

A note to the students:

Congratulations on your entry and participation in the Conrad *Spirit of Innovation* Challenge!! I am happy and excited to review your business plan and provide you with detailed feedback to help improve your future efforts.

In reviewing your proposal, I do not dwell on whether or not I think the product described is a good or bad idea. I try examine the proposal as a potential investor for your fledgling company might; to determine if you have done a good job:

- Describing the product concept,
- Identifying and justifying a need,
- Researching potential offerings which attempt to satisfy that need,
- Providing references and citing sources for materials used in decision making,
- Proposing a new and more innovative solution,
- Developing metrics for evaluating the capabilities of the proposed solution against the needs of the target users,
- Validating and refining the solution to achieve optimal outcomes, and
- Developing a viable plan for further development, testing, production, and deployment.

Even as a reviewer, my primary goal is to assist you in understanding what is good and bad about your BUSINESS PLAN. Expressing my opinion of the proposed product is a secondary concern, and I will almost always do that in the form of a question – a question which will hopefully allow you to step back from where you are and to explore your product from a different angle.

I use this document template for my convenience since it allows me to edit and format my comments to you in ways that the Judge's Portal does not permit. I believe that it provides significantly better feedback than I would otherwise be able to give. Each section in this document exactly matches the criteria given in the Judge's Handbook with one exception noted in the document. In prior years, the final section included commenting on the graphical concept and your video proposal. As indicated in the section, I will use that space to provide feedback on these elements but that feedback is not used as part of the scoring for that section.

I have provided comments for each section which I hope you will read and use constructively in improving this product proposal, but also in helping you to better understand and apply STEM principles and methodology to all your undertakings.

Again, I congratulate you on your submission and hope you will continue to strive for excellence in everything you do.

Scoring Summary		
Category	Points	Awarded
Technical Innovation	20	14
Technical Practicality	20	12
Marketability	10	6
Costs	10	6
Industry Relevance	15	8
Funding Mechanisms	10	5
Team Story	15	12
Total:		63

Technical Innovation (20 Points): *How new or unique is the idea? Does the product already exist?*

We look for innovation in any of 3 forms:

- The technology itself
- A combination of existing technologies into a new system
- Innovative business concepts - The team should show how their product uses one or more of these types of innovation.

Project Aerem appears to be a system for using UV light energy to convert atmospheric carbon dioxide and water vapor into usable methane gas and oxygen. The system promises an “eco” return with several facets:

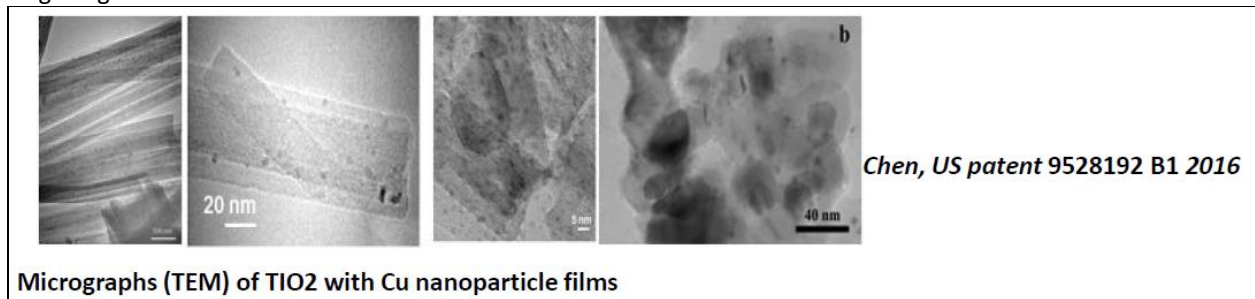
- Reduced energy costs for the consumer
- Reduced energy production costs
- Improved environment by the reduction of the greenhouse gas (CO₂) and the introduction of additional oxygen (O₂).
- Safer environment by reducing the need for natural gas mining techniques such as hydraulic fracturing.

