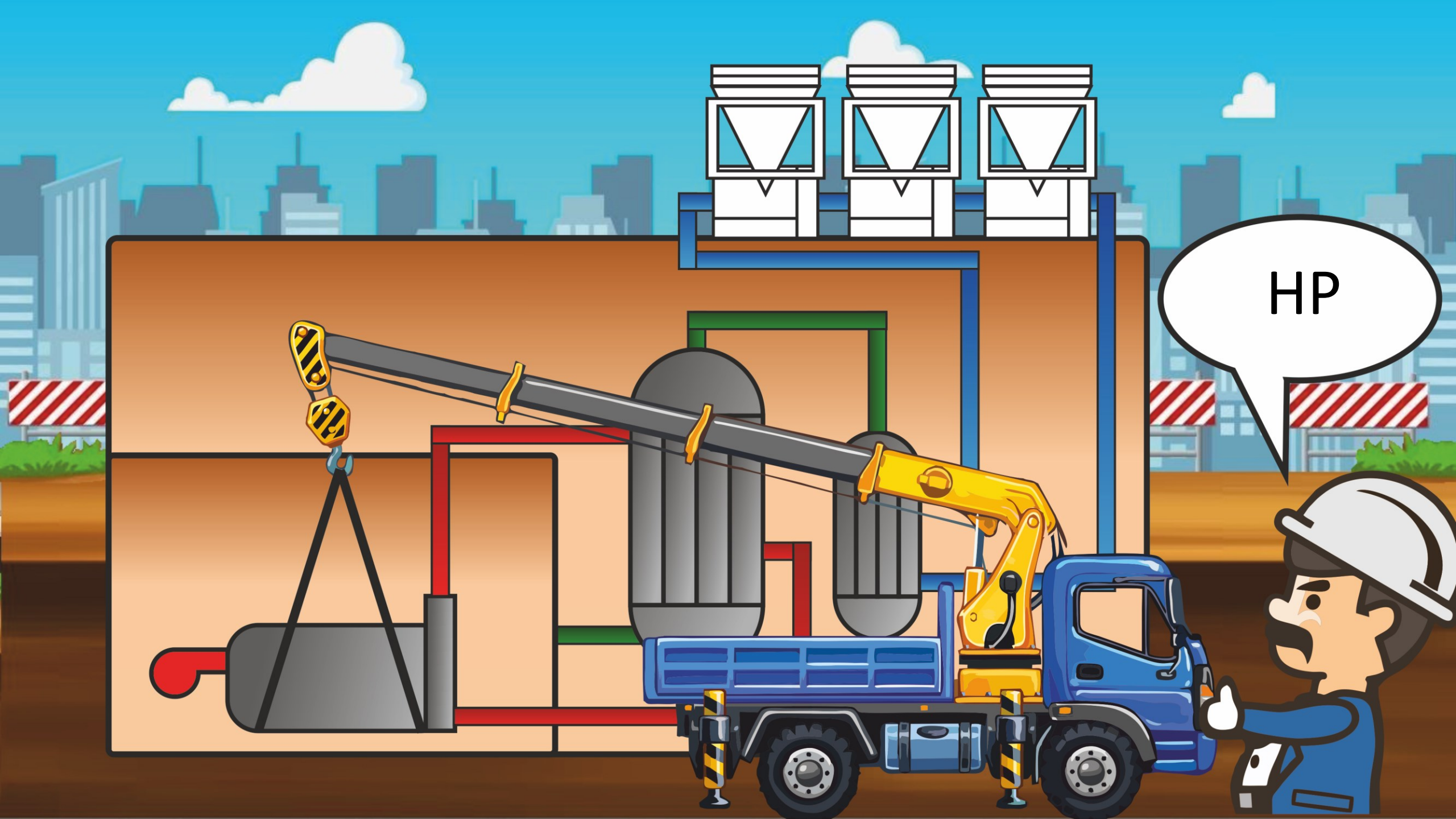
Problem: decarbonisation of an industry

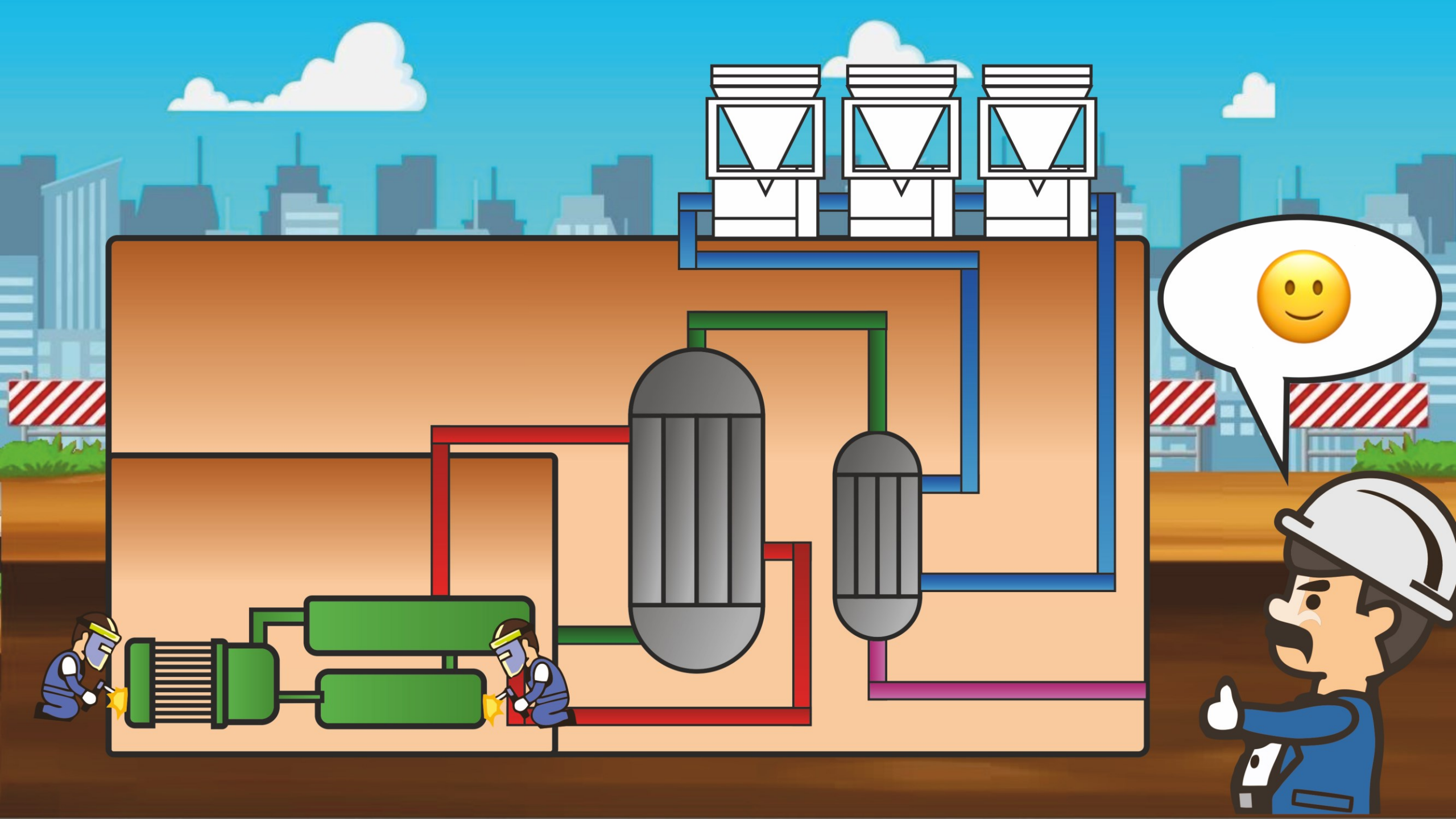




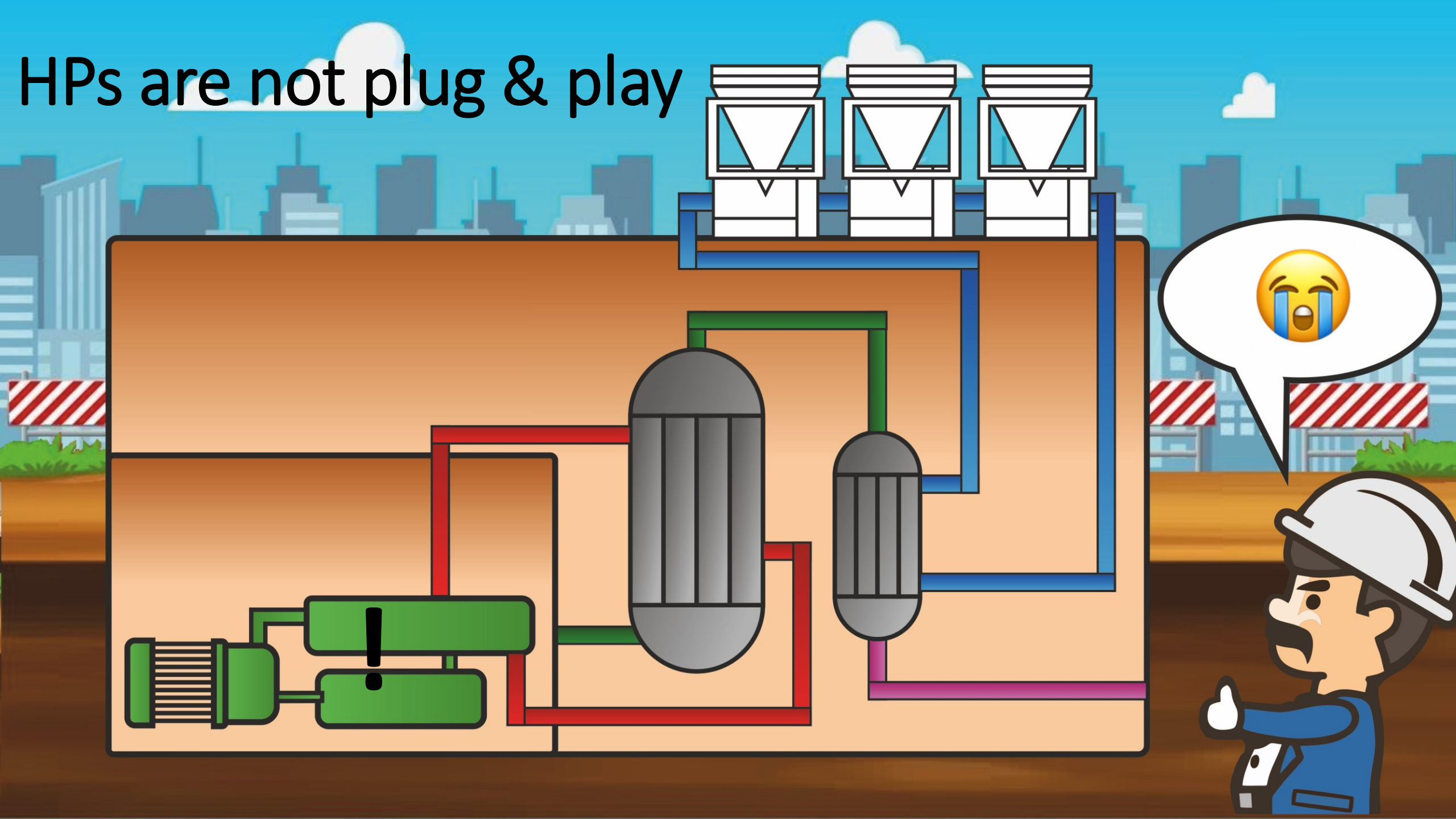



CO_2

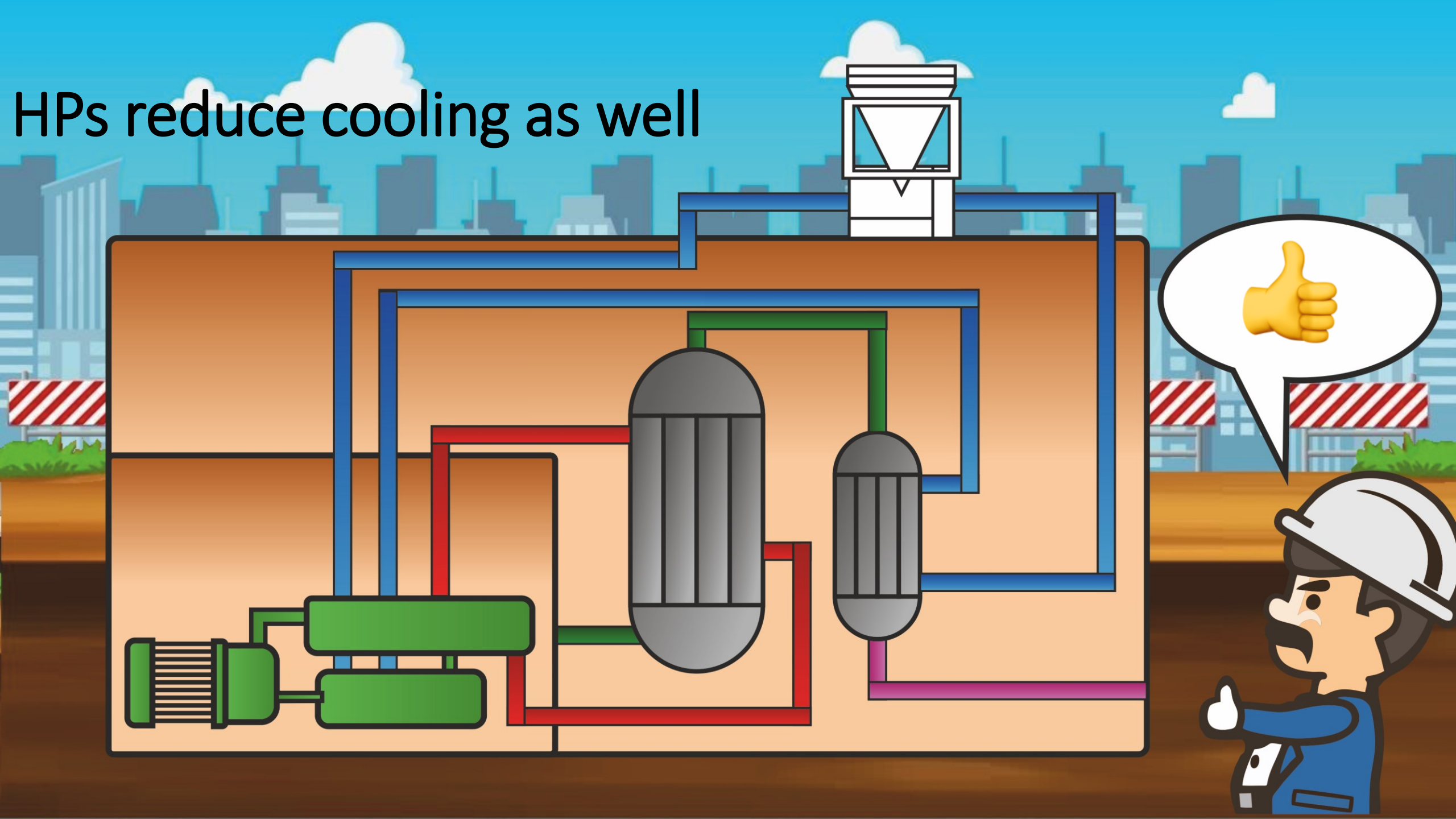

