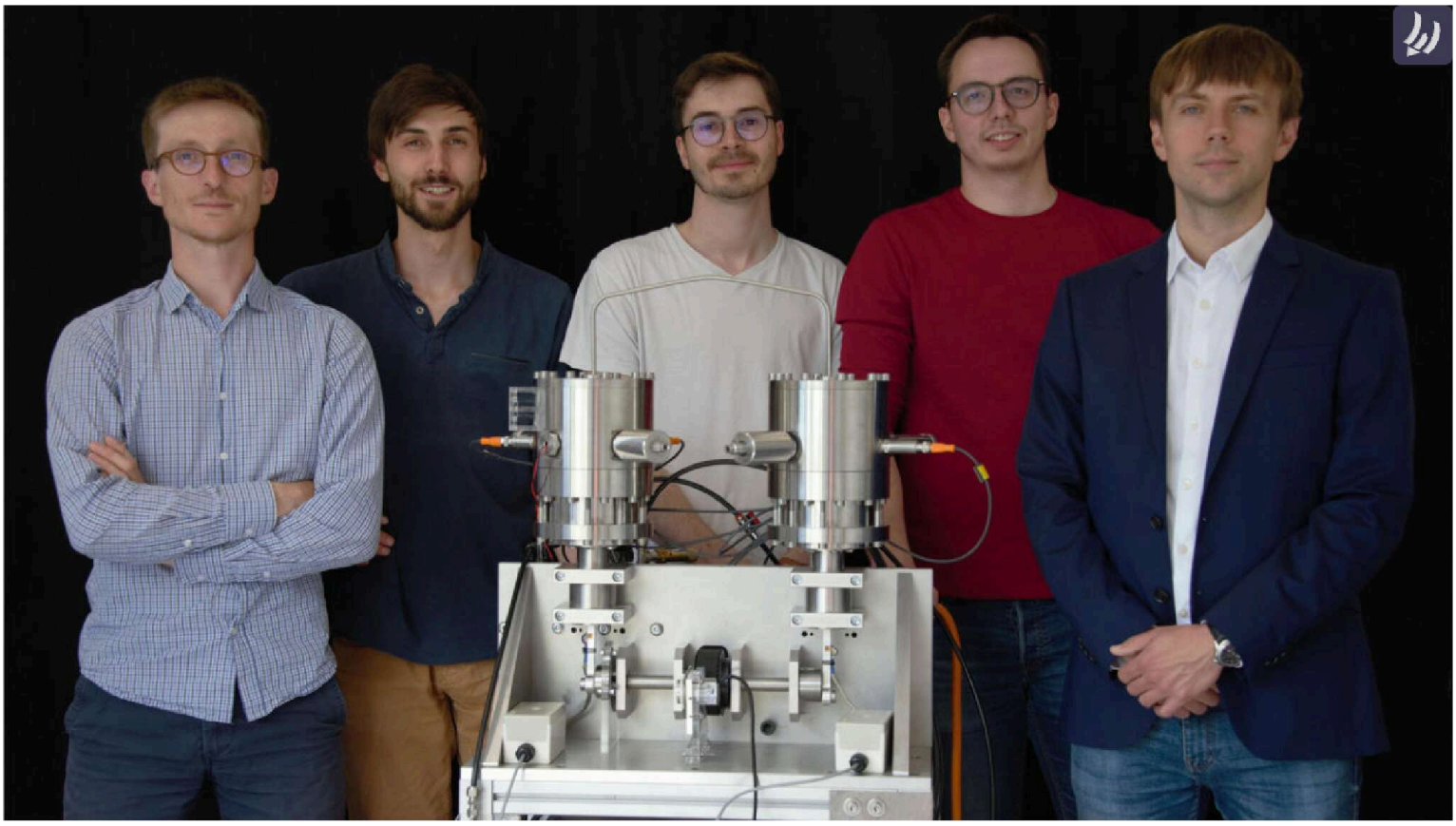

INVEST IN **AIRTHIUM (YC S17)**

A Breakthrough Engine to Outsmart Fossil Fuels

LEAD INVESTOR

Philippe KAVAFYAN Executive Director - Aker Horizons

Airthium's technology is few weeks away from a critical prototype milestone. A successful development of their engine will lead to a massive decarbonization of industrial processes, thanks to what can be considered an innovative High Temperature Heat Pump. Further grid-scale storage applications can be foreseen when converting green ammonia back into power, when reverse operating the engine. One innovation for 2 markets, each with a huge potential to enable the energy transition.

Invested $10,000 this round & $10,000 previously

Learn about Lead Investors

Highlights

1. 🔥 Decarbonizing industrial heat, 3% of worldwide CO2 emissions, with a revolutionary heat engine.

