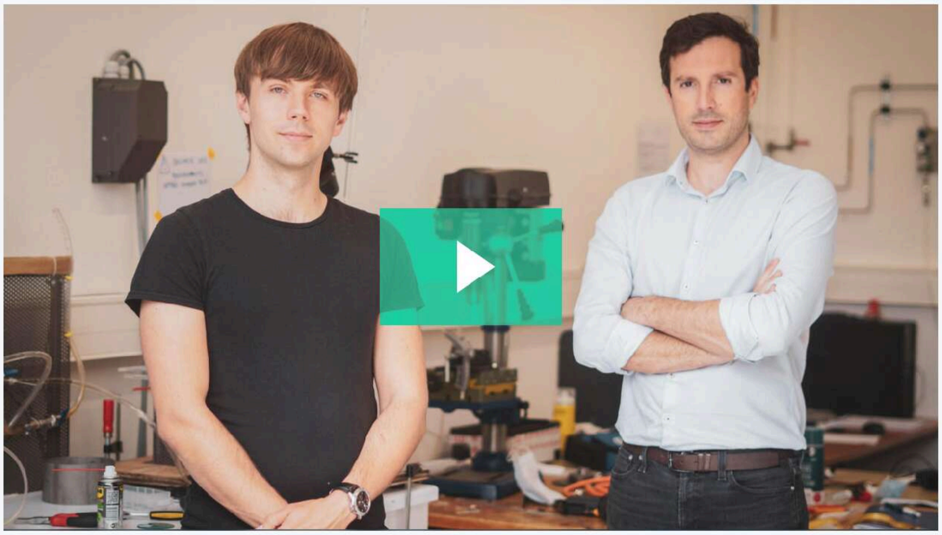
Airthium

100x cheaper battery to stop Climate Change



AIRTHIUM.COM WILMINGTON DE

Infrastructure | Hardware | Technology | Y Combinator | Energy

Why you may want to support us...

1. $50B/year Total Addressable Market
2. The world needs 2.4 PWh (2.4 million GWh) of storage by 2050
3. Most of those 2.4 PWh require batteries that are 100x cheaper than today
4. We are building the only 100x cheaper battery that can scale
5. Y Combinator alum, $500k raised, 2 PhDs from top French unis

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Our team

Andrei Klochko
CEO and cofounder
PhD in plasma physics from Ecole Polytechnique (French top 2 uni), researched the science behind Airthium for 5 years. Went through Y Combinator with Franck in 2017.

Franck Lahaye
COO and cofounder
Ex-EMEA Sales director at Intelsat, one of the world's largest

telecommunications satellite operator, he then ran his own satellite capacity brokerage company for several years

In the news

7 Startups From Y Combinator That Show The Future Of Cleantech

Autonomous Vehicles By Jonny Tiernan The recent Y Combinator batch of 50 startups was exactly what you would expect - a collection of some of the most innovative and

August 25, 2017 @ cleantechnica.com

We are enabling our world to live on solar and wind energy alone. And it's cheaper than all fossil fuels.

A 100% renewable energy world used to be impossible. We designed a long-duration battery that is so cheap that it makes 100% renewables cheaper than coal, gas, and nuclear. Our team with 2 PhDs raised a $500K pre-seed from Y Combinator, DCVC, and more.

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

🔋 Our battery can store 100x more energy for the same cost.