HP

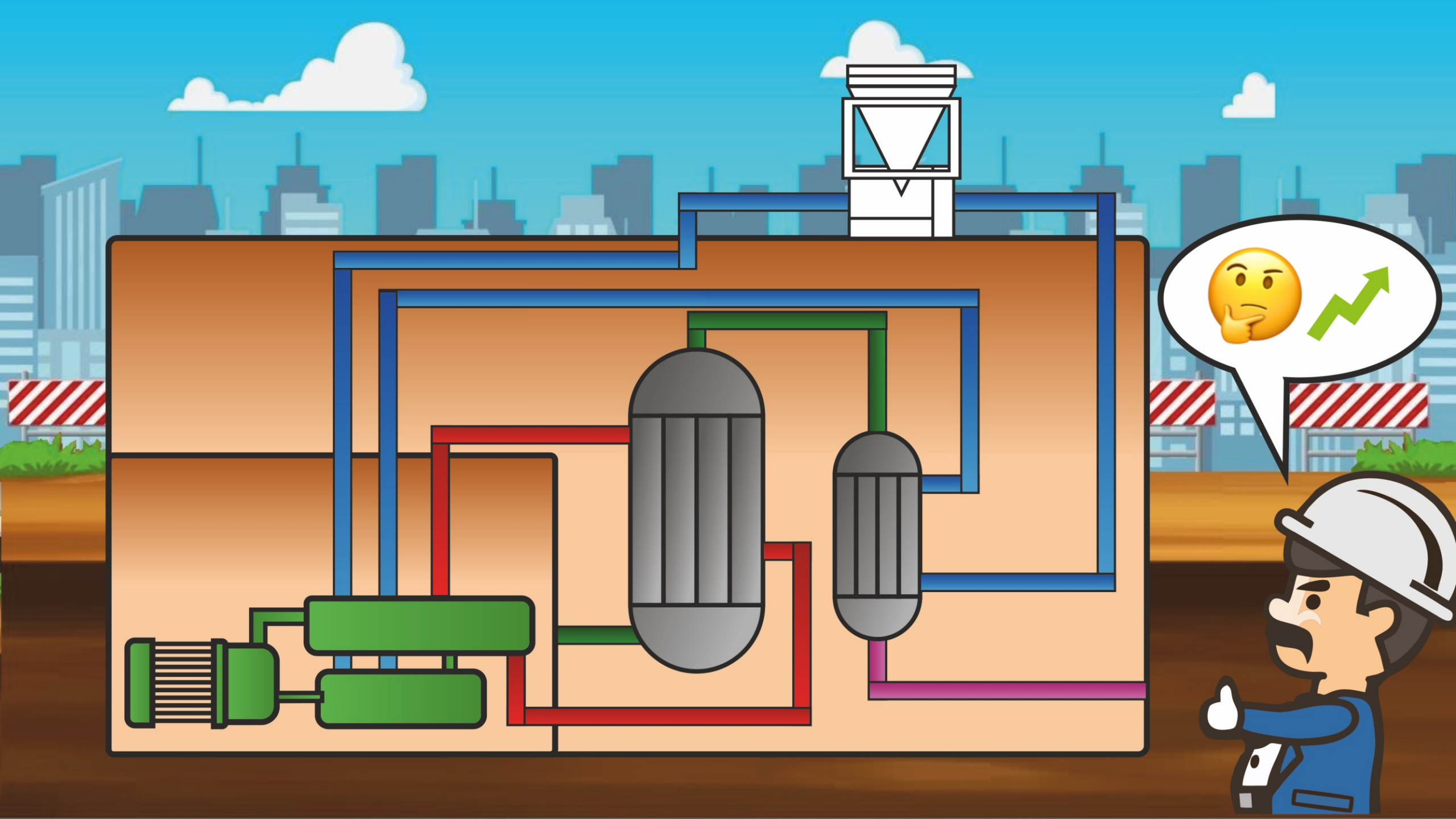


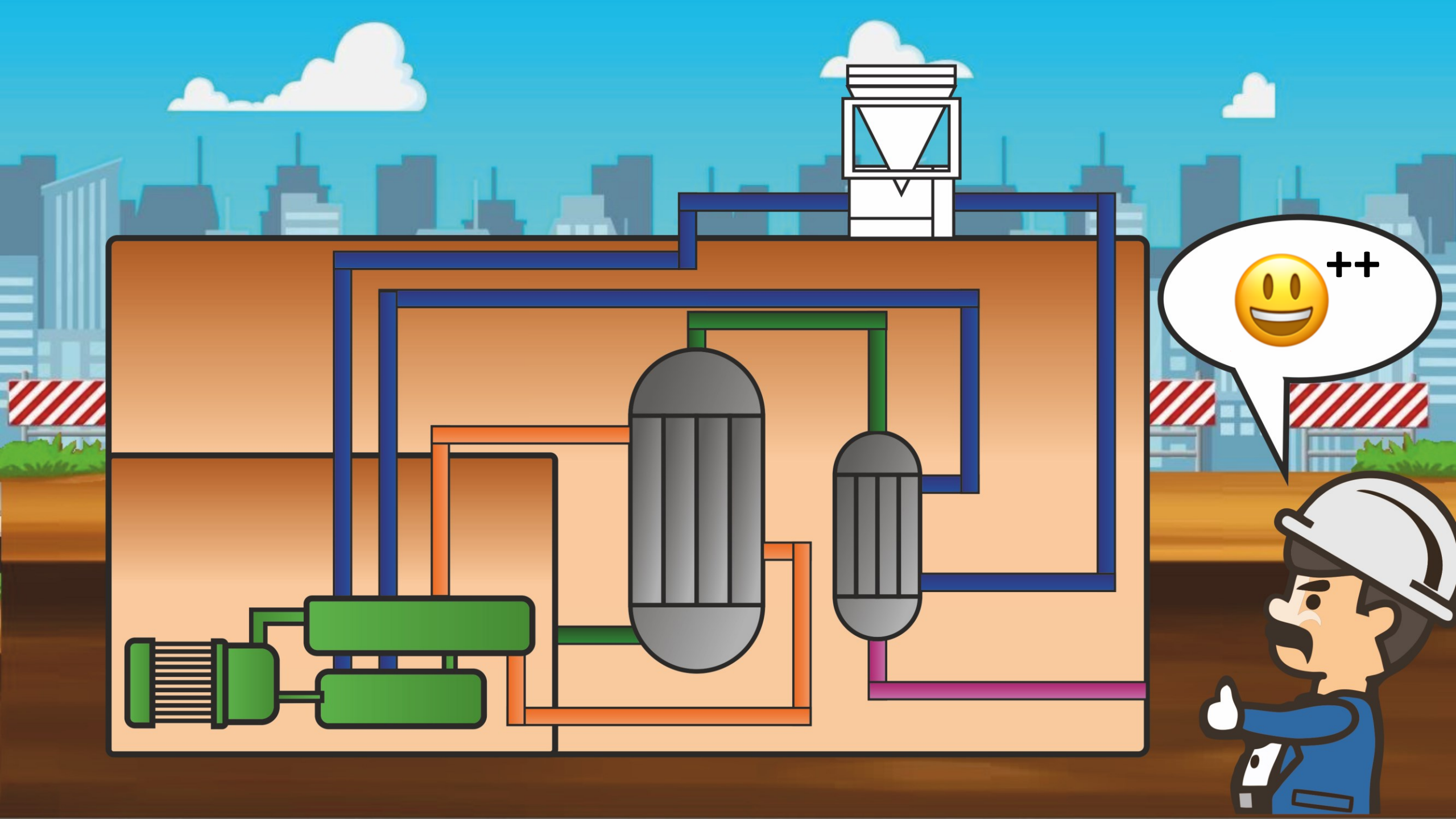
HPs are not plug & play



HPs reduce cooling as well



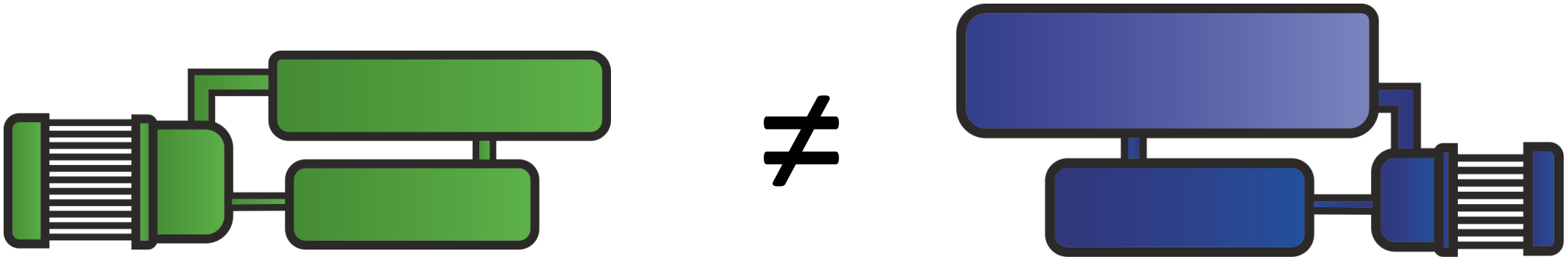