2 ⚡ After 2028: Decarbonizing power generation, 30% of worldwide CO2 emissions, with the same engine

3 🥇 Led by Y Combinator alumni and 6 PhDs; advised by the CEO of GE Renewable Energy

4 🌎 Award-winning clean energy engine delivering record efficiency, low costs & zero carbon emissions

5 💵 Positioned to revolutionize the $13B/yr industrial heat market & $125B/yr seasonal storage market
emissions

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Our Team

Andrei Klochko Co-Founder, CEO & CSO

2017 Y Combinator alum. PhD in Plasma Physics from Ecole Polytechnique. Inventor of the core technology that drives the Airthium heat engine.

We can only impact climate change if we make solar and wind better than fossil fuels in *every* way. The lack of cheap seasonal energy storage, and low-cost green heat, are the last barriers holding renewables back from engulfing the world and stopping CO2 emissions. By unlocking renewables, we are tapping a $138B/year business opportunity.

Franck Lahaye Co-Founder and COO

2017 Y Combinator alum and seasoned entrepreneur. Former EMEA Sales Director at Intelsat, one of the world's largest telecommunications satellite operators. Ran a satellite capacity brokerage company for several years.

Gaétan Lerisson CTO

Former researcher at Swiss Federal Institute of Technology Lausanne. PhD in fluid mechanics from Ecole Polytechnique. Masters in Mechanical Engineering from Ecole Nationale Supérieure de Paris-Saclay.

Houssam Houssein Multiphysics Simulation Engineer

PhD in applied mathematics from Sorbonne Université. Former engineer at STRUSIM. Civil engineering and pure mathematics M2 master degrees from École Centrale Paris and Université Paris-Diderot.

Why Airthium?

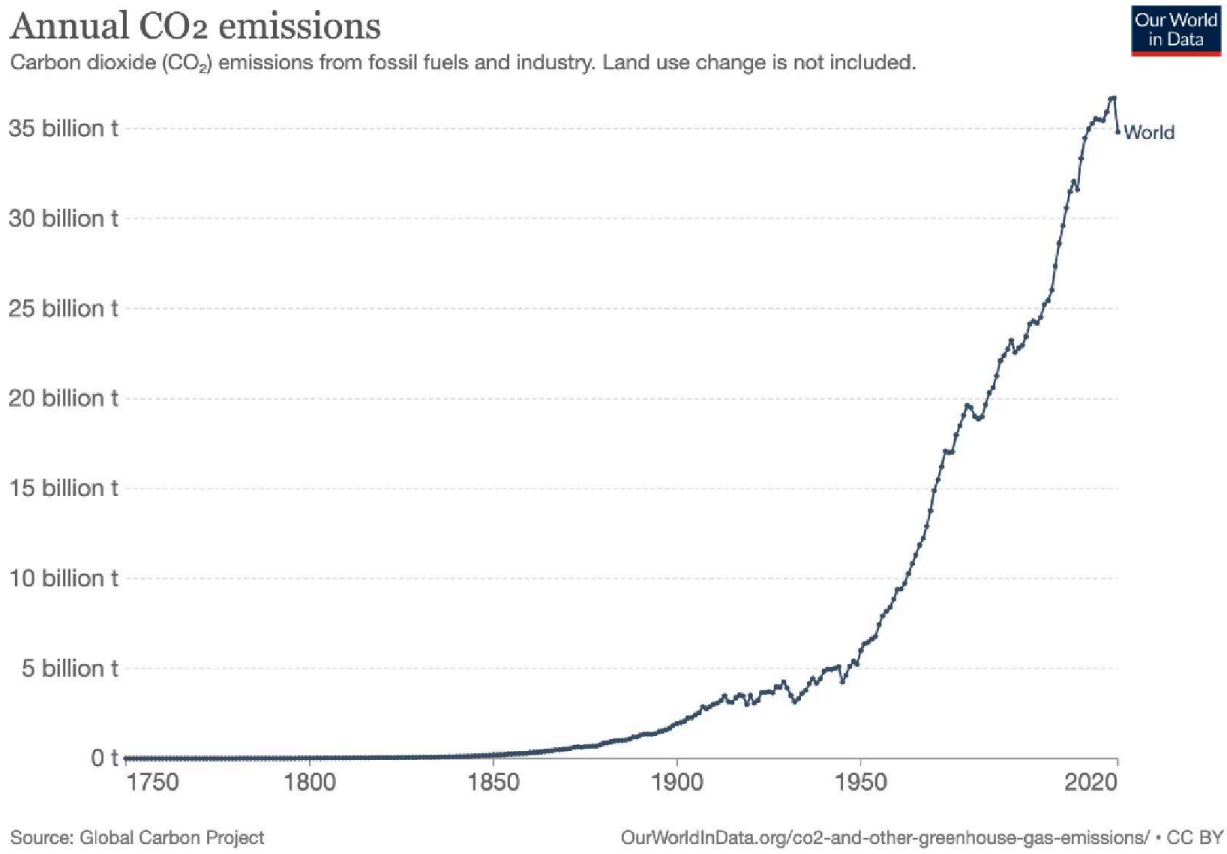
Humanity and our biosphere may become severely damaged in the very near future, if we do not drastically reduce our worldwide CO2 footprint. Airthium brings a solution that can **remove 33% of the world's direct CO2 emissions.** First, we plan to decarbonize **industrial heat between 160 and 500°C (3%)**, and then **electric power generation (30%)**, using the **same breakthrough heat engine.**