Lithium-ion batteries are the only storage system that can be deployed

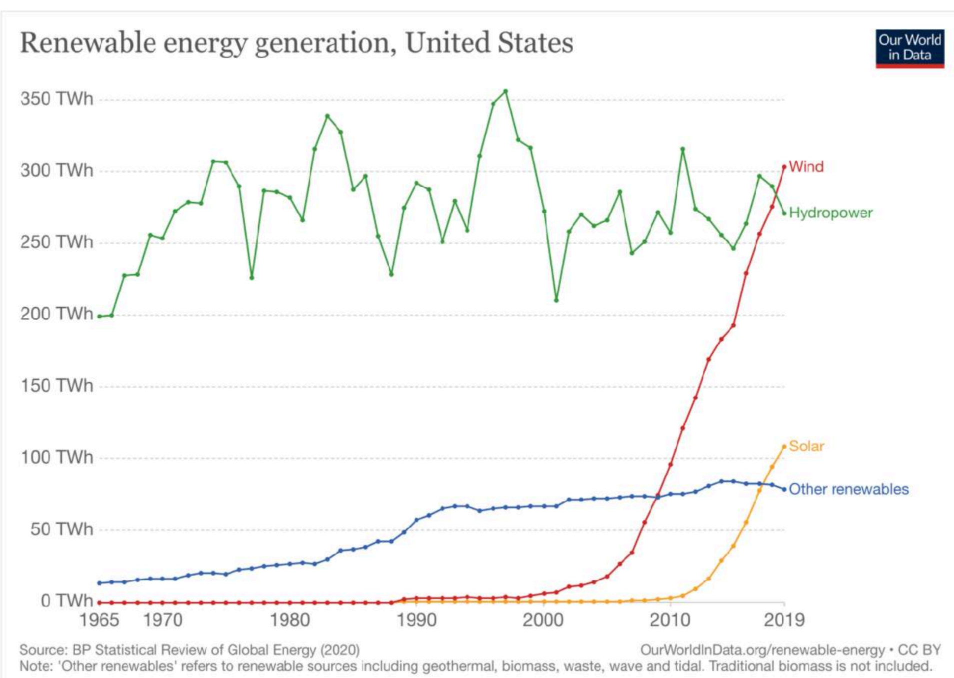
Lithium-ion batteries are the only storage system that can be deployed economically anywhere today. They can store solar and wind energy, but they are limited and expensive — at $200/kWh, it only takes a few hours of discharge to deplete a lithium-ion battery.

Once depleted, recharging isn't always possible as it's not always sunny nor windy. Sometimes, such "droughts" can last weeks, or hundreds of hours. That's why we made a battery that can store 100x more energy for the same cost, at $2/kWh.

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

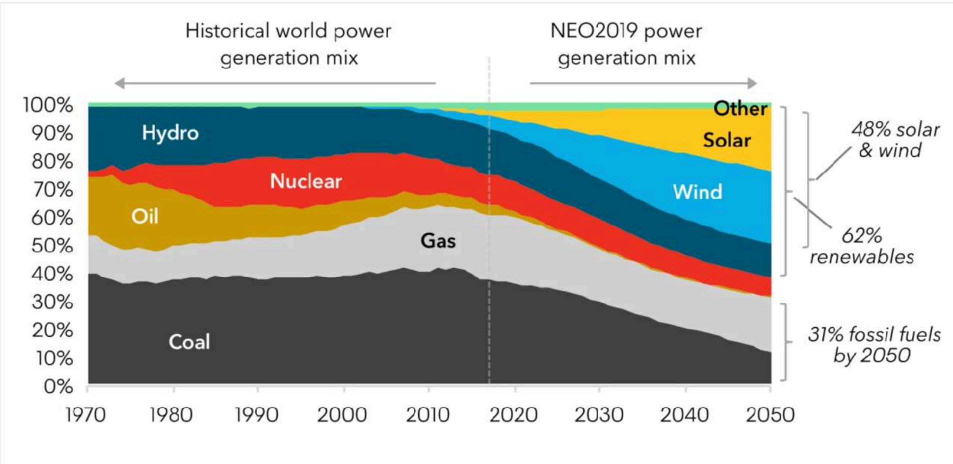
☀️ We are on track to be first in the world to provide affordable, guaranteed 24/7 renewables.

As the demand for renewable electricity surges, so too does the demand for cheap, safe, and sustainable storage. Whereas lithium-ion can only store and deliver *sometimes*, we *guarantee* the availability of renewable energy 24/7, and enable fossil plants to fully retire.



💰 This is a $50B/year market — and we're still 5 years ahead.

