



# DESTINATION STARTUP

## Starfire Energy

**One-Sentence Summary of What You Do:** Starfire Energy makes systems to produce carbon-free ammonia from air and water using clean electricity. Our systems leverage a patent-pending catalyst, novel removal method, and specialized reactor. Ammonia can be combusted for energy, is an easy way to store and transport hydrogen, and has more energy by volume than batteries.

**Affiliated Institution:** Colorado School of Mines

**Have you formed a company yet?** Yes

**Funding/Financing:** Grant Funding, Private Equity

**Please describe your company and the problem you are trying to solve:** Starfire Energy is working to make sustainable energy a reality. Ammonia (NH<sub>3</sub>) can be combusted for energy, is an easy way to store and transport hydrogen, and has more energy by volume than batteries. Just one 50 tonne per day Rapid Ramp NH<sub>3</sub> system will produce enough clean NH<sub>3</sub> to displace more than 20,000 tons of CO<sub>2</sub> each year!

Ammonia fuel is gaining momentum as industries around the globe gear up to use it in transportation, as process heat, and as seasonal storage for electricity grids. But, today's NH<sub>3</sub> process creates 2 tonnes of CO<sub>2</sub> for every 1 tonne produced. NH<sub>3</sub> needs to be made cleanly.

We are developing a system to produce carbon-free NH<sub>3</sub> (ammonia) from air and water using clean electricity. The Rapid Ramp NH<sub>3</sub> system, leverages a patent-pending catalyst, novel removal method, and specialized reactor that produces NH<sub>3</sub> at low pressures. Rapid Ramp NH<sub>3</sub> operates with variable temperatures, pressures, and flow rates to maximize production while directly following the variable power of renewable energy.

The modular Rapid Ramp NH<sub>3</sub> system is designed for ease of deployment and stand-alone operation in field conditions. Companies minimize business risk by adding our systems as the ammonia fuel marketplace evolves.

Through grants we have scaled from benchtop to a 3 kg per day reactor. We are now building a 10 kg per day reactor. In 2020 we will build a 100 kg per day reactor and place it in a field location. We have 6 patents pending and 2 trademarks issued.

**What is/was your go-to-market strategy?** We have defined market verticals where our system will become an integral part of the market's infrastructure.



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Our first market vertical is the hydrogen market place. Hydrogen (H<sub>2</sub>) stores at - 253C or at 10,000 psi. To store liquid hydrogen for just 15 days costs \$1.97 per kg of H<sub>2</sub>. Ammonia stores at - 33C or just 150 psi. To store liquid ammonia for 15 days costs only \$0.06 per kg of H<sub>2</sub>. In addition, many communities where hydrogen fuel cell vehicles are gaining a foothold require that a portion of the hydrogen supplied to the car owners come from renewable resources. Our carbon- free NH<sub>3</sub> can be created near fueling stations, stored affordably, then cracked to provide high- purity hydrogen. This market in California is anticipated to grow to \$200M annually by 2029. We are in contact with a company supplying hydrogen to stations and are working to help them realize early storage and transportation savings. We will soon be able to also offer them carbon- free NH<sub>3</sub> to complete their H<sub>2</sub> product offering.

The maritime industry is preparing to move to NH<sub>3</sub> as their fuel. C-Jobs Navel Architects is designing NH<sub>3</sub> vessels, MAN Energy Solutions has said their NH<sub>3</sub> engine will be ready in 2023, and Maersk who has about 20% of the global shipping market has said they will be carbon- free by 2050 and will be purchasing vessels around 2035. Our Rapid Ramp NH<sub>3</sub> systems pair well with off- shore wind and we will be ready to support this \$245B annual market.

**How will/do you generate revenue?** Our financial model is based on system sales and maintenance contracts. Our smaller scale systems will serve as footholds in our vertical markets. They will demonstrate our product quality and show system stability to lend credibility as we move into larger system sales. We will mass produce our systems so that each system does not have to be individually engineered for a given customer or location. Mass production models have shown the cost of manufacturing reduce by 10- 20% for every doubling of units produced. This reduction allows for both better margins for us and reduced costs to our customers.

Our systems are made for stand-alone operation in field locations. Our maintenance contracts will serve to ensure customer satisfaction and recurring revenue. By performing routine maintenance on moving parts and scheduled maintenance on the catalyst and adsorbent materials, we ensure our customers are maximizing their investment. Contracts will also be offered to include upgrades where our technology evolves and can be retrofitted into our existing systems.

As our product design finalizes and has been proven stable through several years of system installations, we will be able to license our technology for global manufacturing and deployments. We will continue to improve our system and offer those improvements to existing system customers and licensees.

**How will this showcase benefit your company or technology?** Starfire Energy is seeking strategic pins to ensure resounding business success:



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1. We are working to build an advisory board and would welcome conversations from individuals familiar with the energy infrastructure industry.
2. We are seeking strategic partners interested in providing funding and expertise to:
  - accelerate our development scale-ups,
  - help us expand existing early adopter clean NH<sub>3</sub> fuel markets,
  - help us distribute clean NH<sub>3</sub> to early adopters, and
  - help us develop customers for modular clean NH<sub>3</sub> system deployments.

Our ideal strategic partner will:

- have an existing revenue stream that can be improved with our technology
  - help us smoothly transition from development to mass production of modular systems
  - have corporate divisions experienced in facility deployments and operations
  - have a common goal of eliminating CO<sub>2</sub> from the world's energy systems
3. We are seeking venture or corporate capital for our field system and have a cost estimate of \$5M for this deployment. This system will demonstrate our product's viability and lead to smaller system sales. We have been good at writing grants and have the possibility to be awarded \$4M in grant monies but need to match with \$1M in equity funding.
  4. We are looking for opportunities to build awareness about ammonia as a fuel and how Starfire Energy's technology will support clean ammonia on the sustainable energy vector. Our technology isn't just a smaller version of today's high-pressure, static processes but a new, cost-effective way of producing ammonia cleanly.

## **Who are the members of your team and why is this the right team to get the job done?**

We have a highly skilled team. Our CEO has had a previous successful exit from a solar panel manufacturing startup. He is the technical lead and directs the activities of our materials scientist and our mechanical engineering staff. Five of the six are Colorado School of Mines graduates at the master and doctoral levels. Our COO has 20 years of project and program management experience as well as business development and accounting experience. She has a master's degree from the University of Denver in Technology Management with a bachelor's degree in Business Management. We will be ready to grow mid-2020 and will be seeking to add a chemical engineer, a second mechanical engineer, a second system controls engineer, and a business developer. These positions will allow us to increase our pace on scaled development, customer equipment transitions, and business development.

CEO: Joe Beach (PhD in Applied Physics)

- Previous thin film solar panel start-up with a successful exit
- Venture fund-raising experience with previous startup
- Experience in commercialization of IP came through previous startup



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Has always been focused renewable energy sources and sustainability. When exited previous startup began thinking about ways to store renewable energy. Having experience with solar installations and some battery storage, knew there had to be a better answer. Spent a lot of time researching alternatives such as biofuels, hydrogen, and CO<sub>2</sub>-capture. Studied ammonia as a solution because of its relatively low cost of storage and transportation, 100-year history, already established transportation infrastructure, and high hydrogen properties.