The system relies on a titanium dioxide based catalyst and a reaction channel produced through stereolithographic (SLA) means. The proposal indicates that the system would be installed into the HVAC. The product is described as “...unique because it is much more technically versatile than existing products...” and “...does not require special temperature or gas conditions, takes no electrical input, can come in any shape, and does not easily wear...”.¹

The technology is certainly young, and anything that reduces energy costs while protecting the environment is an important innovation. Since the proposal indicates that there are existing products, the lack of any references or summaries of those products is disappointing. Curiously, the Competitive Analysis on page 8 states, “Although no products similar in nature to Aerem exist in the market...”.

The proposal video (at 1:30) says “...our patented co-catalyst...”, but no reference to this patent is provided in the proposal document. In fact, the proposal is devoid of any references to credible sources to substantiate the claims made relative to the product. Statements like “...will save billions...”, “...will greatly reduce...”, “...low-cost of materials...”, and many others have little significance without citations to credible sources.

A simple web search identified a presentation from April 2017 given by Bin Chen (Univ of California/NASA Ames) with the following image:



An identical image appears in the Aerem proposal. In fact, **many** of the images in the proposal can be found in this presentation. Given that the proposal’s introduction states that a team member, “...interned with researcher Dr. Chen at the NASA Ames...”, I presume that the material was used with Dr. Chen’s permission. That being the case, **the materials and images must include citations to their source**. Also, this technology is not on the list of NASA patented technologies which were made available to Conrad Innovation participants. Credit must be given where credit is due. Unfortunately, the lack of any citations to sources for these images combined with the accompanying texts bring into question whether this is original work, copied with permission, or an unsanctioned use.

Score: 14

¹ Text presented in quoted italics is taken directly from the team’s submitted proposal.

Technical Practicality (20 Points): *Will this product work technically?*

- The team must show that its product does not break any physical laws.
- The team does not have to show proof that the product will work, but should show an understanding of what research or experiments are needed to prove that it will work.

The proposal provides some evidence that the chemical reaction, (which takes CO_2 and $2\text{H}_2\text{O}$, exposes them to UV light in the presence of the TiO_2 based catalyst yielding methane (CH_4) and liberating 2O_2), will occur. What I find missing is a clear description of how the **system** will work.

You have a chamber/channel where the reaction takes place. Where in my HVAC system is the device installed? What feeds the reactants into the chamber? How does the light energy get into the chamber, especially when you create a winding, folded, twisty channels? (That is the definition of tortuosity, right?) How long does the conversion reaction take? What gathers the products from the chamber? What happens to these products as they emerge from the process? How do you confirm that all the reactants have been converted? Do they come out separately? As part of the same stream? How do you then use them? Can I take the methane and plumb it into my facility's natural gas supply lines? Do I need to pressurize it to merge with the pressure in the gas main? Do I need to add mercaptan to it to provide the characteristic odor that commercial natural gas sources are treated to provide? Since both methane and oxygen are colorless, odorless gasses, how do I know that they are not leaking out of the system creating a dangerous situation? Are their concentrations of the reactants that optimize the reaction and/or are there concentrations at which the reaction will not occur since the catalysts become saturated? Is there a need for sensors and some form of controller to monitor the reaction or shut it down if there is a problem?

Most SLA resins and materials are UV cured and become brittle from long-term exposure to UV light. Are the SLA resins and materials selected UV stable (ie: they do not undergo characteristic changes due to prolonged exposure to UV-light)? Are those materials compatible with the catalyst materials? After producing the reaction channel, how do you get the catalyst into it? How do you determine if airborne deposits build up in the chamber and impact the reaction?

Can you quantify the energy savings, if only as a percentage of the input reactants? How long is a system expected to function without the need for replacement of catalysts or the reaction chamber? Using those estimates and based on your projected unit costs, what is the 'breakeven' point for the average home-owner or business? Since the proposal discusses achieving carbon-neutrality, at what point does the overall lifecycle of the product achieve carbon-neutrality? (Remember, there is energy expenditure that goes into the manufacturing of the chamber, the catalyst, and the system itself.)

Given the nature of the device (it produces a combustible gas), are there any safety regulations which the product will need to be tested against for compliance? What is it going to take (in design and in cost) to develop the product and test it for compliance with industry-wide safety regulations?

