CO2 Conversion Challenge – FAQ's

NASA CO_2 Conversion Challenge

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1.0 REVISIONS SUMMARY:

Section	Revision #	Description	Date
	0	Original Document	08/30/2018
2.0	1	A2.1 – sentence added to reinforce the focus on conversion to glucose A2.2 – reworded to emphasize the importance of the need Add Q2.3 and A2.3	10/02/2018
2.0	2	Added questions and answers 2.4 through 2.32	11/20/2018
5.0 4.0 3.0 2.0	3	Added section for webinar Q&A Added Q&A 4.7 Added Q&A 3.10, 3.11, 3.12 Added Q&A 2.33, 2.34, 2.35, 2.36	02/15/2019

2.0 CHALLENGE STRUCTURE:

Q2.1 What is the NASA CO_2 Conversion Challenge?

A2.1 The NASA CO_2 Conversion Challenge is a public competition that focuses on discovering ways to develop novel, non-biological synthesis technologies that use carbon dioxide (CO2) as the sole carbon source to generate sugars that can then be used to manufacture a variety of products using both microbial biomanufacturing and chemical synthesis processes. The challenge asks individuals, teams, and organizations that meet the eligibility criteria to design and develop specialized technologies that can produce glucose or other targeted sugars from CO_2 to help advance sustainable space and Earth-based manufacturing approaches.

Q2.2 Why is this Challenge focused on CO_2 conversion?

A2.2 Future planetary habitats on Mars will require a high degree of self-sufficiency. This requires a concerted effort to both effectively recycle supplies brought from Earth and use local resources such as CO2, water and regolith to manufacture mission-relevant products. CO2 is a readily available source of carbon that can be easily obtained from the Martian atmosphere and as a by-product of human metabolism. This carbon (and oxygen) is an essential ingredient in making organic mission products such as food, nutrients, medicines, plastics, fuels, and adhesives. While carbon-containing molecules may be present in mission waste products or in planetary soils, these materials are difficult to use as feedstock for effective manufacturing processes.

Q2.3 Can competitors use a bioreactor technology?

A2.3 The focus of this challenge is to create physico-chemical processes that do not require living organisms or their catalytic products (e.g., enzymes) as a part of the process. Therefore bioreactors are not permitted to be a functional component of the proposed system. Also, systems such as immobilized enzymes are precluded as they rely on the growth, harvesting and purification of organisms to create the necessary process catalysts. Biologically-derived products such as plastics, wood etc. can be used for fabricating parts of the reactor system, but not as a catalytic agent.

Q2.4 Phase I funding is relatively small. Is it necessary to convert CO2 to 3C or larger compound in Phase I? Is it possible to convert CO2 to 1C compound for Phase I, then indicate the established process to convert 1C compound to 3C or larger compound for Phase II study?

A2.4 The Phase I portion of the challenge does not require that actual CO2 conversion be performed. It only requires a plan to make the listed target compounds. If there is some work completed regarding hardware development and testing in pursuit of submitting the Phase I plan, that can be included in the Phase I submission. But the overall intent of the Phase I submission is to evaluate your plan regarding how you would intend to create an actual system that can synthesize the listed compounds. The fabrication and demonstration of your proposed system is the intent of Phase II.

Q2.5 If we have to convert CO2 to 3C or larger compounds in Phase I, then we are considering to propose two-step-approach to convert CO2 to 3C or larger compounds. We wonder if it is acceptable, and if yes, does it have disadvantage against the proposal that applies direct conversion?

A2.5 The Phase I portion of the challenge does not require that actual CO2 conversion be performed. It only requires a plan to make the listed target compounds. If there is some work completed regarding hardware development and testing in pursuit of submitting the Phase I plan, that can be included in the Phase I submission. The conversion of CO2 to the listed challenge compounds can certainly be accomplished in multiple steps. While there is no outright penalty in using multiple steps, in general plans for systems that minimize mass, power and volume, consumables, etc., will be favored during judging. The fabrication and demonstration of your proposed system is the intent of Phase II.

Q2.6 As I was reviewing the requirements and rules, I have noticed that you require that companies participating in this challenge to have insurance coverage for $250,000.00 I have asked a few insurance companies and they want to know what coverage is needed for and why?

A2.6 Please refer to section 11.3 of the team agreement, "this liability insurance shall cover (A) a third party for death, bodily injury, or property damage, or loss resulting from an activity carried out in connection with participation in a competition, with the Federal Government named as an additional insured under the registered Competitor's insurance policy and registered Competitors agreeing to indemnify the Federal Government against third party claims for damages arising from or related to competition activities; and (B) the Federal Government for damage or loss to Government property resulting from such an activity.

Q2.7 Is a hydroponic solution to the CO2 conversion challenge barred from entering the competition?

A2.7 The challenge has the requirement that the CO2 conversion occur without the use of biological systems. It must use physicochemical systems only. If the proposed solution would use a "hydroponic solution" within a biological process, then this would not be allowed.

Q2.8 It is stated that the application for phase 1 should "provide a brief summary description of the physicochemical (no biological components) process/system that uses CO2 as the sole carbon source to produce selected carbon-based molecular compounds you are proposing to construct." My question is- what does "biological component" mean in this context, and furthermore, does this stipulation eliminate all biological-chassis entries to the contest even if the chemistry being performed is assessed from the standpoint of reaction kinetics, a physicochemical property?