This is how electricity and heat are mainly made today: by burning fossil fuels. This picture is a coal-fired co-generation plant. In doing this, we are releasing billions of tons of CO2 into the air, changing the face of our planet

Today's world is addicted to fossil fuels, and it is

reaching its limits

We keep consuming more and more energy every year, and today most of this energy comes from fossil fuels. Consuming so much fossil fuels is already releasing 100 times as much CO2 as Nature has released to the atmosphere every year for millions of years. This is causing catastrophic climate change, and according to experts from the IPCC, this change is on the brink of becoming irreversible.



Electricity and industrial heat cause half of worldwide direct CO2 emissions

Most manufactured products we buy, **including solar panels, wind turbines, and batteries**, are made in large scale factories. Those factories require **electricity**, but they also require huge amounts of **high temperature heat** to function, from 100°C all the way up to 2000°C. Industrial heat is used to melt, dry, separate, react, sterilize, and otherwise process materials, like steel, concrete, glass, paper, and food.

The paper industry is one of the largest consumers of heat between 160°C and 550°C, worldwide.

In today's world, about 50% of direct CO2 emissions originate from electricity and industrial heat generation, because they still rely mainly on burning natural gas or coal. In detail, about **30% of direct CO2 emissions come from electricity generation** for all use cases (not only industry), and **20% come from direct fossil fuel combustion for heat in the industry.**

Currently, there is no cost-effective alternative to decarbonize this electricity and heat. **It is simply cheaper to pollute.**

Oil refineries and industrial facilities in La Marque, Texas

Airthium's breakthrough makes low-cost clean electricity and heat a reality

Our engine converts electricity to heat, and heat to electricity, at very high temperatures of up to **550°C**. It does so with record efficiency, low cost, very low maintenance and zero carbon emissions. This is a total game changer, both for industrial heat, and for electric power generation.

We currently have a room temperature prototype, and are building the first 550°C (1022 °F) prototype for 2023