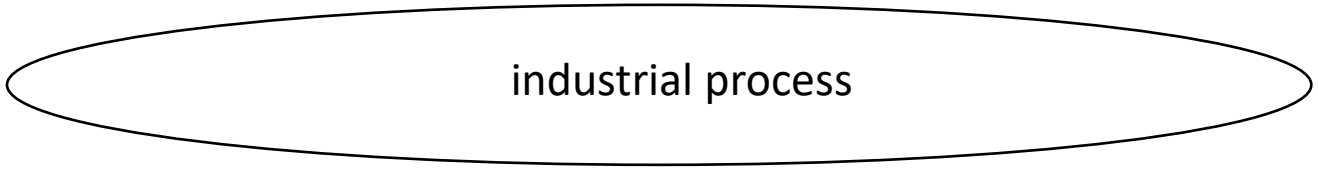
Heat pumps are not a plug & play

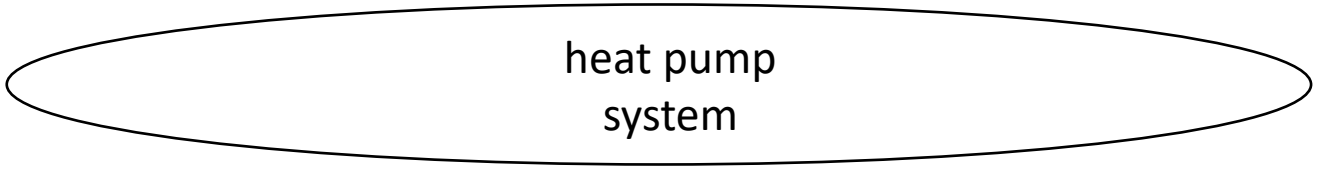
- HPs integration required a broad approach.
- HPs reduce cooling demand.
- HPs are very diverse => great variability