A2.8 The focus of this challenge is to create physico-chemical processes that do not require living organisms or their catalytic products (e.g., enzymes) as a part of the process. Systems such as immobilized enzymes are precluded as they rely on the growth, harvesting and purification of organisms to create the necessary process catalysts. Biologically-derived products such as plastics, wood etc. can be used for fabricating parts of the reactor system, but not as a catalytic agent.

Q2.9 Are we allowed to use any bioreactor at all in the system? I presume that we do not have to build the mechanism to capture CO2, but rather we're assuming we will get X amount of CO2 flow rate into our system, is this true? If the previous is true, what is the assumed CO2 input flow rate? (So I can simulate a real environment using CO2 tanks. Are we simply trying to convert CO2 to glucose? Is that the primary parameter?
Do you have yield expectations based on CO2 input? Is there a project brief with further details about the requirements if input and final output product?

A2.9 Bioreactors are not allowed to be a functional component of the system. The CO2 conversion system must use non-biological methods to convert the CO2 to target products. The CO2 for this system can be obtained from a pure source such as bottled CO2 or some other CO2 containing gas that does not have other carbon-containing molecules. The CO2 flow rate is a parameter that you can control - no restrictions are given at this time. The primary goal is to convert CO2 to one of the compounds listed in the challenge rules. There are also no yield limitations, though higher yields will be preferred. The information about the challenge is contained only within the challenge text on the website. There are no further project briefs.

Q2.10 Why don't you just use the cyanobacterias, photosensitive algae or the plants to produce energy out of co2? That's how life started on earth.

A2.10 The reason this challenge excludes biological processes is that biological systems are already established as the principal means of producing sugar. The challenge is interested in creating new methods that can use CO2 and H as the major input sources that are faster, more selective towards targeted products, and more energy efficient than biological methods.

Q2.11 Could our design concept for the CO2 Conversion Challenge produce Glucose Syrup?

A2.11 Yes, glucose syrup would be an acceptable product. High concentrations of glucose, or other targeted products listed in the challenge, are not required but would be considered highly beneficial.

Q2.12 We don't have a solution that will convert CO2 to molecules to power bio-manufacturing, but we do have a renewable energy concept that could generate electric energy that could power a potential platform and other needs for electricity on Mars… is that of interest? Would we follow the same application process?

A2.12 This challenge is specifically for the conversion of CO2 to create substrates for microbial bio manufacturing. Research on other topics may be of interest to NASA. We suggest that you explore the NSPIRES website (https://nspires.nasaprs.com/external/) for other potential NASA funding opportunities.

Q2.13 Is the goal of the challenge to convert co2 to sugar through an apparatus?

A2.13 The focus of this challenge is to create physico-chemical processes that do not require living organisms or their catalytic products (e.g., enzymes) as a part of the process to generate the targeted products. Systems such as immobilized enzymes are precluded as they rely on the growth, harvesting and purification of organisms to create the necessary process catalysts. Biologically-derived products such as plastics, wood etc. can be used for fabricating parts of the reactor system, but not as a catalytic agent.

Q2.14 If the glucose formula is C6 H12 O6, if the CO2 is divided into two parts oxygen and the carbon as a gas, hydrogen is added in sufficient quantity all in the form of gas and liquefaction is carried out to get glucose?

A2.14 The conversion process must use CO2 and hydrogen as the sources for producing the targeted compounds. Any viable type of physicochemical process (non-biological) system may be used for the conversion.

Q2.15 I understand you are not allowed to use a bioreactor; can you say that a tank of seawater bubbles ofC02 and a diatoms would be allowed?

A2.15 The focus of this challenge is to create physico-chemical processes that do not require living organisms or their catalytic products (e.g., enzymes) as a part of the process to generate the targeted products. Systems such as immobilized enzymes are precluded as they rely on the growth, harvesting and purification of organisms to create the necessary process catalysts. Diatoms are living biological entities and would not be considered acceptable for this challenge.

Q2.16 I have possible competition entries that focus on (a) how to make useful energy (both of electricity and high temperature thermal energy) on Mars and (b) how to transport large amounts of water from known water sources on Mars to any suitable (near) equatorial region on Mars, and (c) producing carbonyl catalysts for the Fischer-Tropsch reactions. Since the sourcing of hydrogen and delivering reaction driving energy are necessary for synthetic organic chemistry and ISRU catalysts would be very useful for implementing the F-T process on Mars, do I have any entry that stands a chance?

A2.16 The focus of this challenge is specifically on producing a method that can convert CO2 and hydrogen to the listed target compounds. Other topics will not be considered for this challenge.

Q2.17 The website https://www.co2conversionchallenge.org/ does not make it very clear whether or not a competition winner just gets a $50,000 cash prize, or whether a winning competition entry also proposes a Phase I research program and that the money needs to be spent on carrying out such a proposed research program. Which is it? A simple cash prize? Or money to fund R&D?

A2.17 The Phase I prize money does not need to be used for any particular purpose. A competitor that wins a Phase I prize is not obliged to participate in any further activity.

Q2.18 What is the relationship between www.co2conversionchallenge.org and NASA?

A2.18 NASA is the sponsoring agency for the CO2 Conversion Centennial Challenge.

Q2.19 Would technology that converts CO2 to syngas qualify for this competition or is it restricted to CO2 to glucose only?

A2.19 The conversion of CO2 to carbon monoxide is an allowable part of the overall process, however the challenge goal is to produce one of the targeted compounds (sugars) listed in the challenge. Only producing carbon monoxide will not satisfy the challenge rules, and would therefore not be eligible for winning one of the monetary prizes.