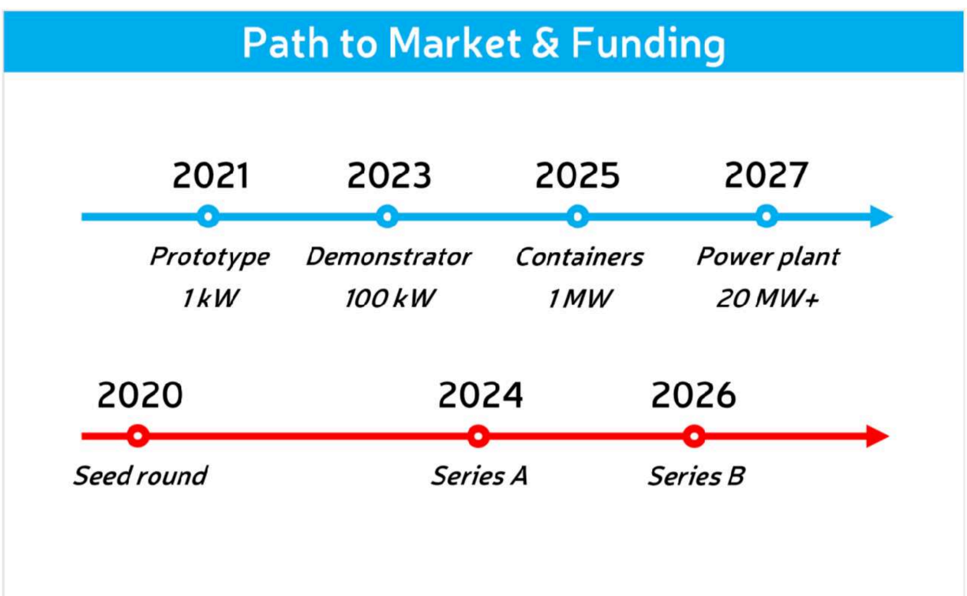
Solar and wind will actually grow so much in the next 30 years, they will supply almost half of our worldwide electricity demand. By then, seasonal storage will become a major, unavoidable player in our electrical grid. Until then, we estimate (yet cannot guarantee) that the world's utilities will spend $50B/year building it from zero. That is our market.



Global electricity generation share by source - history and projection to 2050 (Source: Bloomberg New Energy Finance, New Energy Outlook 2019). Note: this is a forward-looking projection and not guaranteed

💪 3 years in development and a world-class team.

Our work has received several national awards, including the Prix Gerondeau by Zodiac Aerospace, Prix des innovateurs by ArcelorMittal, and the Concours Mondial de l'Innovation. We went through Y Combinator in 2017 and confirmed the patentability of our system in early 2020.



This is how we plan to get to market. Note: this is a forward looking projection and not guaranteed

The Airthium team (YC S17) has won numerous grants and prizes

🌎Help us heal our planet — before it's too late!

We humans are stewards of the Earth, yet we are covering it in all kinds of pollutants, from plastics to CO_2. This cannot be undone unless clean energy and recycling (powered by it) become cheaper than fossil fuels and landfilling. Our battery is instrumental in reaching this goal, and time is running out. Help us heal the Earth faster than it is destroyed!

The Airthium team. Left to right: Houssam, Lea, Franck, Simon, and Andrei

Investor Q&A

– COLLAPSE ALL

What does your company do?

We make a battery that never runs out of solar and wind energy, ever. It is cheap enough to make renewables cheaper than coal, gas, and nuclear year-long. With our battery, we believe we can build a 100% renewable world, and give people cheaper electricity in the process.

Where will your company be in 5 years?

We hope to be shipping megawatt-scale batteries to solar and wind projects all around the world, and gearing up for utility-scale power plants.

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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 is the last thing holding renewables back from engulfing the world and stopping CO_2 emissions. By unlocking renewables, we are tapping a $50B/year business opportunity.

How far along are you? What's your biggest obstacle?

We have successfully tested a prototype of one crucial part of the system, the compression head of the Stirling engine. The Stirling engine is what converts electricity into heat, and heat into electricity, so it is the central and most expensive part of the battery. Nailing down its performance is paramount before building the whole battery, and seeing the compression head perform as planned recently removed the biggest technical unknown that was in our way. The second biggest obstacle that remains is time: the engineering work involved in building the battery takes time, but so does the testing that is required to sell a new energy hardware system on the market.

Who competes with you? What do you understand that they don't?