Variability is a chance



Variability allows to optimize the system to any application





Variability allows to optimize the system to any application

process heat

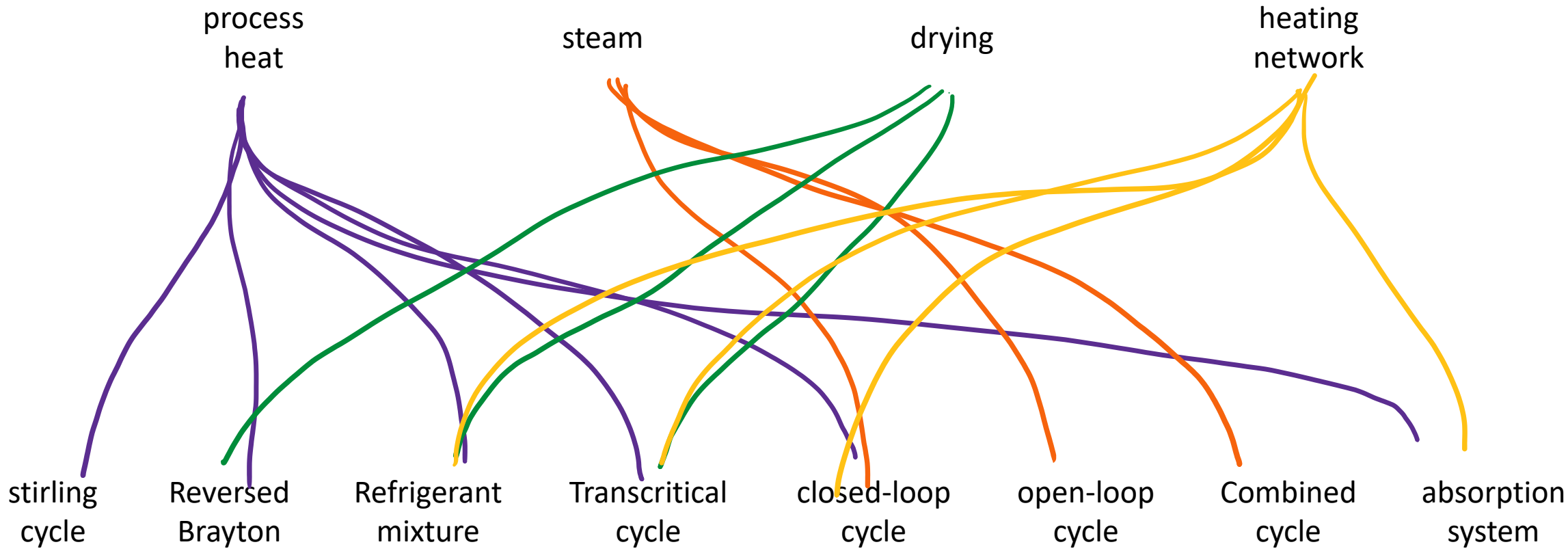
steam

drying

heating network

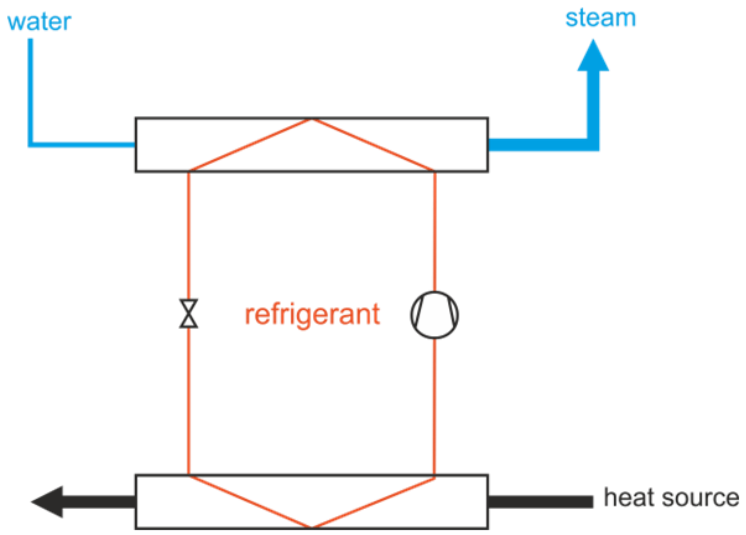
heat pump system

Variability allows to optimize the system to any application



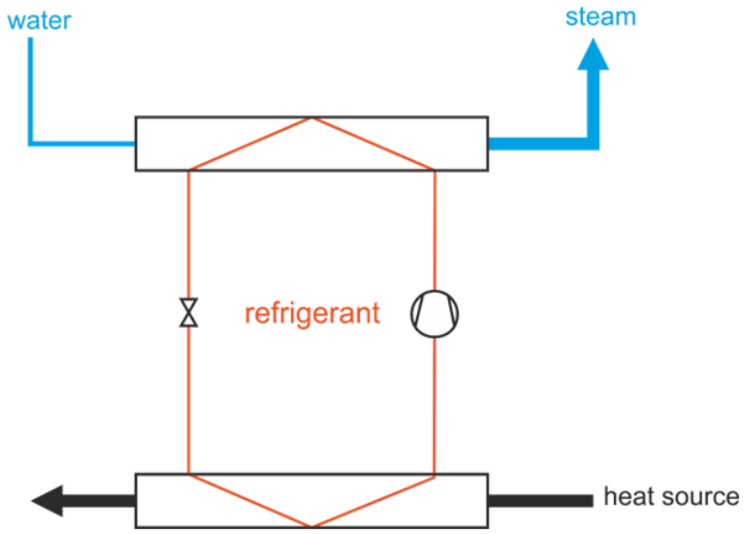
Many heat pump cycles to create steam

HP closed-loop

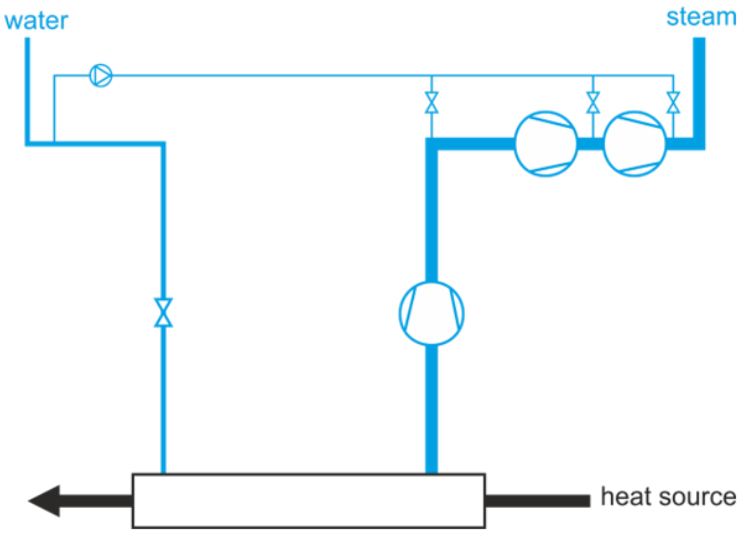


Many heat pump cycles to create steam

HP closed-loop



MVR



Many heat pump cycles to create steam

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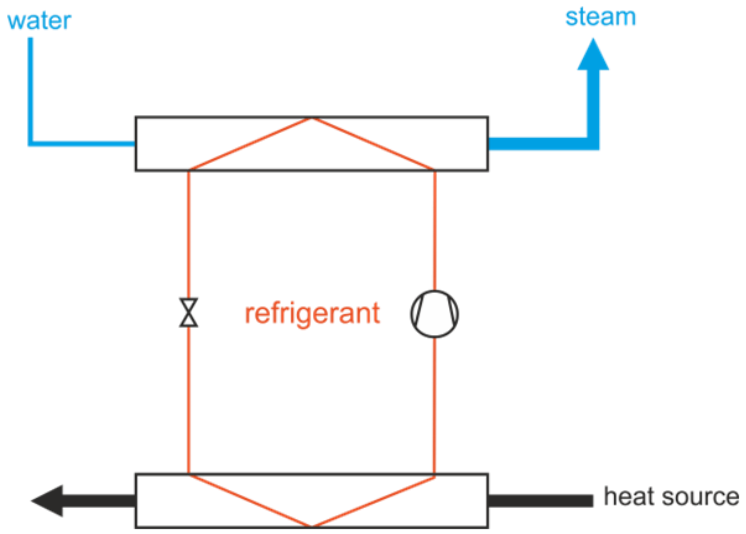
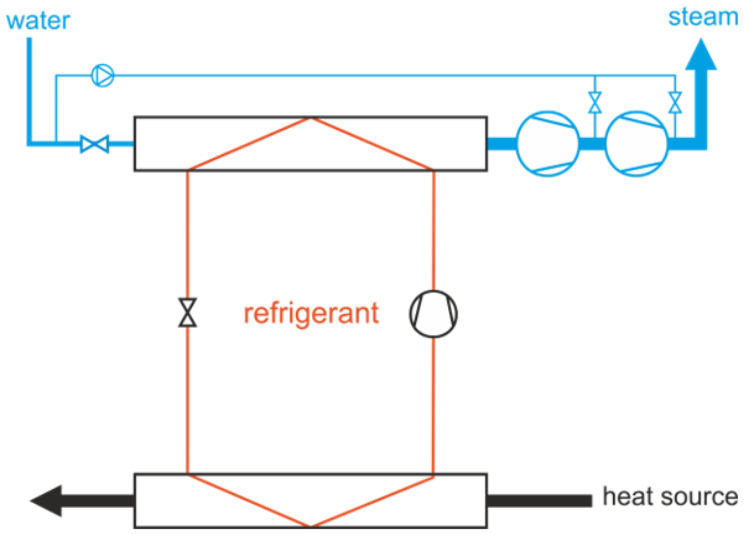
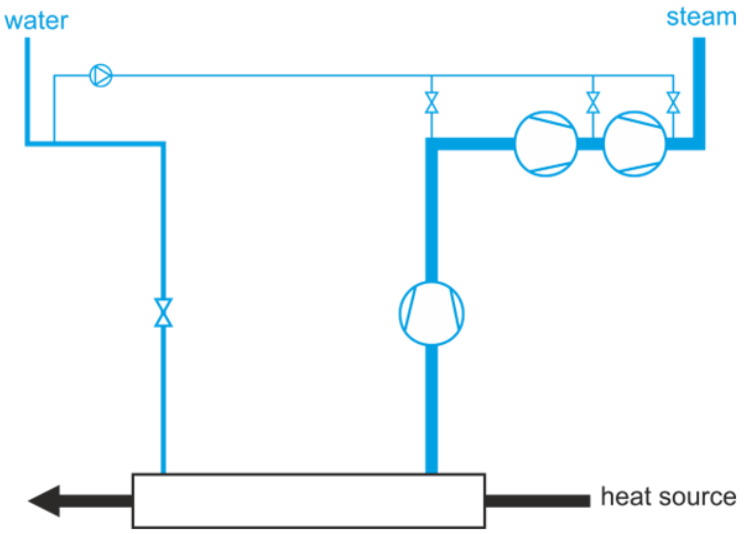