Q2.20 I have been growing plants with numerous styles of systems that I have designed. I now have the knowledge and experience allowing me to use waste water to produce Oxygen from CO2 rich air. How should I prove the system works and? How should I prove the oxygen content? Can you recommend an oxygen meter? I want to contribute all I have learned to this program. I plan on entering as a single family no company at all my family will be helping me with the construction of the system. What is the time frame I need to have the system built and processing CO2 and waste water in to oxygen and food? I have grown plants using aquaponics and hydroponic along with aeroponics. I have had systems that supposedly can't be done and can not work which they do. I never fail a challenge. I plan on building a small powerful enclosed system that uses waste water for ammonia production which then is used to process the CO2. Please let me know the size limitations, weight, power usage, and water volume, temperature and any other requirements you wish to have. I can fabricate and design anything. I currently work for East Coast Machinery Repair LLC in NJ. Which has shown me over a decade of all manufacturing processes. Whatever is needed I will deliver.

A2.20 The focus of this challenge is to create physico-chemical processes that do not require living organisms (plants, microbes, etc.) or their catalytic products (e.g., enzymes) as a part of the process. Therefore a plant/algae/fish based system does not comply with the intent of this challenge. There is currently no limit specified regarding the mass, power and volume of the system, but an overarching goal is to minimize these aspects while converting CO2 to sugars.

Q2.21 I was very excited to read about this challenge as I have been working on a system that fits perfectly with the overall objective, that is a way to convert CO2 into a useable hydrocarbon to make building materials out of for a martin colony. The only drawback is it is a biological system. It wasn't until I read the technical specifications sheet that I realized that a biological system was not acceptable. Is there a reason for this? Is there an exception if the only carbon input to the system is CO2? If this is not acceptable for this challenge is there another place that I could show case such a technology for NASA?

A2.21 The reason this challenge excludes biological processes is that biological systems are already the principal means of producing sugar. The challenge is interested in creating new methods that can use CO2 and H as the major input sources that are faster, more selective towards targeted products, and more energy efficient than biological methods. NASA conducts calls for proposals on various topics that may be related to this challenge, where proposers can submit their concepts. Please see the following website: (https://nspires.nasaprs.com/external/)

Q2.22 It states on your page that a bio-reactor is not permitted to be used when converting CO2 to glucose. Does that mean no organisms are allowed to be used or that you simply require the organisms to be able to operate without a bioreactor? And if organisms are allowed, what non bioreactor conditions would be permitted, for example would a warm water bath be out of the question?

A2.22 The focus of this challenge is to create physico-chemical processes that do not require living organisms or their catalytic products (e.g., enzymes) as a part of the process to generate the targeted products. Systems such as immobilized enzymes are precluded as they rely on the growth, harvesting and purification of organisms to create the necessary process catalysts. Biologically-derived products such as plastics, wood etc. can be used for fabricating parts of the reactor system, but not as a catalytic agent. With respect to reactors, a water bath is certainly allowed.

Q2.23 We see that for phase 1, the concept phase, up to $250,000 will be awarded. Thus, up to five finalists will receive an award of $50,000. For phase 2, the prize purse is listed as up to $750,000. Is phase 2 set up similar to phase 1, what is the expected period of performance and what would be the total funding available: up to five finalists that will receive $150,000 each?

A2.23 The details of Phase 2 of the challenge are still under development and will be shared publically as soon as they are finalized.

Q2.24 Will providing a budget analysis for the proposed work in phase 2 (contingent on how much will actually be awarded for phase 2) be seen as a plus in the phase 1 proposal?

A2.24 While a budget analysis is not required in the Phase I submission, it is permissible to include it. A thorough budget analysis will provide information that will potentially aid judges in understanding the prospect of fabrication and testing, and overall feasibility.

Q2.25 How is the prize purse for phase 2 to be distributed? In other words, is a winner/winners declared at the inception of phase 2 and the prize given out to accomplish the technical aspects of the demonstration challenge or will it be given out at certain timeframes/hit milestones/etc.?

A2.25 The details of Phase 2 of the challenge are still under development and will be shared publically as soon as they are finalized.

Q2.26 Thank you for addressing previously that multiple steps have no outright penalty. Would a modular type system where joining certain aspects of the proposed solution together on Mars be seen as a penalty? Would it be seen as a plus, as it may mean easier packaging of the hardware for spaceflight, or both?

A2.26 The utilization of multiple components for carrying out the conversion is perfectly acceptable and anticipated. Modularity of the components can offer both advantages and disadvantages. For example, modularity may allow separate components that have different maintenance requirements or lifespans to be more readily serviced or replaced. Modularity may also allow a range of compounds/processes to occur with modest changes (component change-out) in the system. In contrast, integrated units may benefit from decreased volume and mass, and simplified control system coordination. Therefore the benefits or detriments will be judged on a case-by-case basis.

Q2.27 Would including a small part on potential terrestrial applications of our technology be viewed favorably or have no effect on winning the challenge?

A2.27 While the primary judging metric of the challenge is directed towards space applications, the potential for the technology to additionally provide terrestrial benefits will be considered favorably. Please feel free to include discussion on potential terrestrial applications.

Q2.28 Would risk mitigation strategies, such as alternative (but potentially worse performing) catalysts that could be obtained from the Martian surface (in case something is damaged by accident, for example) be helpful to our chances?