Building seasonal storage is hard because it has to be abysmally cheap to make sense economically: 100x cheaper than lithium-ion is today, or about $2/kWh. Only renewable liquid synthetic fuels (detailed in another question below) can achieve such low cost. Beyond side projects from large energy hardware companies, no one has tried this. What we do that they don't, is that we found a way to seamlessly complement renewable synthetic fuels with very cheap "middle"-duration storage (10-40 hours) in molten salt, and use it to decrease the total cost of the supplied electricity by discharging seasonal storage less often in a typical year. Airthium's hybrid storage design is what will make 100% renewables with seasonal storage cheaper than fossil fuels.

How will you make money?

At first, we intend to sell our energy storage systems outright through renewable energy project developers, to solar and wind farm owners. Once enough systems have operated in the field for enough years, we will be able to secure financing to start a leasing business, and capitalize on the very long lifetime (up to 40 years) of our storage assets, to generate stable, long-term profits.

What are the biggest risks? If you fail, what would be the reason? What has to go right for you to succeed?

Like in most "tough tech" startups, many things could go wrong, and this is part of the game, or we would already be valued much more. The industrialization phase could prove challenging, despite deliberately choosing technical blocks that are backed by existing suppliers whenever possible; or, some new tech could come along and change everything with impossibly low prices. Our typical "nemesis" scenario is if an existing engine manufacturer finds a way to build an even cheaper high-performance NH_3-fired generator, and at the same time, second life lithium-ion batteries reach prices several times lower than predicted in currently accepted scenarios.

Why is this a good idea, right now? What changed in the world? Why wasn't this done a few years ago?

A few years ago, storage did not have a market, let alone seasonal storage. 12 years from now, lithium-ion will be extremely cheap and engine developers will have caught on with synthetic fuels, if only for the ocean freight propulsion business. But right now, we can get to market fast enough (on the energy generation asset time scale), and grow to a market size where our other systemic advantages will show (economies of scale, integration with various green industrial/chemical/recycling processes including H2-fueled steel mills, and vertical integration of our manufacturing).

What do you need the most help with?

What would help us the most is to accelerate our current recruitment of a stellar-level VP of engineering, and an industrialization expert. The candidates should have led teams who brought to market complex mechanical systems, and laid out actual industrialization road maps to reach very low unit costs as fast as possible.

What would you do with the money you raise?

Regarding the overall goal, we will use the proceeds from this crowdfunding round to build a 100 kW demonstrator, and test it in the field at a customer site. Once we reach this milestone, we will become eligible to funding from conventional cleantech VCs, reach market, and execute on our long term vision of impacting climate change.

To achieve this, we plan to expand our team with the two technical and management roles mentioned above, a few support roles including technicians, and several engineers in design, development and testing. Beyond this, we will buy heavy machining equipment to iterate faster, buy the parts and consumables for our next prototypes, launch a research contract with an academic lab we have identified to refine the cost of a core part of our system, lease larger lab/workshop space, and enlist the help of external consultants where recruitment would not be the best/fastest option.

What are synthetic fuels and which one are you using?

Renewable synthetic fuels are fuels that are made from electricity and net zero carbon resources. We use “green” ammonia as our renewable synthetic fuel. Ammonia can either be made in a clean (environmentally friendly) or non-clean way (like it is made today by large industrial corporations); we use the clean way. The clean way, also called the electric Haber Bosch process, makes ammonia from water, air, and renewable electricity. When ammonia burns in our Stirling engine, it releases nitrogen, water, and trace amount of nitric oxide and nitrogen dioxide (NOx) back into the air. Nitrogen is 80% of the natural air we breathe; NOx levels will be low enough so that total emissions from the entire world running on our storage technology will be much lower than natural NOx emissions caused by, e.g., lightning. Hence, the clean way is a closed cycle that does not harm the environment.

The non-clean way, however, also called conventional Haber Bosch, produces ammonia from air and natural gas. In that case, the process releases a lot of CO_2, which is why we do not use that process.

In other words, it is the way that the fuel is made that determines whether it is a renewable synthetic fuel or not.