1. Our beachhead market: clean industrial heat at scale

Our first application is industrial heat between 160 and 550°C. Industrial users

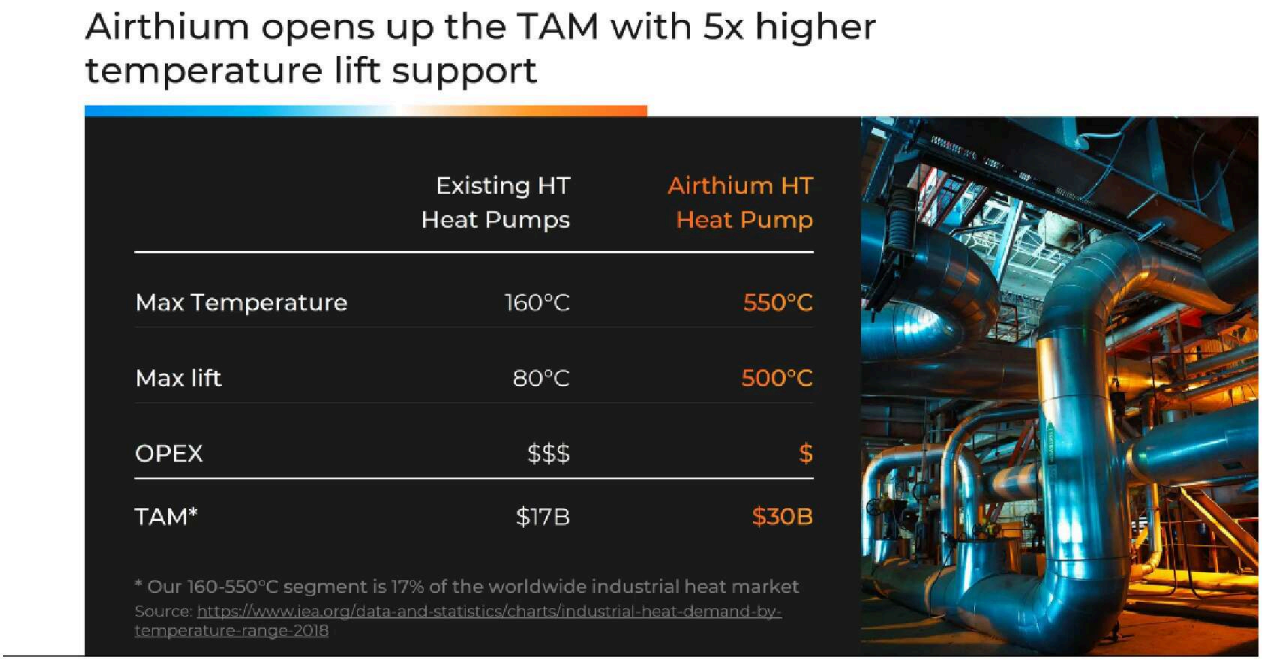
Our first application is industrial heat between 100 and 550°C. Industrial users need an efficient heat-generating engine that can produce high temperatures — hot enough to generate steam or to dry materials. However, today's technology requires them to burn natural gas or coal, or to run large amounts of electricity through a resistor — electricity which, today, is typically also made from fossil fuels. None of these processes are environmentally friendly or sustainable, since they release huge amounts of CO2.

Gas-fired industrial steam boilers release lots of CO2 when they operate. By replacing those boilers with Airthium heat-pump-based boilers, industrial users will meet their low-emission targets, and even save money in most geographies.

Enter Airthium's revolutionary heat pump, a reverse heat engine that can produce temperatures far higher than any comparable technology on the market today—without relying on fossil fuels. **Our heat pump can generate up to 3 times as much heat as a resistor, using the same amount of electricity.**

Heat pumps can make clean industrial heat cheaper than natural gas. Data from 2019 Wholesale US energy prices

If this electricity is made from renewable resources, then our heat pump makes **100% green heat that is cheaper than fossil heat**, even at high temperatures. Even if the electricity is made from fossil fuels, then we are still using up to 3 times less electricity for the same heat demand, strongly reducing CO2 emissions. Finally, as electricity becomes more and more renewable each year with the deployment of solar and wind, so too does industrial heat, for factories which invested in heat pumps. Our heat pump currently has **no established competitors** in its **160-550°C segment**, which represents **3% of all worldwide CO2 emissions**. It is also a **$13B market**.



Our TAM (total addressable market) is extended by $13B compared to existing heat pumps. We have no established competitors on those $13B, because we reach much higher temperatures than existing heat pumps

temperatures than existing heat pumps

We identified the sectors of **paper, food & beverage, chemicals, and automotive** as having the most need for heat in the 160-550°C segment. We're currently conducting feasibility studies with several industrial prospects in those sectors, so that we can adapt our technology to their needs. This will allow us to zero in on the highest value applications, and get our first paying customers.

The food industry uses gigawatts of steam to dry products. We plan to use our heat pumps to electrify and decarbonize cost-effectively such dryers, like the steam dryer pictured here (Credit: Dupps)

Decarbonizing industrial heat is already a great opportunity. However, our vision goes further. We designed our engine so that it can also decarbonize electric power generation itself.

2. Our long-term market: 100% clean electric power at scale

Our second application, after 2028, is fully renewable power generation at scale. Solar and wind energy are the cheapest sources of energy in most parts of the world, and they are fully renewable. However, they can dwindle to 50 or even 30% of their typical yield for weeks at a time, during so-called "renewable droughts", because of weather conditions. Such droughts consistently happen for a few weeks every year in most geographies. Because of that, **solar and wind alone cannot provide continuous, reliable power.**

Cloudy weather with no wind regularly lasts for weeks in most parts of the world. Until we can store energy over very long durations, solar and wind won't be able to provide 24/365 reliable power

This is why, today, polluting coal-fired and gas-fired power plants are needed to provide **backup electric power for sufficiently long durations** in case of bad weather. As an example, the U.S. can power most of their electrical grid for **4 months** straight using strategic natural gas reserves. However, this reliability comes at a cost: fossil-fired power generation is currently responsible for **30% of direct CO2 emissions worldwide**.