A2.28 In general, techniques that provide robustness, reliability, and resilience are favored. The potential to use in situ resources during missions to mitigate risk and provide sustainability may be considered favorably, but will depend on the feasibility of implementation. For example, if a metal catalyst can be obtained from Martian regolith, but it requires extensive processing (e.g., multi-step separations and purification) and fabrication (e.g., complicated surface coating procedures) to implement, this may not be viewed as a viable method. Please feel free to include discussion of intended risk mitigation approaches in the Phase I submission, as it will provide a greater depth of understanding for judging potential implementation strategies.

Q2.29 Is there a targeted TRL for the end of phase 2?

A2.29 The details of Phase 2 of the challenge are still under development and will be shared publically as soon as they are finalized.

Q2.30 What is the daily capacity of a glucose synthesis unit? Is it enough to produce 70 grams of glucose a day per person (based on nutritional standards on Earth)?

A2.30 There is currently no daily target production level for glucose or the other target products. The potential need for these target compounds is not defined for future mission scenarios. Therefore, it is suitable for contestants to select their own desired level of production for the Phase I submission. It is permissible to select a small amount to provide a proof of concept and feasibility assessment, or to provide a larger scale conversion system to demonstrate scaled operation. For this challenge, the judges will be examining many facets of the technology, such as energy use, yield, and selectivity of the target compounds. Scaling potential will also be considered, but there are no known target compound supply requirements developed as of now. Regardless, the ability of a system to readily scale will be considered favorably.

Q2.31 What are the maximum dimensions and weight the installation should have?

A2.31 There are no dimensional or mass design requirements established for Phase I submission. However, due to the inherent mass, power and volume constraints during space travel, minimizing these factors is crucial to implementation. The cost and availability of electrical power or light to drive conversions will depend on the specific characteristics of future missions scenarios. Mass and volume will also exert variable costs depending on mission location, duration, and other factors. Therefore, it is advisable that contestants design their systems with these general design constraints in mind.

Q2.32 What should be the marginal energy consumption for the production of 1 gram of glucose?

A2.32 There are no constraints on the energy utilized for target compound production for this challenge. However, due to the high cost of providing power during space missions, contestants should strive to minimize energy requirements of their process in accordance with overall system optimization of their system.

Q2.33 Would a modular type system where joining certain aspects of the proposed solution together on Mars be seen as a penalty? Would it be seen as a plus, as it may mean easier packaging of the hardware for spaceflight, or both?

A2.33 The utilization of multiple components for carrying out the conversion is perfectly acceptable and anticipated. Modularity of the components can offer both advantages and disadvantages. For example, modularity may allow separate components that have different maintenance requirements or lifespans to be more readily serviced or replaced. Modularity may also allow a range of compounds/processes to occur with modest changes (component change-out) in the system. In contrast, integrated units may benefit from decreased volume and mass, and simplified control system coordination. Therefore the benefits or detriments will be judged on a case-by-case basis. Would including a small part on potential terrestrial applications of our technology be viewed favorably or have no effect on winning the challenge? While the primary judging metric of the challenge is directed towards space applications, the potential for the technology to additionally provide terrestrial benefits will be considered favorably. Please feel free to include discussion on potential terrestrial applications.

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Q2.35 Phase 1 funding is relatively small. Is it necessary to convert CO_2 to 3C or larger compound in Phase 1? Is it possible to convert CO_2 to 1C compound in Phase 1, then indicate the established process to convert 1C compound to 3C or larger compound for Phase 2 study?

A2.35 The Phase I portion of the challenge does not require that actual CO2 conversion be performed. It only requires a plan to make the listed target compounds. If there is some work completed regarding hardware development and testing in pursuit of submitting the Phase I plan, that can be included in the Phase I submission. But the overall intent of the Phase I submission is to evaluate your plan regarding how you would intend to create an actual system that can synthesize the listed compounds. The fabrication and demonstration of your proposed system is the intent of Phase II.

Q2.36 If we have to convert CO_2 to 3C or larger compounds in Phase 1, then we are considering to propose two-step-approach to convert CO_2 to 3C or larger compounds. We wonder if it's acceptable, and yes, does it have a disadvantage against the proposal that applies direct conversion?

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3.0 PROCESS

Q3.1 I'd like to participate – how do I get started?

A3.1 You must first register no later than 5:00 PM Central on January 24, 2019. Registration is a simple two-step process. First, create a username and password and then check your inbox to confirm your registration. Next, complete the online registration form. Once you are registered, submit your application no later than 5:00 PM Central on February 28, 2019.

Q3.2 Do I have to participate in phase 1 in order to participate in phase 2?

A3.2 NASA envisions this competition having two phases. Phase 2 is contingent on the emergence of promising submissions in Phase 1 that demonstrate a viable approach to achieve the Challenge goals. Teams do not have to participate in phase 1 in order to participate in phase 2. However, any team registering for phase 2 must provide specific information that shows they are equipped to successfully compete in phase 2. The full description of requirements for phase 1 can be found in the official rules on the challenge site. The official rules and requirements for Phase 2 will be released prior to the opening of Phase 2.

Q3.3 How will submissions be assessed?

A3.3 During Phase 1: Concept, each valid application will receive scores and comments from a highly qualified Evaluation Panel who will use a trait-scoring rubric to assess their assigned submissions. All scores are normalized to ensure a Level Playing Field for everyone. Based on the rank order of submissions as determined by the Evaluation Panel, up to five top-scoring submissions will be named as Finalists and will receive $50,000 each.