Combined cycle

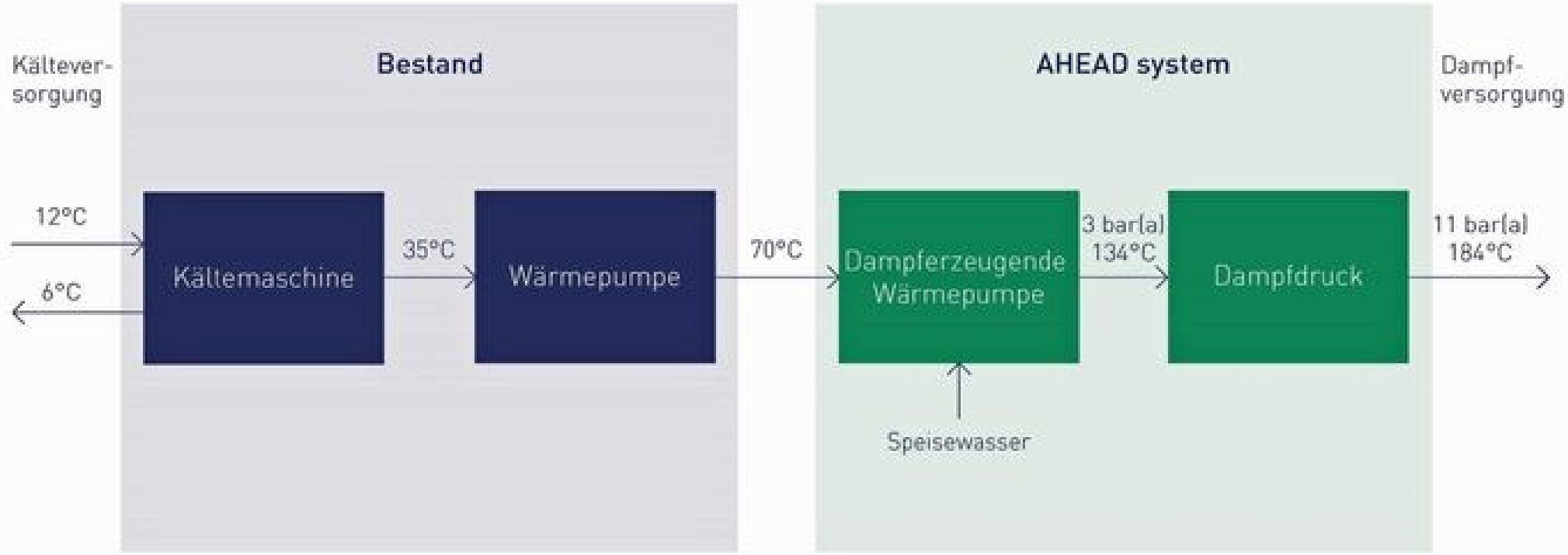


MVR



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

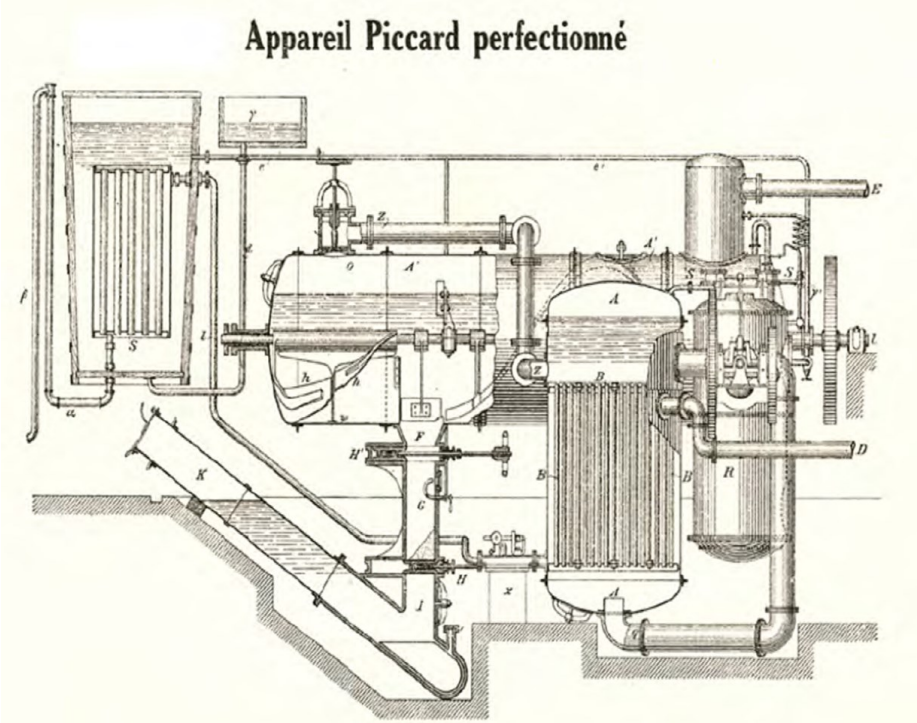
→ Dampf mit 11 bar(a) und einer Kondensationstemperatur von 184°C