Natural gas can be stored in liquid form, in bulk, at -161°C for shipping, like in this LNG (Liquefied Natural Gas) terminal

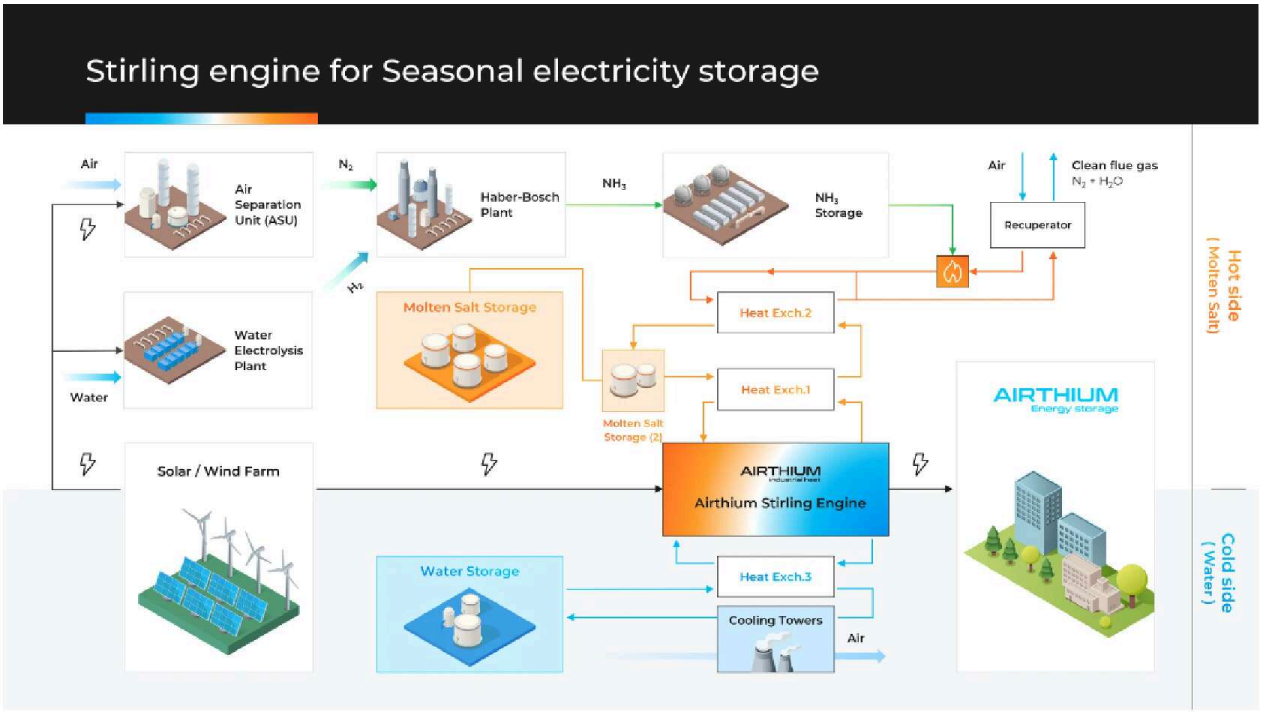
One of the only alternatives to fossil-fired backup power is clean energy storage, like lithium-ion batteries. The problem with existing batteries is that they can only provide power for a few hours until they are depleted. Until batteries can achieve the same storage duration as natural gas cost-effectively, clean energy sources will never replace power plants that are fueled by natural gas.

Today's alternative to fossil fuels, which can be sited anywhere, are lithium-ion batteries. However, they only provide backup power for a few hours, whereas thousands of hours (months) are needed for a stable electric grid without fossil fuels

This is where our vision comes into play. The engine we designed to decarbonize industrial heat can also decarbonize electric power generation, by solving the clean reliable backup power problem.

Indeed, it is possible to build a seasonal energy storage system that uses our

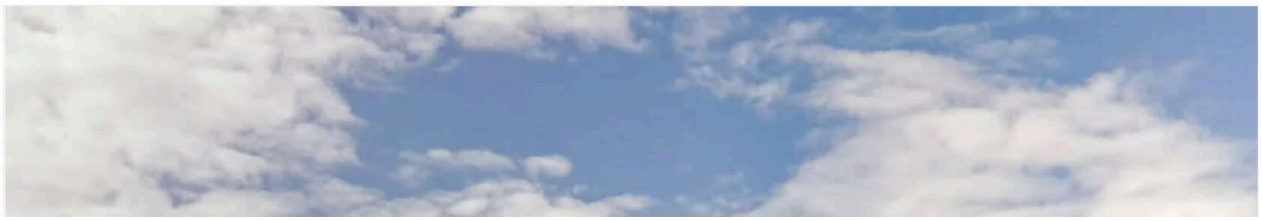
engine as its centerpiece. Our “battery” uses a combination of CO2-free synthetic ammonia combustion and pumped heat energy storage (PHES) in molten salt or sand. This architecture allows us to achieve a storage capital cost that is 100x lower than lithium-ion batteries, at $2/kWh, and thousands of hours of storage duration, enough to fully replace fossil fuels as backup power.