Q3.4 What can I win?

A3.4 During Phase 1: Concept, up to five Finalists will receive an award of $50,000.

Q3.5 What is the collection method for the molecules? How should they be captured to use for conversion?

A3.5 In answering this question, it is assumed that the "molecules" referred to are CO2 molecules. For this challenge, no capture/collection/concentration of CO2 is required. It is expected that a pure source of CO2 (e.g., compressed CO2 in a tank) will be used as the CO2 source. While it is permissible to use other methods of CO2 sourcing, the source must not contain other carbon-bearing molecules (e.g., carbon monoxide, methane, etc.) that could contribute to intended CO2 conversion products. The products produced must be able to be made from CO2 and hydrogen source molecules only. It is up to the team members to decide how they would like to source hydrogen. Other consumable reagents/catalysts are of course allowed as part of the conversion process (e.g., acids/bases/metals).

Q3.6 Do we have to use a bioreactor for the conversion?

A3.6 The use of a bioreactor is not allowed as a component in the conversion of CO2 to products, nor required to demonstrate utilization of CO2 conversion products.

Q3.7 Will there be potential to test/send the entries to space or ISS for further testing?

A3.7 At this time, the Challenge will not directly lead to space-based testing or demonstrations. There is, however, the potential for all eligible participants to apply for future NASA grants and other opportunities which could possibly lead to further testing and eventual testing in space.

Q3.8 What happens to my intellectual property?

A3.8 While the Proposal Title, Technical Abstract, and Video for your submission may be published on this website and/or the NASA website, neither NASA nor any of the entities administering this competition shall obtain any right, title, claim or interest in the Entry, except as expressly identified by You to us in writing in Your application. NASA claims no right, title, or interest to any such intellectual property solely as a consequence of your participation in the competition, including the winning of a prize. NASA reserves the right to share any submissions received with its civil servants and contractors, and reserves the right to approach individual participants about any future opportunities at the conclusion of the competition.

Q3.9 How can I contact someone at NASA about my application?

A3.9 Please direct all questions regarding your CO_2 Conversion Challenge to questions@co2conversionchallenge.org, and a member of our support team will respond as quickly as possible.

Q3.10 We see that for phase 1, the concept phase, up to $250,000 will be awarded. Thus, up to five finalists will receive an award of $50,000. For phase 2, the prize purse is listed as up to $750,000. Is phase 2 set up similar to phase 1, what is the expected period of performance and what would be the total funding available: up to five finalists that will receive $150,000 each?

A3.10 The details of Phase 2 of the challenge are still under development and will be shared publically as soon as they are finalized. Will providing a budget analysis for the proposed work in phase 2 (contingent on how much will actually be awarded for phase 2) be seen as a plus in the phase 1 proposal? While a budget analysis is not required in the Phase I submission, it is permissible to include it. A thorough budget analysis will provide information that will potentially aid judges in understanding the prospect of fabrication and testing, and overall feasibility.

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Q3.12 Is there a targeted TRL for the end of phase 2?

Q3.12 The details of Phase 2 of the challenge are still under development and will be shared publically as soon as they are finalized.

4.0 ELIGIBILITY

Q4.1 Who is eligible to participate?

A4.1 Anyone can participate in the competition as long as they meet the eligibility requirements as stated in the Official Rules, and they are not a citizen or an entity from a country listed on the NASA Export Control Program List of designated countries under Category 2/Column 2. (The current list of designated countries can be found at https://oiir.hq.nasa.gov/nasaecp/docs/DCList_02-15-2017.pdf)

NASA welcomes applications from individuals, teams, and organization or entities that have a recognized legal existence and structure under applicable law (State, Federal or Country) and that are in good standing in the jurisdiction under which they are organized with the following restrictions:

1. **Individuals must be** U.S. citizens or permanent residents of the United States, and **must be** 18 years or older.
2. **Organizations must be** an entity incorporated in and maintaining a primary place of business in the United States.
3. **Teams must be** comprised of otherwise eligible individuals or organizations, and led by an otherwise eligible individual or organization.
4. **Teams must** conduct their demonstration work in facilities based in the United States, to include AK, HI and U.S. territories.

Refer to the Official Rules for a complete set of eligibility requirements.

Q4.2 Can a person with a green card (not US citizen) participate in the competition?

A4.2 Foreign citizens **may only participate** through an eligible US entity as

(i) An employee of such entity,
(ii) A full-time student of such entity, if the entity is a university or other accredited institution of higher learning,
(iii) An owner of such entity, so long as foreign citizens own less than 50% of the interests in the entity, **OR**
(iv) A contractor under written contract to such entity.

Q4.3 I am a Federal Employee, may I participate?

A4.3 U.S. government employees may enter the competition, or be members of prize-eligible teams, so long as they are not acting within the scope of their Federal employment, and they rely on no facilities, access, personnel, knowledge or other resources that are available to them as a result of their employment except for those resources available to all other participants on an equal basis.

U.S. government employees participating as individuals, or who submit applications on behalf of an otherwise eligible organization, will be responsible for ensuring that their participation in the Competition is permitted by the rules and regulations relevant to their position and that they have obtained any authorization that may be required by virtue of their government position. Failure to do so may result in the disqualification of them individually or of the entity which they represent or in which they are involved.

Q4.4 We're a Small Business Innovation Research (SBIR) program grantee. Can we apply?

