**CONCEPT PAPER DEVELOPMENT TEMPLATE**

Due January 23 5:00 PM to:

PI/Center: Steven Christensen/5K00

Category/Sub-Category (Page 5):

Project Title (draft): Developing a hybrid battery-liquid fuel cell for transportation applications

Lead Organization:5K00

Project Team and Role: Branden Kappes/Co-PI (Colorado School of Mines/PGI Inc.), Chunmei Ban, Katherine Hurst

**CONCEPT DEVELOPMENT TEMPLATE**

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| **EXPLICIT GOAL(S)**  (of ARPA-e) | * Reduces reliance on imported energy by promoting methanol as fuel source. * This proposed concept could be operated as a closed carbon system. * The concept proposes a solution to energy density problems with electric vehicles. |
| **ISSUES/NEED(S)**  (unwritten) | * Addresses need for high energy density in transportation applications. * Combines a battery and direct-methanol fuel cell (DMFC) as a hybrid power source * Will address specific issues with methanol crossover current. |
| **CONCEPT/IDEA**  (adddressing ARPA-e goals/needs) | We will develop a hybrid battery – direct methanol fuel cell (DMFC) system for application in electric vehicles. The technical issues we will address are reducing/eliminating methanol crossover current by developing composite membranes. We will also target catalyst dissolution by developing ternary acid-hardened catalysts. The team is comprised of Steven Christensen, Branden Kappes , Chunmei Ban, and Katherine Hurst. |
| **BENEFIT**  (to the customer) | Providing sustainable and scalable electric transportation that can serve private and commercial applications is a significant issue for US Energy Policy. This proposal provides a power system that has the energy density and energy-on-demand required and could be made to be a closed carbon system. |
| **PROOF/**  **VALIDATION** | Resolving issues with methanol crossover current will overcome the challenges to battery-fuel cell hybrid with a liquid fuel source. |

**STRATEGIC RESPONSE TO EVALUATION CRITERIA**

**In Purple -** RESPONSE CRITERIA (Page 32 of FOA)

Concept Paper Submissions will not be evaluated against each other since they are not submitted in accordance with a common work statement. The criteria will be weighted as follows:

1. *50% - Impact of the Proposed Technology*
2. *50% - Overall Scientific and Technical Merit*

| **CRITERIA** | **STRATEGIC RESPONSE** |
| --- | --- |
| **(1) *Impact of the Proposed Technology* (50%) ‐** This criterion involves consideration of the following factors: | |
| The extent to which the proposed **quantitative material and/or technology metrics demonstrate the potential** for a transformational and disruptive (not incremental) advancement compared to existing or emerging technologies; The extent to which the proposed concept will have a **positive impact on at least one of ARPA‐E’s** **mission areas** in Section I.A of the FOA; and | * Can you demonstrate potential?   Hybrid battery-liquid fuel cell power generation offers the potential to overcome major shortfalls in transportation.   * Extent of Mission Area Impact: Reducing imported energy: methanol; Reducing energy related emissions: methanol can be produced from biomass, resulting in a closed carbon system; This improves energy efficiency for electric transportation. |
| The extent to which the Applicant demonstrates **awareness of competing** commercial and emerging technologies and **identifies how** the proposed concept/technology provides **significant improvement** over existing solutions. | * Competing Technologies: Relative to transportation: combustion engine, battery electrics, all fuel cell electrics, hybrids * Significant Improvement: Hybrid battery – fuel cell systems combine the high specific energy of liquid fuels with the rapid charge/discharge (power) kinetics of battery technology. Therefore, this hybrid system mitigates the shortcomings of each technology while harnessing their strengths. The battery, charged by the fuel cell, can be maintained within an optimal depth of charge. |
| **(2) *Overall Scientific and Technical Merit* (50%)** ‐ This criterion involves consideration of the following factors: | |
| The **feasibility** of the proposed work, as justified by appropriate background, theory, simulation, modeling, experimental data, or other sound scientific and engineering practices; | * Is the idea feasible? Advancements in highly selective semipermeable membranes allow for a dramatic reduction in the the crossover current in DMFCs. This is the primary technical challenge we can address through the development of composite membranes. Additional improvement in longevity can be obtained with acid hardening of catalysts. |
| The extent to which the Applicant proposes a sound technical **approach to accomplish the proposed R&D objectives**, including why the proposed concept is more appropriate than alternative approaches and **how technical risk will be mitigated**; | * Technical Approach:   1) Develop composite fuel cell membranes that enable hydrogen permeation and block methanol.  2) Pursue acid hardened ternary catalysts: Pt-Ru-X, X = C, N, B  3) Improvement in battery technology results in a multiplicative increase in specific energy and energy density, as a reduction in battery volume or mass can be replaced by higher-energy dense methanol. A nanostructured, highly networked, silicon-based lithium ion battery chemistry will be developed for incorporation into the hybrid power system.   * Identified risks and mitigation:  1. Ineffective proton transport in the composite membrane has been mitigated by chemical modification of the inorganic component. 2. Concurrent development of both fuel cell and battery components risks disparity in development timelines. Low power DC electronic coupling between the two components separate the two components and permit such disparity by affording the use, during development, of existing, commercially available technologies: “stand-ins”. |
| The extent to which project outcomes and final **deliverables are clearly defined**; | * Project Outcomes are: a hybrid battery – fuel cell power system. |
| The extent to which the Applicant identifies **techno‐economic challenges** that must be overcome for the proposed technology to be commercially relevant; and | * Techno-Economic Challenges: Market insertion. Methanol production/availability. |
| The **demonstrated capabilities** of the individuals performing the project, the **key capabilities** of the organizations comprising the Project Team, the roles and responsibilities of each organization and (if applicable) previous collaborations among team members supporting the proposed project. | * Key Personnel Qualifications: * Project Team Qualifications: |