Dampf ohne Gas: Möglichkeiten moderner Wärmepumpen-Technologie | HLK

Example of heat pump cycle to create steam

Dampf ohne Gas: Möglichkeiten moderner Wärmepumpen-Technologie | HLK

From origins to latest developments



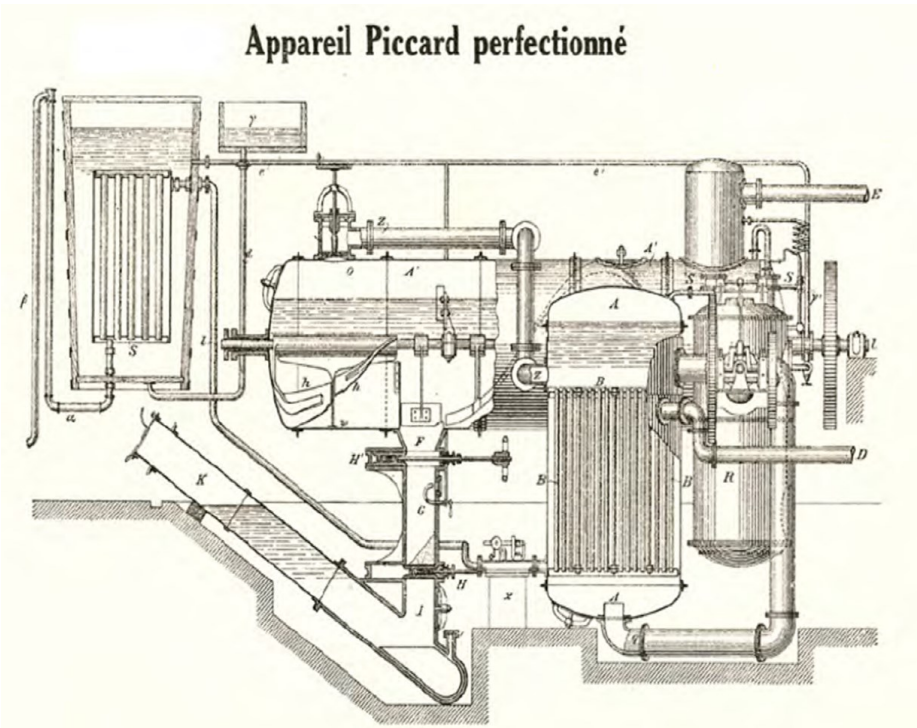
1877 – 1st (steam driven) heat pump …

Source : IEA Annex 58

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



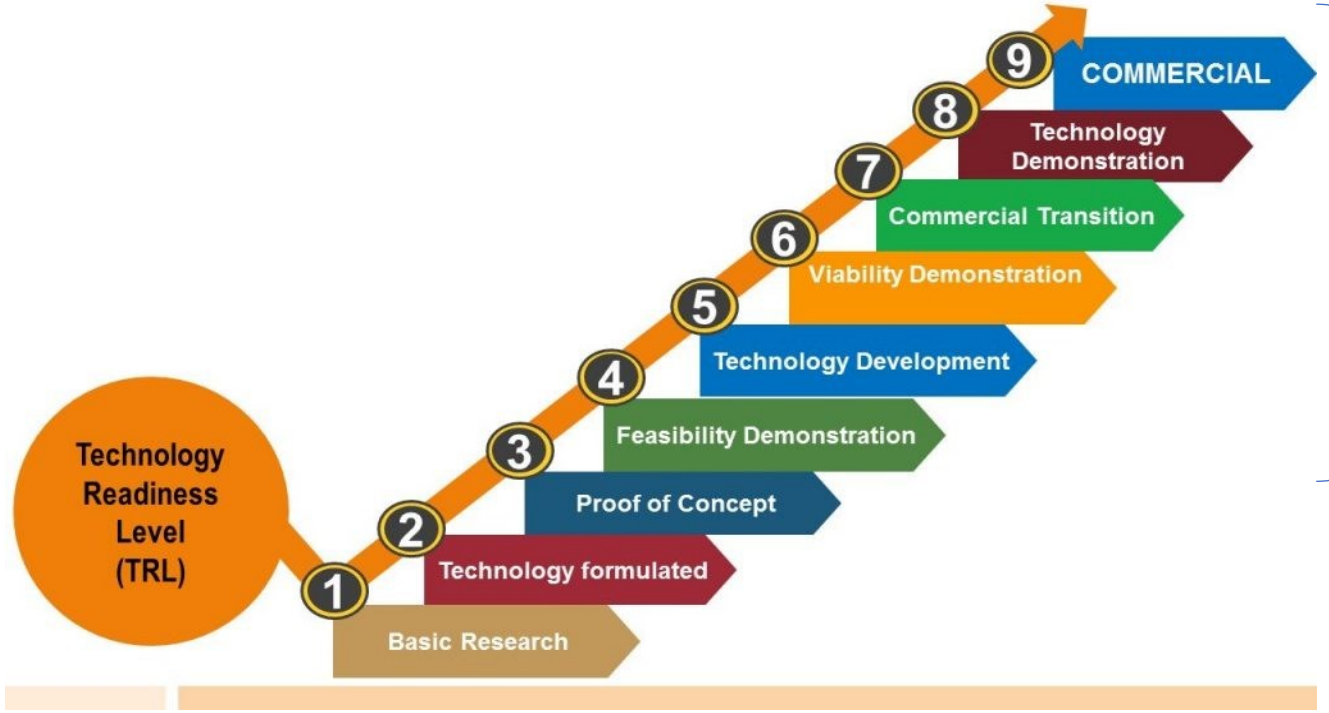
1877 – 1st (steam driven) heat pump …

2023 – Heat pumps allowing steam production

Source : IEA Annex 58

Heat pumps supplying heat over 100°C