There are other possible renewable synthetic fuels: hydrogen, methanol, and even

There are other possible renewable synthetic fuels: hydrogen, methanol, and even methane can be made in a renewable way. Hydrogen is a promising fuel (and a building block for renewable ammonia), but it is difficult to store at large scale and low cost. Methanol and methane require CO_2 captured from industrial processes as a building block to be built; as a result, CO_2 is released back when they burn, and then it has to be captured again. CO_2 capture is an additional burden that comes at a cost. By having no CO_2 at all in ammonia (since it does not contain any carbon), we make our storage cheaper.

What differentiates your ammonia engine from competitors?

We are the only company developing a high-efficiency ammonia-fired Stirling engine on the market. All existing competitors use two- or four-stroke engines (i.e. "Diesel"-type Otto cycle engines), or gas turbines instead. Both of those options are internal combustion engines, meaning ammonia is burned inside the heat engine. The problem with such an approach, is that the design engineer has very little room to adjust the conditions under which ammonia is burned: pressure and temperature are dictated by the engine requirements.

Ammonia, however, does not burn easily, and can create very large amounts (over 1000 ppmv) of NO_x (NO, NO_2) if the burner is not designed right. If this happens, the designer will have to use large (and expensive) SCR (Selective Catalytic Reduction) systems to eliminate those NO_x from the exhaust.

In our case, since we have a Stirling engine, we can tailor the burner to the best possible combustion conditions. It has already been documented that in this case, emission levels as low as 47 ppmv (20x less than competitors) can be reached, without even resorting to SCR. A small SCR can then take this level further down to 10 ppm or below to always meet regulatory requirements. This means we save a lot on the SCR cost, and have the best chances to have the cheapest, highest performance engine on the market.

It seems your first press dates back from 2015. What happened in 5 years?

Our project pivoted twice: once, in mid-2017, during Y Combinator, we switched from our original approach of compressed air energy storage, to pumped heat energy storage (storing electricity as heat and then later converting heat back into electricity). This first change was motivated by the plummeting price of lithium-ion that did not warrant the use of above-ground compressed air tanks anymore. We found a way to use our initial core tech as a high temperature heat pump instead of an air compressor.

The second pivot was in mid-2019. After two years of research, we realized our initial core tech (a gas compressor with no moving parts) could not be brought to market as an industrial pumped heat energy storage system, because of corrosion concerns. We were aware of this corrosion issue since day 1, but thought all along that we had found a sufficiently robust technique to address it. It was only after the completion of a research contract with a partnering academic lab, and thorough investigation with the help of outside experts, that we understood that our envisioned technique would not be feasible for real-world machines.

Since then, we changed our material combinations to remove the system-wide corrosion issue altogether. This change forced us to rework the main drive of our Stirling engine, and with this new setup, we were able to successfully test our innovative compression head, at low pressure and low temperature.

In addition to those two pivots, the team has gained tremendous experience along the way. We now know much more precisely which profiles we need, when, and in what manner (recruitment or consulting) to develop and prepare the industrialization of our system.

How does your battery work?

Our battery is a hybrid system that has two functions: on one hand, it can store electricity on very long durations (months to years); on the other hand, it can store electricity on shorter durations (10-40 hours). The centerpiece of the system is our proprietary Stirling engine, which acts like reversible heat pumps: it can both convert heat into electricity, and electricity into heat, all with very high efficiency.

To perform short duration storage, at first, our Stirling engine converts abundant solar or wind energy into heat. Then, the heat is stored in large molten salt tanks. Molten salt is a kind of “industrial lava” that is 100% recyclable. Finally, when electricity is needed, heat is taken from the molten salt and converted into electricity by the Stirling engine running in “reverse”.

To perform long duration storage, a clean chemical plant called an “electric Haber-Bosch plant” converts electricity, water and air into the chemical ammonia (NH_3). Ammonia is then stored, again, in large tanks, in liquid form, at a mild cold temperature (-33°C, or -27.4°F). Ammonia can be stored this way for years without any noticeable degradation. When electric power is needed, ammonia is taken from the tank, burned in a clean way (without harmful emissions) and the heat of ammonia combustion is used to operate our Stirling engine in generator mode.