Those questions are just the key ones that leapt to mind when I considered productizing your underlying technology. I still have questions/reservations about the technology. I take CH_4 and O_2 , I burn them (assuming complete combustion) to produce CO_2 and H_2O together with energy in the form of broad-spectrum EM radiation which I perceive as heat (EM radiation in the IR range) and light (EM radiation that our eyes respond to). Now I take the CO_2 and H_2O , stuff in some EM radiation and recover my original two CH_4 and O_2 reactants. Can you say 'law of conservation'? Something doesn't add up.

You have indicated some of the additional research into the chemical process which must be undertaken, but I do not feel that you have adequately explored the rigor involved into turning that chemical process into a market-viable product.

Score: 12

Marketability (10 Points): *Understanding of the key markets for their product must be demonstrated.*

- Who is the buyer?
- Will the team pursue government Research & Development (R&D) grants, licensing to another company, or create an entrepreneurial startup?
- Is there data showing how similar products have been successful?

The proposal suggests that the buyer could be private home-owners followed by businesses and ultimately into wide-spread commercial adoption. While the business plan does suggest some grants would be sought, none of their sources appear to be governmental. Instead, the team seems to favor social media funding sources together with possible funding from humanitarian organizations and environmental non-profits.

While the team may have an idea that anyone who consumes fossil fuels is a potential customer, the reality is that until the team fully understands the Return on Investment proposition for the consumer, they really cannot target the appropriate market. It may be that, when Aerem is installed in a residential setting, the overall cost is too high and potential benefit too low for that to be a viable market.

Since the proposal does not identify other similar products, there is not any data on how similar products have been received by the market. While Aerem's technology may indeed be unique, there are certainly any number of other energy-saving, environmentally aware products that could be evaluated for success.

Score: 6**Costs (10 Points): *The team should break down estimated costs of taking this product to the chosen market.***

- Costs should include any material estimates, R&D (including grants), market studies, and labor costs.
- Teams should including costs for the team to participate at Innovation Summit.
- Teams should be as detailed as possible.

The proposal presents some cost estimates for the materials and some production costs, but does not provide sources for those material costs and does not fully understand the product development, testing, and regulatory certification process involved for a product of this sort. Also, they have not estimated the costs of finishing the research on the underlying chemical processes.

What is more problematic is that on page 11 in the costs section, the proposal indicates a first year production cost (including capital equipment) of approximately USD \$225K. In the next section (Funding sources), the proposal indicates that they believe they could raise total start-up funding of USD \$90K. Where is the other USD \$135K coming from?

Score: 6

Industry Relevance (15 Points): *How important is the idea to the industry?*

- Does the product represent a substantial improvement in its industry or are there already products on the market that fill the need?
- The team should list examples of similar products, including patent searches or other examples of technology on the market, and explain how its product is an improvement of what already exists.

Energy conservation and environmental protection? Always relevant. There do not seem to be any products in the market place today so it cannot be measured against other offerings.

There is at least one patent on the underlying technology but this information is not mentioned in the proposal. There are not citations of any credible sources throughout the proposal.

Score: 8**Funding Mechanisms (10 Points):** *Does the team understand the basics of how its product could be funded?*

- If it is relatively simple, can the team raise money for prototypes and begin sales through friends and family?
- Does the team need to consider grants, loans, or bringing on investors or partners in their efforts?

While the proposal describes a wide variety of funding sources, none of them seem adequate to properly fund the remaining research, development, testing, productization, and certification of Aerem into a saleable product.

Score: 5**Team Story (15 Points):** *Introduce your team to the potential investors.*

- How did the team form?
- What roles did each member play?
- What barriers or hurdles did the team overcome to develop its idea and complete its business plan?

Note: In previous years, this section also included the following items. Comments relative to these items will not be included in the scoring but are provided as feedback to the team.

- Graphic Concept - Is the product design clear and easy to understand visually? Did the team produce quality graphics in professional manner? Did the graphic representation enhance the overall business plan?
- Product Video - Did the video clearly explain the product and need? Was the video engaging for future investors? Did the team's video enhance the overall business plan?

The team background was described with some detail including the individual's backgrounds and contributions to the project. I did find it odd that the team member last names were not included. The team did indicate some of their initial struggles with product positioning.

The graphics presented in the video were quite good with a somewhat professional look and feel. The graphics provided in the proposal, when compared with some of those in the video, seem incomplete. Also, many of those images appear to be taken from other publications which should be referenced.

Score: 12