Airthium's Seasonal electricity storage system. This is our long term vision: a power plant just as dependable as natural gas, 100% renewable, without CO2, without CO2 capture, without geopolitical constraints, all of that at low cost.

By deploying this low-cost seasonal storage near large-scale solar and wind farms, developers will save on transmission costs, which typically represent 25 to 50% of the capital cost of large renewable farms. Then, by generalizing this solution of renewables + seasonal storage, no more fossil-fired backup power will be needed in most parts of the world, thereby eliminating the majority of today’s 30% of worldwide CO2 emissions produced by fossil-fired backup power.

Seasonal energy storage is a **$125B/year market.**



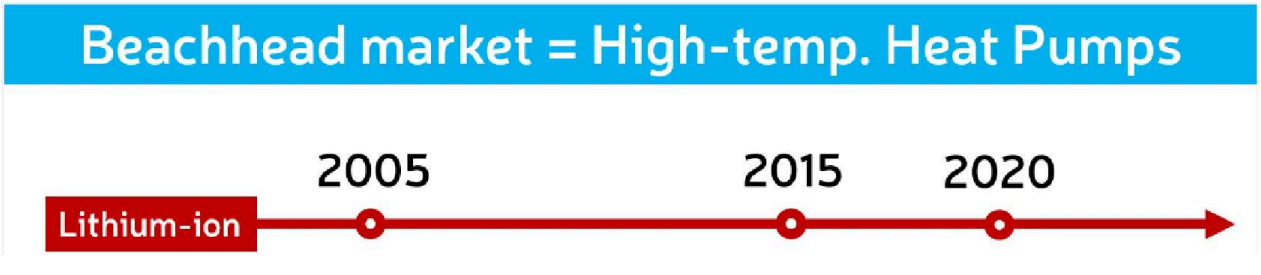
The core of our battery: a large scale liquid ammonia tank. Credit: TIW Steel Platework Inc.

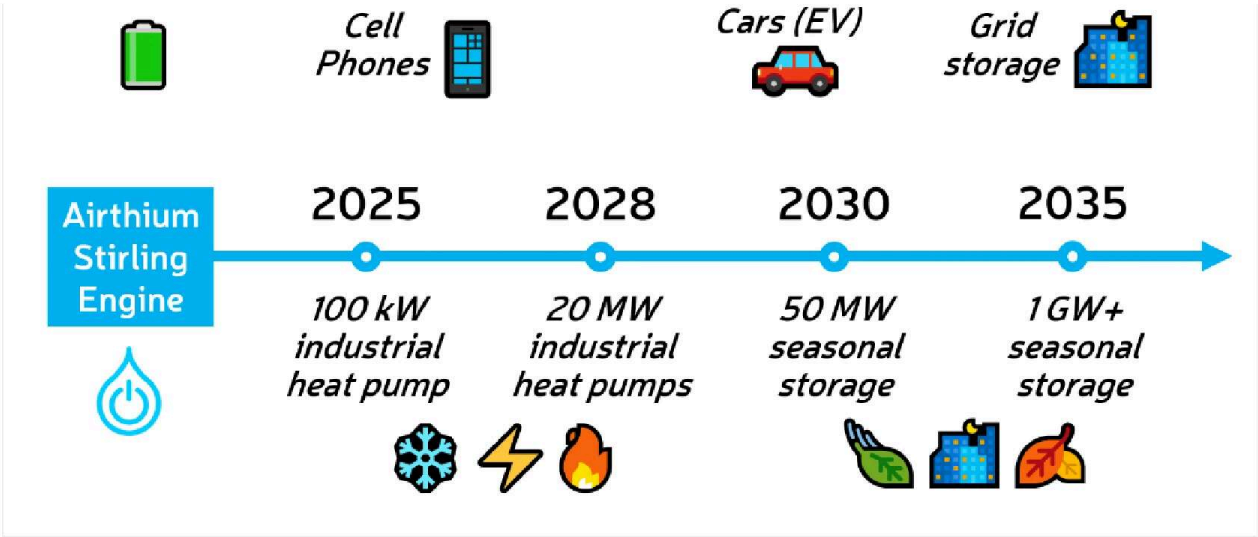
Airthium has a clear path to commercialization

Both our seasonal battery, and our industrial heat pumps, rely on the same breakthrough, proprietary heat engine at their core. This is no accident: it is our go to market strategy.