A4.4 If you are a past grantee of the SBIR program, you may apply. If you are a current grantee, please note that no U.S. government funds may be used to prepare your submission. If you have any questions about your eligibility, please contact us at questions@c02conversionchallenge.org.

Q4.5 Can you participate as an individual in the competition?

A4.5 Individuals can participate in the competition as long as they meet the eligibility requirements as stated in the Official Rules.

Q4.6 Can we add additional team members after we have registered and completed the Team Registration form?

A4.6 New team members may be added to the team after the initial registration period ends. Team members previously registered for the challenge on one team may not switch teams during the same phase of the competition. The Team Leader must submit a revised Team Roster notifying NASA of the change, and the new team member(s) must sign an Adoption Agreement and Foreign Participation form (if applicable). Any changes to the team roster are not official until accepted by NASA. The existing Team Leader is accountable for any decision to make changes to the team roster, including bringing on new team members and/or releasing registered team members.

Q4.7 I am registered as an individual team. I am wondering what level of information I can request from professionals and companies while maintaining an individual status. I.e. if I contact a major manufacturer for designs or schematics or if they were to even create something on my behalf or run a test on my behalf, would I still count as an individual? What level of input can I have from 3rd party sources while still being considered an individual?

A4.7: You may reach out to any professional or company for help with the challenge as long as they maintain a primary place of business in the US. If a person is helping you and they are a US Government Federal Employee there are specific rules around their help. Please reference the Eligibility rules on the website. If you receive help from outside sources, please make sure you cite in your application that each party is aware of their official role, what is expected in the way of acknowledgement, and if you win or a new discovery is found, who owns the intellectual property. For more information, see Treatment and Use of Intellectual Property on the Rules web page.

5.0 WEBINAR Q&A

Questions 1-22- 1st Webinar, December 13, 2018
Questions #23-44- 2nd Webinar, February 15, 2019

Q5.1: If glucose has been made in in low earth orbit, what proportion of l-glucose/d-glucose are obtained?

A5.1: Glucose has not been made in low earth orbit using CO2 and water as starting chemicals. The proportions of l vs. d will be based on the type of process used. Biology has a great way of creating d-Glucose; whatever system we are using chemically must be able to differentiate between that mixtures.

Q5.2: What if my skill set isn't related?

A5.2: Your skill set may very well be applicable even if it's not directly related. Challenges are really good at bringing out participants that may not have direct experience. But often we find that people with different skill sets and in other disciplines are able to turn their attention to the problem and they may indeed have transferable skills. We encourage you to look at the application and find out what is needed to participate and determine if it's appropriate for you.

We do not look at your background, just the product. So anybody that thinks they can solve this should read the instructions and feel free to provide a product for us to consider.

Q5.3: Can you contact judges ahead of time?

A5.3: No. The judges need to remain impartial and need to indicate whether they have a conflict of interest with the applicants. This is something we take very seriously. All information (i.e. questions) will be shared with everyone so all the competitors have the same answer and information.

Q5.4: I created a shipping container that grows crops via aquaponics and powered by renewable energy. It can be controlled remotely though would require minimal human intervention. Should I still apply, or is this not what you were looking for?

A5.4: An aquaponics system is a biological system, and one of the conditions of the challenge is that the conversion of CO2 and Hydrogen be completely non-biological. A biological component to the process would not be applicable for this challenge.

Q5.5: If it's possible to generate a C4+ compound, but it is maybe unproven as a good growth substrate, would that be of interest for the challenge?

A5.5: We have listed the types of target compounds we wish to have on the website under the Technical Specifications.

Q5.6: Is the challenge for companies only or can universities also participate?

A5.6: Anyone can participate as long as they meet the eligibility requirements in the Official Rules. One restriction is also that competitors cannot use NASA funding to compete. If you are a Federal Employee, there are also some restrictions. Any specific questions can be submitted to questions@co2conversionchallenge.org.

Q5.7: Is there any complication if we license NASA technology...i.e. plasma rocket or related technology. As an example, could we use NASA technology, for example photodissassociation for CO2 conversion, in the challenge?

A5.7: As long as you are not directly funded to do that technology currently.

Q5.8: Can we license current technology from NASA?

A5.8: Likely yes, but it is not something that Centennial Challenges does. Our team can help you find the right process to go through, but this should be handled on a case-by-case basis.

Q5.9: The application form requires a large amount of liability insurance. Interested in the details of this constraint.

A5.9: Part of the legal authority for the Centennial Challenge Program includes that everyone who participates must have liability insurance. In this case, because it's only a proposal, you could be covered by your home or office insurance. Please refer to the website for a more extensive explanation. Any specific questions can be submitted to questions@co2conversionchallenge.org.

Q5.10: I understand the challenge is to "convert carbon dioxide into sugars". However, I thought that the oxygen in the carbon dioxide molecule does NOT convert into sugar, rather the oxygen in the CO2 molecule is a byproduct of photosynthesis and is exhausted into the atmosphere, whereas the oxygen from the water molecule is the oxygen that gets converted into glucose, is that correct?

A5.10: During the process of photosynthesis, that is true. But we are not interested in photosynthetic processes for this challenge. Only physical chemical conversions.

Q5.11: Is a proof of concept required? Or will a proposal that is theoretically sound do?

A5.11: The criteria section lists out the requirements and expectations for the proposals. For Phase 1, it is not required that you have something physically built. Proof of concept would provide more detail and certainty.

