STATE OF CALIFORNIA

EPIC TRIENNIAL INVESTMENT PLAN 2015-17
Proposed Energy Research Initiative
Questionnaire

CALIFORNIA ENERGY COMMISSION

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

Title of Proposed Initiative: Combined Cycle Partial Refueling with Biomass Derived Syngas

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

X☐ 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

X☐ Generation

☐ Transmission

☐ Distribution

☐ Demand-side management

California Energy Commission
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Issues and Barriers: Due to its low energy density, transportation of biomass collected from various locations over long distances to a central plant makes it economically prohibitive to compete with well-established energy carriers such as coal, oil and natural gas. Energy planners are thus moving away from large centralized biomass based power plants to a more decentralized concept of supply which fits nicely with the nature of biomass resources. Furthermore, due to the seasonal variation in the feedstock availability and due to the smaller size of decentralized biomass gasification facilities, the construction of a pipeline dedicated to transportation of the syngas over long distances would not be an economically attractive option. Thus, the biomass facility has to be located in close proximity to the feedstock as well as to the existing combined cycle plant to be refueled.

Initiative Description and Purpose: An applied research and development study is proposed to evaluate the techno-economic feasibility of constructing a biomass gasification facility to supply at least a portion of the fuel gas required by an existing combined cycle plant with syngas. The biomass derived syngas which is considered "CO_2 neutral" would thus displace a portion of the natural gas used by the existing combined cycle. During seasons of low biomass feedstock availability, the existing combined cycle plant would have to increase its natural gas usage (i.e., approach its original consumption rate) to off-set the decrease in the biomass derived syngas supply.

The key objectives of this study will consist of identifying the suitable refueling or partial refueling (depending on the size) scenarios of a natural gas fired combined cycle plant with syngas derived from biomass gasification by developing plant performances, the environmental signature and rough order of magnitude capital and operating expenditure requirements for a selected number of combined cycle power plant sizes and site locations. The technical and economic feasibility of this concept will be established and any hurdles or improvements to implementing such systems will be identified. The length projected for the study is two years with a projected budget of $180,000 per year.

Stakeholders: The stakeholders who would support the initiative include utilities that should be able to get credit for the reduction in greenhouse gas emissions due to replacing a portion of their fossil fuel usage with biomass.

Background and the State-of-the-Art: Current state-of-the art gasification technologies to produce syngas from carbonaceous feedstocks entails partial oxidation using O_2 supplied by an air separation unit. Small scale air separation units required for these biomass based plants will be quite inefficient and prohibitively expensive. Air blown gasification is used in some applications but the resulting syngas is diluted with N_2. Hydrogasification technology consisting of reacting the feedstock with H_2 separated from the syngas and recycled back to the gasifier for the reaction: $C + 2H_2 = CH_4$ shows a number of advantages not only in terms of thermal efficiency but also plant cost by not requiring an air separation unit. The hydrogasification technology is under development for coal conversion[1] but biomass feedstock with its higher reactivity and potassium content (a catalyst for the above hydrogasification reaction) is especially suitable to this gasification technology. Studies have been conducted for the DOE and NSF on large scale applications of this technology for electric power generation[2]. The syngas generated by this gasifier will have a high concentration of CH_4 which will make the syngas more suitable for blending with natural gas. The conversion of the remaining H_2 and CO in the syngas to CH_4 may also be accomplished by including a methanation unit, if required.

Justification: This technology / strategy will provide California IOU electric ratepayer a number of benefits while reducing greenhouse gas emissions of the state. The electric utility sector will be able to benefit from implementation of this renewable energy technology. An assessment of the biomass resources in California was made by the California Biomass Collaborative for the California Energy Commission in a Public Interest Energy Research Program[3]. The findings of this research program indicated that one of the principal sources of biomass in California was agriculture waste. For example, California produces about 4.5 million tonnes (5 million tons) per year of field crop residues, principally as cereal straws and corn stover. These materials are not currently used for power generation due to problems with ash slagging and fouling in combustion systems.

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

☐ Promote greater reliability

☐ Potential energy and cost savings

☐ Increased safety

x☐ Societal benefits

☐ Environmental benefits - specify

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

☐ Low emission vehicles/transportation

☐ Waste reduction

x☐ Economic development

[1] bluegas™ using proprietary catalyst performed pilot testing in 2006 – 2007 at 1 TPD coal. A demonstration unit in partnership with China Wanxiang at $30x10^9$ m^3/yr of SNG is being developed.

[2] (i) Li M, Rao AD, Brouwer J, Samuelsen GS. Design of highly efficient coal-based integrated gasification fuel cell power plants. Journal of Power Sources 2010; 195: 5707–5718. (ii) Li M, Rao AD, Samuelsen GS. Performance and costs of advanced sustainable central power plants with CCS and H2 co-production. Applied Energy 2012; 91 (1), 43-50.

[3] CEC-500-2005-066-D, April 2005.

Describe specific benefits (qualitative and quantitative) of the proposed initiative: One of the specific benefits of the proposed initiative is that the greenhouse gas, CO_2 emissions will be reduced by substituting some of the fossil fuel, natural gas used currently for electric power generation. The pollutants generated during the disposal of the agricultural wastes are also avoided as the waste will be utilized. Hydrogasification technology has been found to be both an efficient and an economically attractive alternative for conversion of carbonaceous feedstocks to a clean fuel gas.

Public Utilities Code Sections 740.1 and 8360: This technology / strategy addresses the principles articulated in California Public Utilities Code Sections 740.1 and 8360 since this project offers a reasonable probability of providing benefits to ratepayers without duplicating research that was undertaken previously or being currently undertaken by other electrical or gas corporations or research organizations for biomass conversion. Yet it leverages the knowledge accumulated on coal conversion to reduce the research and development funds required for commercializing biomass hydrogasification technology. It also supports environmental improvement by (i) reducing greenhouse gas emissions, (ii) conservation by efficient resource use of biomass, and (iii) development of new renewable fuel resources and processes for their effective use. Finally, it allows for the deployment and integration of cost-effective distributed renewable resources.