(This is a Request for Information only - Complete Pages 1 and 2 for each initiative)

Title of Proposed Initiative: Hybrid Fuel Cell/Gas Turbine

Investment Areas (Check one or more) – *For definitions, see First Triennial Investment Plan, page 12*:

☒ Applied Research and Development

☒ Technology Demonstration and Deployment

☐ Market Facilitation

Electricity System Value Chain (**Check only one**): *See CPUC Decision 12-05-037, Ordering Paragraph 12.a. http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/167664.PDF.*

☐ Grid operations/market design

☒ Generation

☐ Transmission

☐ Distribution

☐ Demand-side management

California Energy Commission
DOCKETED
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Issues and Barriers:

Hybrid Fuel Cell/Gas Turbine hybrid technology portends a paradigm shift for the manner by which electricity can be generated and simultaneously meet strict environmental goals. The combination provides a synergism that is unique. Required is an opportunity to optimize the combination and thereby guide the design of systems that will achieve the exemplary performance anticipated for the technology.

Initiative Description and Purpose:

The proposed technology is a new class of hybrid combined heat and power systems based on the integration of a high-temperature fuel cell (HTFC) with a gas turbine (T). The HTFC-T hybrid overcomes the constraints of the Carnot efficiency and synergistically converts fuel-to-electricity (FTE) at unprecedented efficiency, while still providing high grade heat for cogeneration for overall efficiencies that are even higher. The technology portends the most energy efficient and environmentally sensitive means of transforming natural gas to electricity, but is sufficiently flexible to operate with biofuels and mixtures of natural and biogas. The proposed project envisions the first commercial HTFC-T hybrids as molten carbonate based fuel cells (MCFC-T) and the next generation hybrids as solid oxide based fuel cells (SOFC-T). As a pathway forward to a megawatt-class hybrid SOFC-T, the proposed project will OPTIMIZE a megawatt-class hybrid MCFC-T for an immediate demonstration and, based on lessons learned, design an optimally integrated megawatt-class SOFC-T for a future demonstration and subsequent market introduction.
Recommended minimum funding level = $600,000/project; Recommended maximum funding level = $1,800,000/project.

Stakeholders:

Capstone Turbine; FuelCell Energy; Solar Turbines; Caterpillar; California Air Resources Board; University of California; Sacramento Municipal Utility District; Southern California Edison; Southern

California Gas; PG&E; SempraEnergy Utilities; U.S. Environmental Protection Agency; Air Pollution Control Districts and Air Quality Management Districts; Bloom Energy;

Background and the State-of-the-Art:

State-of-the-Art. Prior experimental and theoretical experience has resulted in a significant understanding of HTFC-T capabilities and potential. Robust dynamic simulation codes for HTFC-T systems have been developed based on a foundation of rich data sets from:

- A 2003 U.S. Department of Energy (DOE) prototype 220kW SOFC-T that operated successfully at the NFCRC for 2900 hours with FTE efficiency of 53% (natural gas LHV-basis),
- A DOE "Vision 21" integration of a 250 kW FuelCell Energy molten carbonate high-temperature fuel cell with a 30 kW Capstone microturbine (MCFC-T) that operated for 2800 hours in an atmospheric fuel cell configuration with 52% FTE efficiency, and
- A 2007 DOE MCFC-T demonstration in Billings Montana, achieving unprecedented small-scale (250kW) electrical generation performance at 56% FTE efficiency.

Shortcomings, Limitations, and Challenges. The need to establish a gas turbine for a megawatt-class HTFC-T and OPTIMIZE the system components for better integrated performance is the principal shortcoming, limitation, and challenge. The principal target for the OPTIMIZATION is the integration of the two components, the design of the compressor and turbine mass flows, and the operating temperatures and control flexibility.

Justification:

Describe how this technology or strategy will provide California IOU electric ratepayer benefits and provide any estimates of quantified annual savings/benefits in California, including:

- The increased efficiency will reduce operating costs and result in a reduction of costs to the IOU rate-payer.
- The environmental characteristics of HTFC-T systems (high efficiency, virtually zero criteria pollutant emission, acoustically benign, virtually zero water demand) allow strict environmental constraints to be met with systems that are attractive aesthetically
- HTFC-T systems are an excellent fit for TIGER (Transmission Integrated Grid Energy Resources Stations) and thereby portend the opportunity to dramatically increase the reliability of grid networks, a goal of direct benefit to the IOU rate-payer
- This research is appropriate for public funding because it is not currently being accomplished by the private sector.

Ratepayer Benefits (Check one or more)**:**

☒ Promote greater reliability

☒ Potential energy and cost savings

☐ Increased safety

☒ Societal benefits

☒ Environmental benefits – better air quality, less waste disposal

☒ GHG emissions mitigation/adaptation in the electricity sector at the lowest possible cost

☐ Low emission vehicles/transportation

☒ Waste reduction

☐ Economic development

Describe specific benefits (qualitative and quantitative) of the proposed initiative

Public Utilities Code Sections 740.1 and 8360:
The proposed research initiative is in alignment with section (e) (1) of CPUC Code Section 740.1 by supporting environmental improvement associated with the State's climate change and air quality goals. Additionally, the proposed research meets the criteria of these public utilities code sections by (a) providing benefits to ratepayers and (d) as no similar research is currently being undertaken.