Q5.12: Would intellectual property developed in the challenge be the full rights of the innovator?

A5.12: Yes. NASA will not keep any of the IP. The teams that bring the solutions forward keep their IP.

Q5.13: Does the oxygen molecule need to come from the CO2 or just the carbon? As in could the O2 come from another source? As in how much of the CO2 molecule needs to become the glucose molecule?

A5.13: It doesn't matter as long as Carbon Dioxide is used as the Carbon source.

Q5.14: Have any of the previous Centennial Challenge winners obtained any follow-up funding for their successful idea?

A5.14: We cannot promise follow up funding. Once the challenge is finished, work between NASA and the competitors ends, but Centennial Challenges will help with ways competitors can continue to stay engaged with NASA through proposals, etc. CCP will try to guide competitors through these processes as much as we can. Past Challenge winners have been very successful inside and outside of NASA, but we cannot promise these opportunities will always happen.

Q5.15: How much detail do we need on sorting of regolith catalysts? Can we simply provide a schematic on what materials are available in the soil and dust or do we need to detail its sorting?

A5.15: We don't need to use a regolith as a catalyst. If you can its fine, if not, that's fine too. We don't have any regolith for testing, so if you have a plan of wanting to use regolith, you could use information that is currently known about it from the literature and propose how you would plan to use it accordingly. If you have a clear idea of how to use it, it would be better to include that in your concept rather than just including a "big idea".

Q5.16: Does that mean we can bring a metal catalyst from Earth?

A5.16: Yes.

Q5.17: If I have current NASA funding for the development of a given step in a process I propose, but is not the focus of the new technology to be developed. Would this be disqualifying?

A5.17: Send more details to questions@co2conversionchallenge.org and we will consult with our lawyers.

Q5.18: My proposal includes a trade secret. Could you expand on how is intellectual property protected? Revealing the trade secret, even as a provisional patent application, is risky for a small company like mine.

A5.18: All judges are civil servants with Non-Disclosure Agreements with strict penalties under the law. Common Pool is also under a Non-Disclosure Agreement. Be aware that there are a couple places in the application that may be shared on the website – proposal title (5 words), the technical abstract (50 words), and the video. Be thoughtful and cautious about what you share in these sections.
If you feel uneasy about it and want to contact us for more explanation or assurance, you can contact us at questions@co2conversionchallenge.org.

Q5.19: Is the brief video a requirement?

A5.19: Yes. It should be no more than 90 seconds.
This is your opportunity to connect with the judges in a personal and authentic way. Since these will be posted on the website, don't give away secrets of your technology. Does not have to be sophisticated – can be done with a cell phone. But you are encouraged to write a script and practice before submitting.

Q5.20: Can the data we present include links to government research OR do we have to rewrite the data in our own words and source articles?

A5.20: Be careful and thoughtful about including links. If your proposal includes a bunch of links, the judges will not be able to review those. You can include pictures and diagrams also, but do not include screen shots of words and documents in an effort to get around the word limits.

Q5.21: Can we use non-photosynthetic biological processes?

A5.21: Biological processes are not of interest. We are looking to push the thermodynamics and understand it better.

Q5.22: How much time do judges spend reviewing each application?

A5.22: The judges spend an appropriate amount of time reviewing that the quality of the proposal requires.

Q5.23: What happens, for example if a part of your submitted application, like the insurance, is found unacceptable upon review by NASA? Can you correct and resubmit that portion of the application or is your whole application rejected?

A5.23: During the Administrative review, which occurs after the submission deadline, Common Pool and NASA will review all applications. If there are issues with elements such as insurance, team leaders will be contacted and given an opportunity to make changes if needed. This is a good reason to submit your complete application as soon as possible so the reviewers have enough time to contact you.

Q5.24: Does the team bio and/or video for the application factor into the scoring rubric? If so, how much?

A5.24: The application as a whole is how it will be scored. See the scoring rubric here:
https://www.co2conversionchallenge.org/#scoring
The video is required and should support the overall details by adding clarity of what is being scored. It is not about high quality video production it is about establishing a relationship with the judges and speaking briefly about your proposal to add clarity to the submission.
The team bio is for reference purposes only and serves to better understand the team.

Q5.25: What purity of sugar is required?

A5.25: There is not a set requirement for the purity of the sugar at this point. Be careful if toxins are present, they are unwanted ingredients, but it is understood this may be a factor in the process. The target of the challenge is the ability to produce the sugar. The more pure the sugar, the higher your score will be.

Q5.26: Is a racemic mixture acceptable?

A5.26: Yes, it is. A racemic mixture may not be the best, the ultimate solution for us is D-Glucose. Mixed solutions or L-Glucose can cause problems in terms of sugar metabolism for some organisms. If you can make D-glucose rather than L-glucose you will receive a higher score in the rubric. You can reference the rubric for types of acceptable sugars and their scores here: https://www.co2conversionchallenge.org/#technical-specifications

Q5.27: Is a continuous process preferred?

A5.27: We are not requiring the process be a continuous process for Phase 1 of this challenge. The overall effectiveness of the process will be judged, regardless of whether it is a continuous or batch-type system. Reference high efficiency and specificity here: https://www.co2conversionchallenge.org/#technical-specifications

Q5.28: Are chains above C6 worth more points?

A5.28: Chains above C6 compounds are not current targets. If you are able to make these compounds it could positively affect your score, keeping in mind the other factors that will also have weight such as mass, power, etc.
Currently, D-Glucose is the target compound.

