Title of Proposed Initiative (Short and concise): **Real Time Response to Feedstock Variability**

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
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Issues and Barriers:

The performance of combustion systems for electrical generation is highly sensitive to slight variations in fuel compositions. This has been a major technical barrier for the power, transportation, and heating industries to adopt renewable fuels and/or their natural gas fuel blends. Because of this known problem, land-fill-gas is not allowed into natural gas pipelines in California. To circumvent the transportation restriction of biofuels, burning them in stationary systems for heat and power generation on-site or within the neighborhood (i.e. local) seems the best strategy to help meet our aggressive renewable energy and GHG reduction goals. Burners for stationary systems are slightly more tolerant to fuel variations than reciprocating engines. However, they are subjected to more stringent emissions regulations. Some stationary systems have been configured specifically for renewable fuels to meet these regulations but they cannot operate on natural gas or propane without significant performance degradation in terms of lowering efficiency and increasing emissions. Because availability of renewable fuels can be intermittent, not having a fuel-interchangeable option relegates renewable-fuels-only systems to be relatively costly niche products. CEC and the utilities (e.g. SoCalGas) recognize this barrier and are supporting research to develop gas fuel interchangeability indices. However, applying such knowledge to heating and power products of all sizes requires a fundamental design change in the dry-low-NOx (DLN) combustion systems so that they can be responsive to fuel changes without requiring costly peripheries to monitor and control their performances and/or even costlier exhaust gas cleanup. Fuel-interchangeable combustion systems that are competitive in cost, reliability, and performance with contemporary natural gas DLN systems will overcome these barriers to accelerate the penetration of renewable fuels into the California market.

Initiative Description and Purpose:

This purpose of the initiative is to develop and demonstrate gas fuel interchangeable DLN combustion systems for commercial to large industrial heaters and power generators. The collaborators are national lab, universities, AQMD, renewable fuel generators, equipment manufacturers and end users. The foundation of the approach is to exploit advanced fuel-interchangeable combustion concepts that are compatible in size, shape, and functionality with most existing equipment. Proven concepts developed by research institutions and equipment manufacturers will be sought. The fuel

interchangeable indices from a current CEC study will be used to determine their fuel-interchangeability potential. The performances of the burner in terms of fuel acceptance (i.e. renewable fuel, natural gas and their fuel blends), flame stability, flame size, flame shape, combustion efficiency, emission, and turndown will be determined and compared. Prototype systems for the higher ranked concepts selected by an independent advisory committee will be developed and demonstrated in a boiler simulator and/or a gas turbine combustor simulator. The outcome of the initiative is to confirm that new combustion concepts can address the issues brought about by interchanging between renewable fuels and natural gas. That these systems can be retrofits and do not increase the size, the foot print, or limit the deployment readiness of the systems will ensure market acceptability and eventual penetration.

Stakeholders:

Micro turbine and mega-watt size gas turbine manufacturers, Commercial to large-industrial heating equipment manufacturers, End-users of heating and power equipment, Renewable fuel generators, California rate payers, California utilities and AQMD, Research universities, national laboratories and other research institutions

Background and the State-of-the-Art:

Research and development of gas-fuel interchangeability combustion systems have mainly focused on hydrogen-syngas-methane blends for the gas turbines in an Integrated Gasification Combined Cycle (IGCC) plant. Hydrogen is an energetic fuel. Results from the DOE Office of Fossil Energy projects show that operating hydrogen in a gas turbine required fundamentally different combustion concepts. On the other hand, renewable fuels are less energetic than natural gas. Studies have shown that natural gas burners can be re-tuned for renewable fuels. Products are available in the market for specific types of renewable gas fuels but meeting the stringent emissions standard in California remains a great challenge. Truly fuel-interchangeable and clean equipment for heating and power are not widely available. The main technical challenge is to maintain a stable flame when burning the weaker renewable fuel while not causing flashback when switching to the more robust natural gas flame. In the past two decades, several ultra-clean burner ideas have been developed for DLN systems and they are ripe for fuel-interchangeable developments. The surface stabilized burner concept pioneered by Alzeta Corp. and the low-swirl burner developed at Lawrence Berkeley National Lab. (both received funding from CEC DOE) have found their ways to industrial heating products, and have also been demonstrated in gas turbines. The basic premise behind these burners is to promote more stable flames by reducing the levels of shear turbulence. Through DOE support, a fuel-flexible low-swirl burner (hydrogen/syngas/natural gas) has been demonstrated. CEC is supporting the demonstration of a low-swirl burner based 65 kW microturbine operating on digester gas. For conventional DLN high-swirl burners, the development of staging strategy holds promise for fuel-interchangeable operation. In development and adaptation of these technologies to fuel-interchangeable systems, the technical issues will be to find passive means to mitigate blow-out, flash back, while maintaining a clean and stable flame. Other issues concern with engineering of a fuel injection and premixing system optimized for different fuel properties. For these systems to have maximum impact on renewable fuel penetration, the key challenge is to make them compatible in size, shape and functionality with most existing system platforms.

Justification:

Renewable gaseous fuels from waste water treatment plants, agricultural biomass, and landfills are often released into the atmosphere because they require special and costlier equipment to utilize on site, and their supply can be intermittent. Cost-competitive and reliable gas-fuel interchangeable combustion systems, i.e. ones that operate efficiently and ultra-clean on renewable fuels, natural gas and their blends, will eliminate releasing or flaring by providing a reliable platform to convert waste gases to energy, and ensuring a stable energy supply because natural gas can be used as a makeup or backup fuel. This initiative will create an excellent opportunity for California to accelerate

renewable gas fuel penetration through on site or local utilization. This will be a significant component in helping the State reach our 33% renewable energy goal for 2020. Additionally, increasing fuel-interchangeability with greater turndown capability saves energy by allowing combustion systems to operate at maximum efficiencies at different load points.
This strategy will provide natural gas ratepayer benefits through

- A market enabler for broader and direct utilization of renewable gaseous fuels to impact on all economic sectors that utilize natural gas combustion systems.
- Fuel-interchangeable combustion systems will have maximum technology potential for commercial to large industrial heaters and power generators.
- Fuel interchangeable combustion systems that are compatible in size, foot-print and functionality with current heating and power equipment have maximum market potential for retrofits and new installations.
- The technical potential of available renewable biomass in California is estimated to be 40M tones in 2020. Utilizing all the biomass will offset 50M tones of CO_2 from fossil fuels. The economic value in terms of carbon offset credit of $15 - $20 /ton CO_2 approaches $1B

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

☒ Promote greater reliability

☒ Potential energy and cost savings

☐ Increased safety

☐ Societal benefits

☒ Environmental benefits – specify

☒ 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

This project offers a technical solution to address market barriers to the use of biogas fuels. The benefit to California natural gas ratepayers, industry, and utilities is a reduction of pipeline natural gas consumption. The demonstration will show that fuel switching, system efficiency, ultra-low emissions, and cost effectiveness are not mutually exclusive.

Public Utilities Code Sections 740.1 and 8360:
Please describe how this technology or strategy addresses the principles articulated in California Public Utilities Code Sections 740.1 and 8360. The California Public Utilities Code is available online at www.leginfo.ca.gov/cgi-bin/calawquery?codesection=puc.
As described above, this technology meets Code Section 740.1 (a) offer a reasonable probability of providing benefits to the ratepayers, (e)(1) environmental improvement through reduced water consumption and air emissions, (e)(3) reducing or shifting system load, and (e)(5) improving operating efficiency and reliability. It also meets Code Section 8306, the State's policy to modernize the electrical transmission and distribution system to maintain safe, reliable, efficient, and secure electrical service (b) dynamic optimization of grid operations, (c) deployment and integration of cost effective demand response and demand-side resources, (d) deployment of cost-effective smart technologies that optimize the physical operation of consumer devices.