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



Range covered in present overview

1/3 in TRL 9

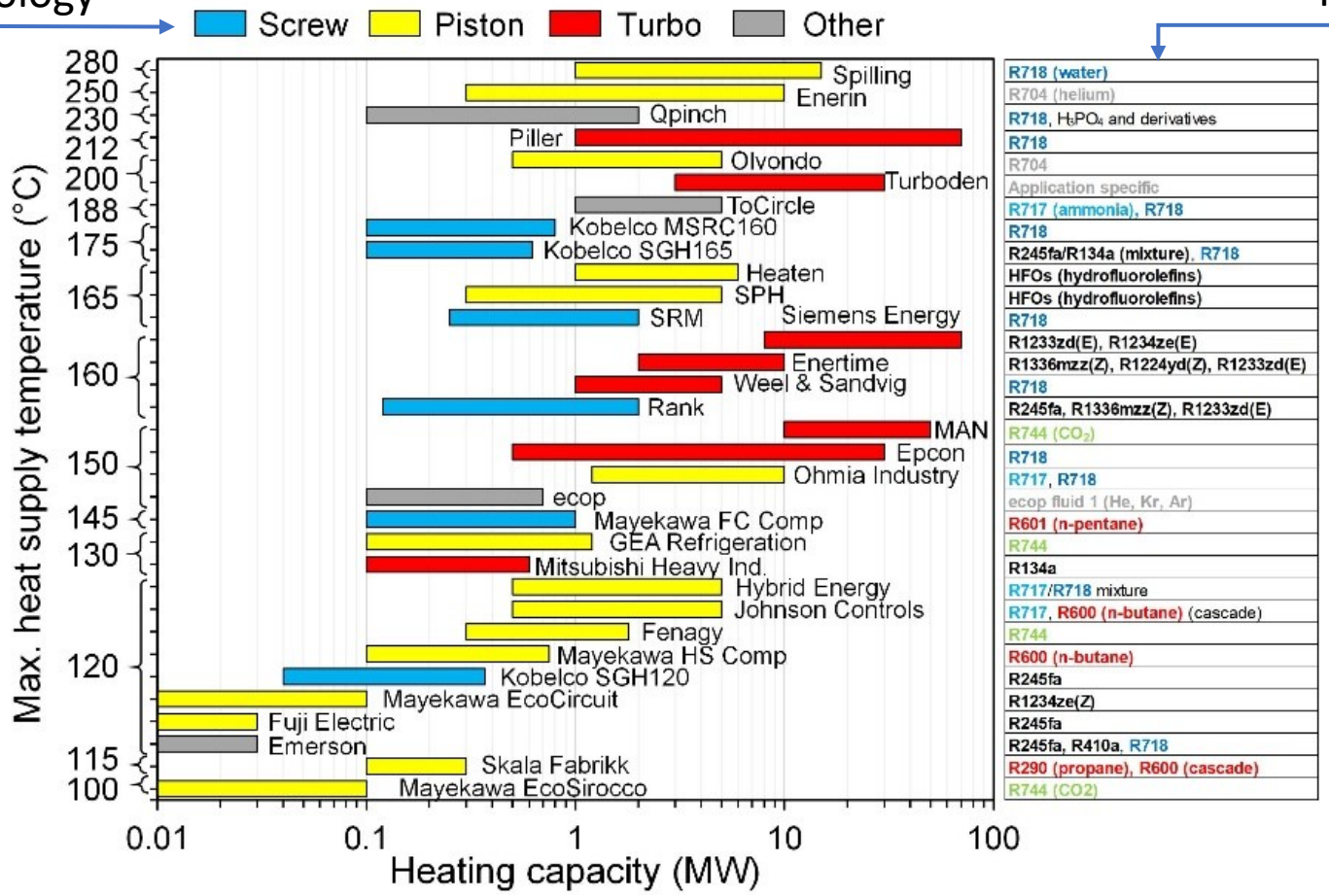
https://mcyportal.mosti.gov.my/

Overview of HTHP technologies

- High temperature achievable ! …from what source ?

Compressor technology

Refrigerant fluid

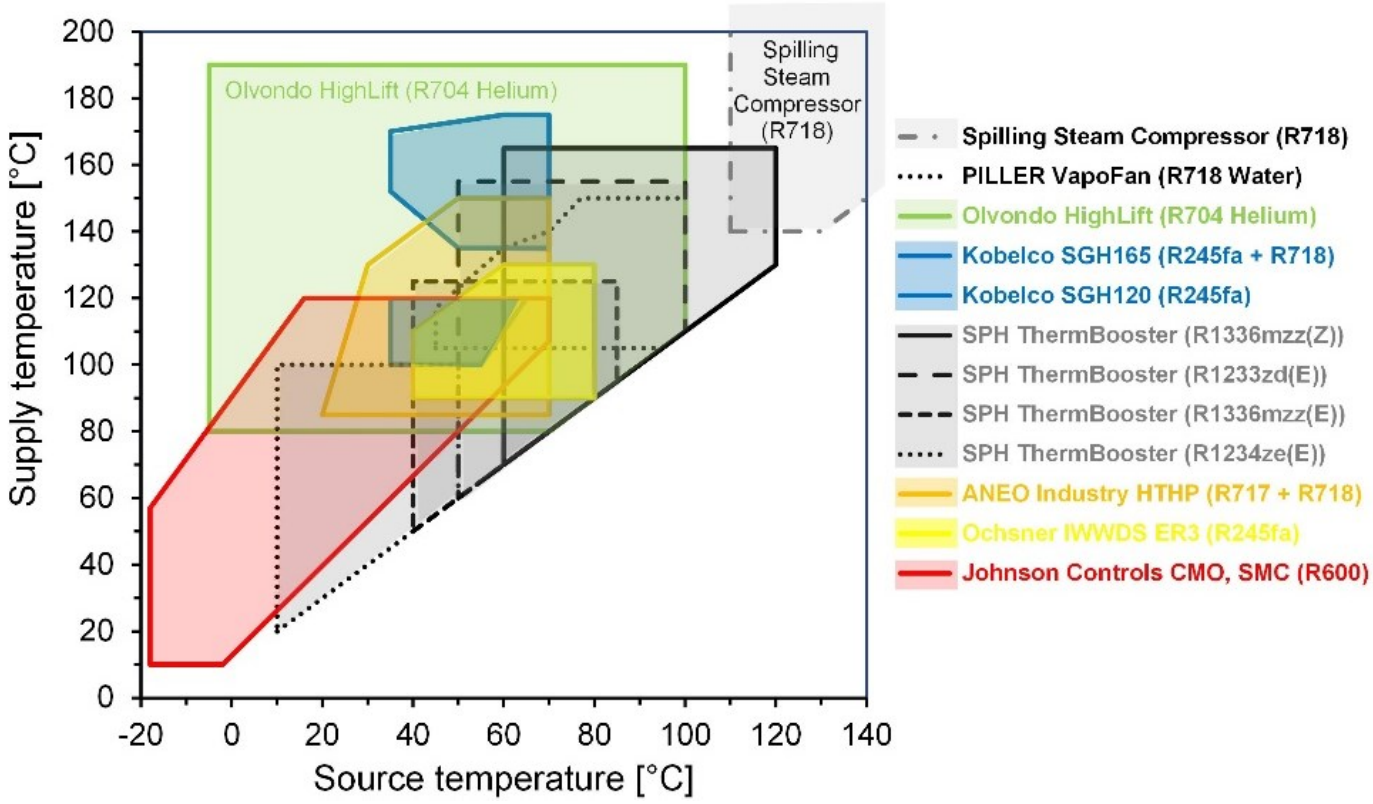


Information provided by technology suppliers without 3rd party validation

IEA Annex 58, Arpagaus et al. 2022

Adequacy between HP and project conditions

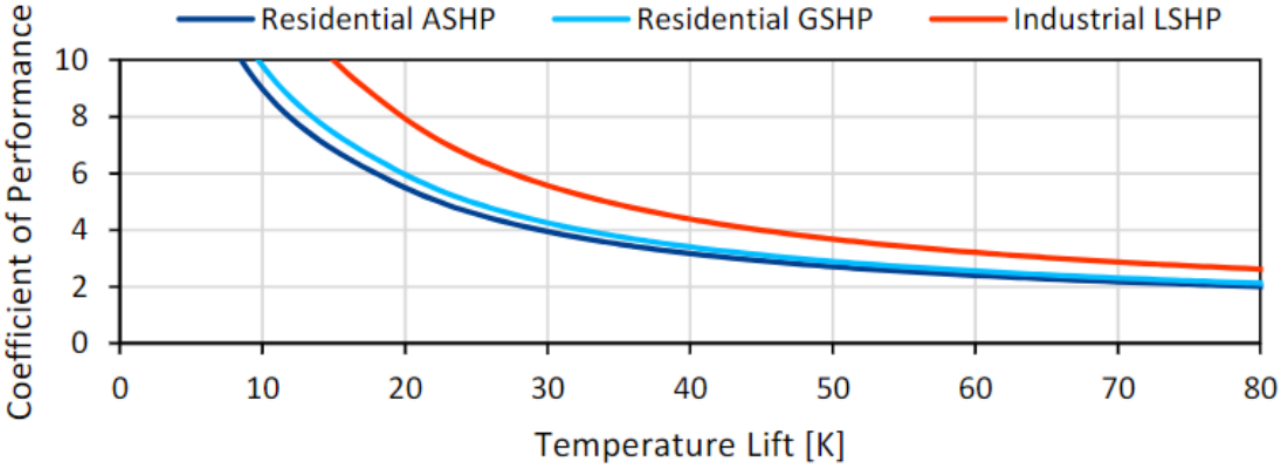
- Operating range = physical limits of the components
- The best heat pump ?