Q5.29: Can we change carbon dioxide into oxygen by using UV light with high intensity?

A5.29: Cannot comment about the method the apparatus uses to achieve the goal. If oxygen is omitted that is fine but, to clarify, the target compound is D-Glucose or other sugars.

Q5.30: On the "Trait Scoring Rubric" page, Feasibility section, one criteria for scoring is "Does the team clearly understand the risks and address them in their synopsis?" Please expand on what you mean by risk? Risk to a crew in Mars, or risk of the research to achieve the goal?

A5.30: We are unable to know what the particular risks are for your solution. From a project perspective, you should describe any risks to your approach as well as how to mitigate the risk within the method of conversation you are proposing (assuming different environmental factors and limitations such as microgravity or water etc.)?

Q5.31: Our system collects CO_2 out of ambient air (we have a working prototype) and then uses that CO_2 with co-generated H2 to make CH3 which can then be fed to engineered methanotrophs to make organics and food. Must the starting molecule be glucose, or can we use CH3 as our starting molecule?

A5.31: There are going to be many different pathways in the scenario for a solution to the challenge. Much research has been done with various organic compounds to feed organisms. The reason we have chosen glucose for this challenge is because it can feed many different host organisms to produce a broad range of products. The products we are hoping to create are most efficiently made from the target compounds we have listed in the challenge. The compounds produced in the solutions which will receive points can be found here: https://www.co2conversionchallenge.org/#technical-specifications

Q5.32: Do we have to provide a synthesis pathway for any catalysts used in the process or can we assume these are "off-the-self-products"?

A5.32: If the solution contains catalysts which are off-the-shelf and well characterized, there is no reason to explain the synthesis. If it's a unique catalyst, you should explain how you will make it so we can understand the feasibility of what you're proposing.

Q5.33: So the product must be glucose, so our CH3 to methanotrophs won't be considered?

A5.33: We are looking for a target product of glucose. The scoring rubric does show other compounds you could produce, and those will be given the appropriate score. CH3 is not one of the target compounds. See the target list here: https://www.co2conversionchallenge.org/#technical-specifications

Q5.34: We will not be able to test the whole synthetic pathway to D-glucose before the application deadline. We have a technology that shows promise in breaking up CO_2, and selectivity for making D-glucose. Will the application be weak if we do not present yields and purity but we just propose a research pathway on solid theoretical grounds?

A5.34: Proof you can do this is not required at this point. If you do have proof, it will make the application stronger. Any supporting evidence will help your application and will be taken into consideration in your overall scoring.

Q5.35: Should this concept be considered for deployment in space or a planetary surface, such as Mars?

A5.35: The challenge rules are independent of specifics of where the solution will be applied. You should take into consideration the application for the solution of the challenge is not intended to be on Earth. However, technologies often spin into other ideas that can be used on Earth.

Q5.36: Must this be all chemical reaction, nothing else?

A5.36: That's a difficult question. Both abiotic and biotic methods are chemical reactions. Biological processes are not allowed in this process. We are targeting completely abiotic solutions.

Q5.37: Is this challenge only converting into glucose?

A5.37: No, if you look on the website you can see we have a number of different targets. Your solution might contain a mix of these or only one. All of these compounds are target compounds, not just glucose. The highest preference factor is for D-Glucose. The preference levels and scoring rubric for the sugars can be found here: https://www.co2conversionchallenge.org/#technical-specifications

Q5.38: What if the end product is a mix of organics on the list?

A5.38: A mixture of those compounds is fine. We will be looking at specifics of what and how much of each of the target compounds are present, with D-Glucose scoring highest.

Q5.39: What is the target scale of product production?

A5.39: We would like to make this efficient and with little waste as possible. Scalability is impacted but we are not asking for a range at this point. Consider making your solution as fast as possible so the mass and volume and power requirements are minimized. The ability to scale is a beneficial feature but not a specific and strong driver at this point.

Q5.40: So we should look for abiotic process?

A5.40: Yes. We are limiting this challenge to abiotic processes.

Q5.41: Any thoughts on any exotic catalyst that are required? Toxicity, availability, favorability? I prefer not to use them but I am not sure if I can do without them.

A5.41: Exotic catalysts may or may not be required to accomplish this challenge in reality. They would be acceptable. The more difficult it will be to obtain the materials the less interesting the solution becomes. However, we are innately fine with exotic catalysts.

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Q5.42: Do we have to calculate power requirements (e.g. Kw usage) for the total process for the application?

A5.42: We are interested in understanding (an estimated) overall power, mass and volume. The more reasonable your solution for space missions, the more feasible the solution. Yes, we would appreciate a realistic estimate if possible.

Q5.43: The challenge would be easier if we knew more about waste products that can be recycled on mars? Human organic waste or garbage that can processed to make glucose?

A5.43: For the purpose of this challenge, we will not be considering these materials. We have looked at organic wastes – but that is a totally different area. The focus of this is challenge is to use in-situ materials (i.e. water, CO_2). Organic waste such as garbage is not in the scope of this challenge.

Q5.44: Is there a plan to announce any details on Phase 2?

A5.44: It depends on success of Phase 1. If we find there are ideas that may or may not work, we may continue to Phase 2. First we want to see the feasibility to make glucose in a design. Depending on submissions in Phase 1, we will decide on how to proceed to Phase 2. If Phase 2 seems reasonable, we will announce plans in the summer.