

Airthium's ultra-high temperature heat pump (commercial name TBD) Airthium

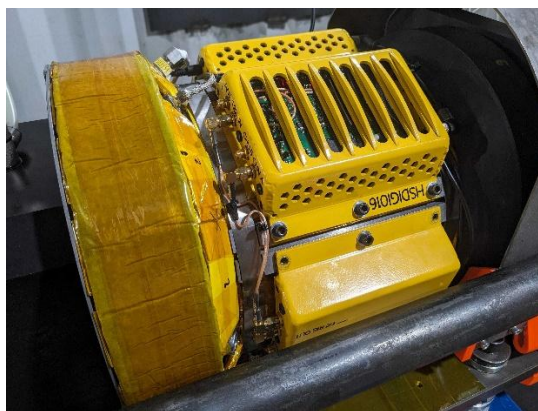


Figure 1: Close-up picture of Airthium's ultra-high temperature heat pump lab-scale demonstrator with onboard DaQ system.

Summary of technology

Airthium's ultra-high temperature heat pump implements the Stirling cycle in a highly innovative design. In this closed, regenerative cycle, the gaseous working fluid is compressed and expanded in a near isothermal fashion, without phase change, by a piston-like mechanism powered by electricity. Standard engine oil is used for lubrication of the drive shaft, without risk of working fluid contamination. Helium or Nitrogen are suitable non-toxic, non-flammable working fluids with zero GWP. The technology is under demonstration at Airthium's laboratory.

A patented concept allows to very efficiently transfer heat to and from the working fluid with an excellent power density. Heat exchangers on the source and sink sides will be off-the-shelf and circulate water-based heat transfer fluids or thermal oil in the heat pump. Heat from the source can be harvested from any medium at any temperature below 200°C thanks to the high lift capabilities of Airthium's heat pump. Heat can be delivered to the sink as steam, hot air, thermal oil, or any other fluid via a standard heat exchanger.

Standard units supplying up to several megawatts of heat will be developed. Calculated performance data is indicated in Table 1 and should be treated as a preliminary, rough estimate.

Airthium's ultra-high temperature heat pump can operate at part load and accommodates high temperature glides on both sink and source sides without major efficiency loss. Alongside temperature flexibility, the heat pump permits flexible operation with very short start-up, shut down and output modulation times (minutes). It is therefore suitable for use alongside thermal storage for energy cost arbitrage, or batch processes.

Table 1: Theoretical Performance.

$T_{\text{source,in}}$ [°C]	$T_{\text{source,out}}$ [°C]	$T_{\text{sink,in}}$ [°C]	$T_{\text{sink,out}}$ [°C]	COP _{heating} [-]
165	145	290	300	2.2 – 2.6
85	65	206	212	2.0 – 2.4
16	12	206	212	1.6 – 2.0
135	115	155	160	3.1 – 3.7

Project example

A customer producing base chemicals requires 32 barg saturated steam for its processes. Waste heat at 90°C is available from one area of the plant in the form of liquid water. The heat pump would operate 8000h per year.

A water/water heat exchanger will be installed on a derivation of the waste water circuit. The heat pump will

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.



provide thermal oil at ~250°C to a steam generator feeding the 32 barg steam distribution network.

The COP of the system is expected to be close to 1.9. Assuming an incumbent gas boiler efficiency of 95%, the energy consumption would therefore decrease by more than 50%.

Assuming an all-included electricity price of 80 €/MWh, a gas price of 35 €/MWh and 100 €/tCO₂ for EU ETS quotas, a levelized cost of heat of 50 €/MWh can be reached with the heat pump, against 58 €/MWh for the natural gas incumbent.

A letter of intent is undergoing revision with this client and should pave the way for a first pilot installation within three years.

FACTS ABOUT THE TECHNOLOGY

Heat supply capacity: 100 to 5000 kW

Supply Temperature, max: 250°C first, then 550°C

Temperature lift, max, per stage: 150 K

Working fluid: Helium (R704) or Nitrogen (R728)

Heat carrier: steam, thermal oil, hot air

Compressor technology: piston

Specific investment cost for installed system without integration: -

TRL level: TRL 4

Operational hours achieved: -

Expected lifetime: 20 years

Size: -

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