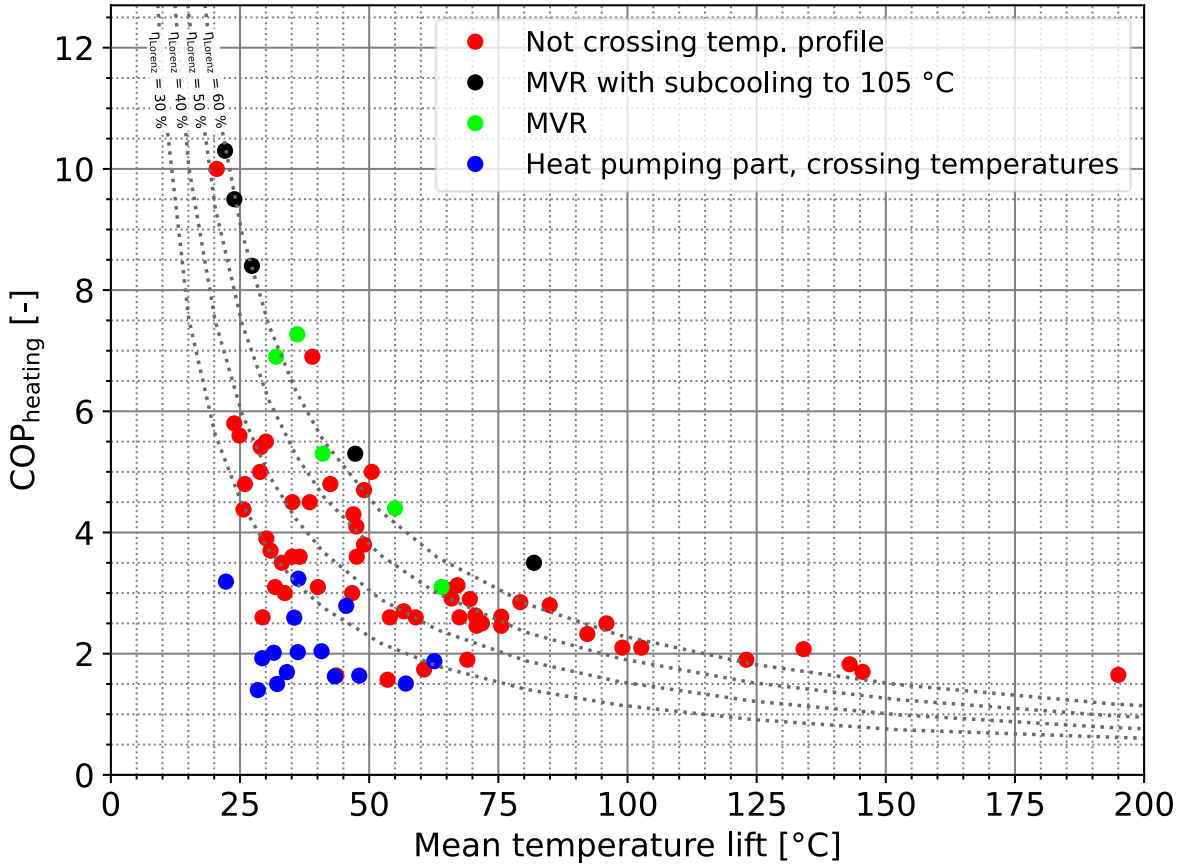
Source : Arpagaus et al. 2023

Overview of HTHP efficiency

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



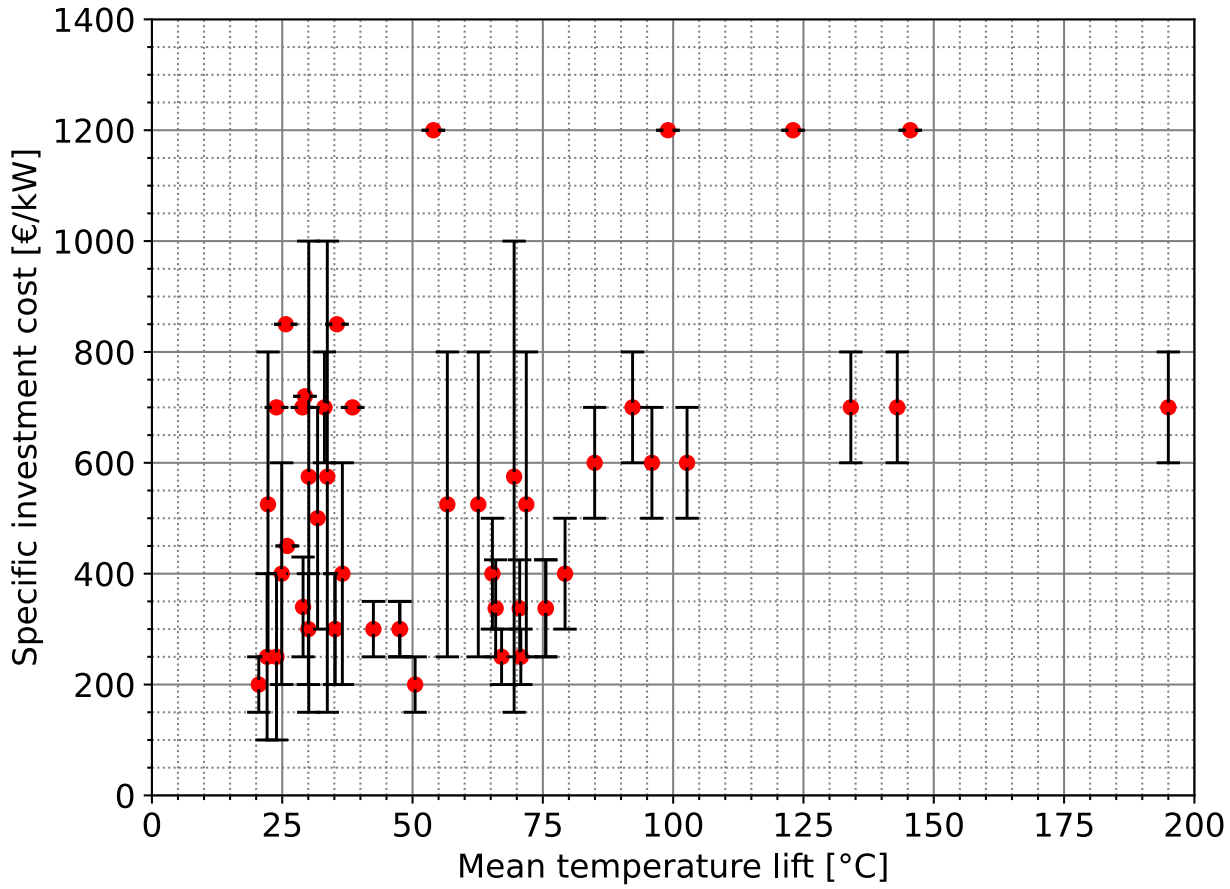
Source : Wolf and IEA Annex 35, 2014



Source : IEA Annex 58, 2022

Specific cost

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



Source : IEA Annex 58

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/

- 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