First, we plan to sell our heat engine to OEMs who will use it as a heat pump, to build **cost-effective electric boilers, dryers and furnaces** to replace their gas-fired equivalents. Then, once our **unit costs are lower and our reliability is proven**, we will sell the **same engines** to renewable energy project developers. Those developers will use our engines to power **seasonal energy storage systems** based on pumped heat electricity storage, and synthetic ammonia combustion.

We are not the first to use this strategy. From 2000 to 2020, Lithium-ion batteries followed a similar path to profitability and scale: they first powered cell phones, then cars, and only then, the electrical grid. Many emerging energy storage solutions failed because they did not have such a step-by-step path to large scale commercialization. But we do.

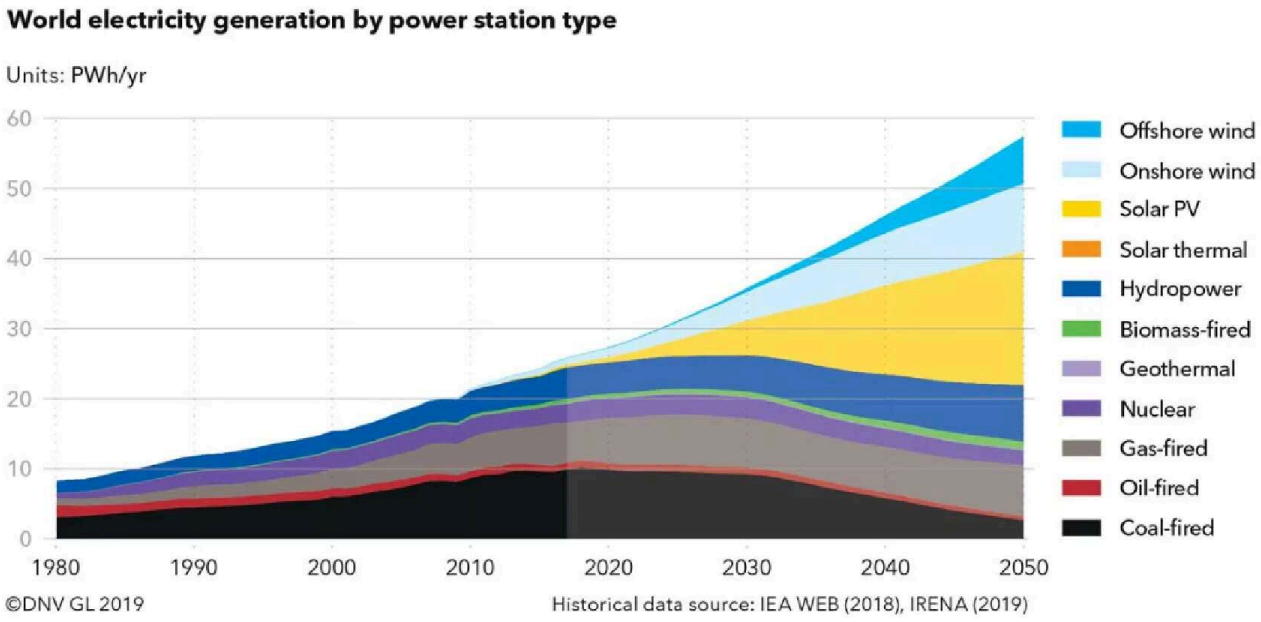




We plan to first sell our Stirling as a high temperature industrial heat pump, then scale up our operations and reduce costs, then sell our engine as the centerpiece of a seasonal energy storage system. Lithium-ion did the same in its time to industrialize profitably. The above dates and milestones for Airthium are forward-looking projections and cannot be guaranteed.

This is the solution to the climate crisis we've been waiting for

With these ubiquitous applications of heat pumps and energy storage, we can make both medium-temperature industrial heat and power generation 100% clean — all with a single proprietary heat engine. Combined, these opportunities can eliminate one third of worldwide CO2 emissions—enough to change the fate of our climate.



If all goes well, by 2050 solar and wind will become the major electricity source, despite the

large rise in electricity generation caused by electrification (vehicles, heat, etc). Airthium provides a solution to replace natural gas and coal in this picture. This is a forward-looking projection, and not guaranteed

We're a winning team of scientists and entrepreneurs

Making this vision a reality will require a great deal of brain power and support from established industry players and institutions. And that's exactly what we have. Our all-star team includes 6 PhDs in physics, applied mathematics, and thermodynamics. Alongside our world-class advisors, we have what it takes to create breakthrough innovations and bring them to market.

The Airthium Team in our French facility, except Franck (US) and Charles (Belgium)

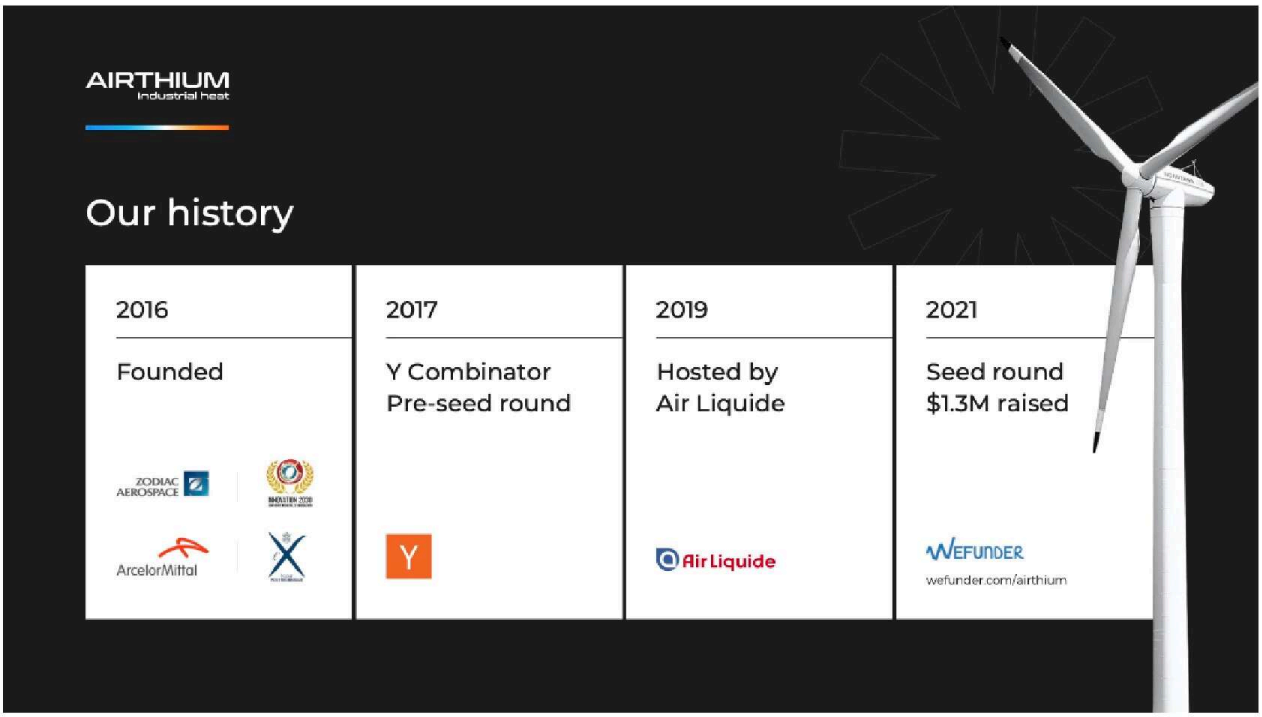
Our engine has been 5 years in the making and is ready to be patented.

Since we went through Y Combinator in 2017, it took us several attempts to find a theoretical path beyond the 62% Carnot efficiency (state of the art) toward 86%, all the while reducing costs by up to 3x. No one has done it in 200 years, and we're well on our way to make 86% a reality!

We currently have a room temperature prototype. Now, we're building the first

550°C (1022 °F) prototype, set to be completed in 2023.

Our work has won several national awards, including the Prix Gérondeau by Zodiac Aerospace, Prix des Innovateurs by ArcelorMittal, and the Concours Mondial de l'Innovation. We're now raising capital to bring our heat engine to market and to close deals with leading industrial companies.



A tremendous global market awaits

By capitalizing on the $13B global heat pump market in the near term, we can deploy our engine in the field and accumulate millions of operating hours. This will lower our unit costs, thereby allowing us to build the capabilities and scale needed to deliver seasonal energy storage batteries for the grid—a $125B market on its own.

As an Airthium investor, you're backing technology that actually has what it takes to curb climate change. Our engine makes renewable energy better than fossil fuels in every way. Renewable energy was already cleaner—and now it will also be cheaper, more reliable, and just as flexible and universal as fossil fuels used to be.

What if solar and wind farms provided all of our electricity?

Don't let future generations suffer when we can act today

We can tackle climate change now by making fully renewable power cheaper at scale through engineering innovation and business strategy. The planet simply can't afford to wait.