ATTACHMENT 2
Executive Summary Form

PON-14-505 - Advancing Clean Energy from Biogas, Biomethane and Natural Gas

Project Title: Wood Chips on the Natural Gas Pipeline - RNG Production from Biomass

Project Applicant: University of California, San Diego

1. **Project description:** The project targets energy conversion of the 61 million dry-tons of annual biomass resources (out of 78 million dry-tons) that are not suitable for biochemical conversion. Thermal conversion of this underutilized resource to syngas and upgrading by methanation to Renewable Natural Gas (RNG) for pipeline injection would have a significant impact on the state's renewables portfolio, with a potential to replace 10 to 20% of our current fossil natural gas usage. Because the syngas needs to be very clean before the methanation step, this project proposes to focus on cost reduction and technical performance of the gas cleanup after biomass gasification. It also investigates methanation in a fluidized-bed reactor, which would allow a larger amount of certain contaminants and allows for superior thermal management of the exothermic methanation reactions. The innovations proposed in these two areas would bring down the overall cost for commercial methanation, enabling our vast biomass resource to be utilized to generate RNG. The technical and economical performance of the system will be analyzed in order to support a commercial demonstration project capable of producing 60 MW of RNG for pipeline distribution and renewable power production in a high efficiency gas power-plant facility.

2. **Project goals and objectives:** The goal of the proposed project is to reduce the costs of cleanup of producer gas and to reduce the costs of methanation to generate RNG. One objective of the proposed project is to accurately measure trace contaminants in the producer gas from a state-of-the-art gasifier in order to determine necessary cleanup steps. Another objective is to select and test gas-cleanup methods that bring the contaminant level to the level required by fluidized-bed methanation catalysts. The next objective is to verify that the cleaned gas is able to perform in the methanation process without deactivating commercial catalysts. The final objective is to use the technical results of the study to conduct technical economic analysis for full scale demonstration plant that address the most significant potential risks associated with biomass resource, the thermal biomass gasification, gas conditioning, and methanation processes.

3. **Explanation of how project goals and objectives will be achieved, quantified, and measured:** A FICFB (Fast Internally Circulating Fluidized Bed) gasifier at the pilot-scale of 5 dry-tons/day has been built and commissioned by West Biofuels over the last years. The gasifier is able to achieve very low levels of tars before any gas cleanup (tars larger than toluene less than 50 mg/Nm^3 or 10 ppmv). Online testing of further gas cleanup steps will be performed and producer gas from the gasification will be collected and stored in order to conduct further in-depth study of the removal of trace contaminants. Measurement methods will be developed in order to measure the level of contaminants down to low levels. Once the cleaned gas is suitable for methanation, it will be tested over a fluidized-bed methanation catalyst to prove the long-term economic viability of the catalyst. A technical and engineering study will be developed based on the information gathered at the studies, combined with the information available from other operating plants of similar technology for a projected future commercial scale RNG plant.

4. **Project task description:**

Task 1: General Project Tasks. UC San Diego leads the administrative task including the schedule, meetings, progress reports, final report, and the technical advisory committee.

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Task 2: Contract Execution. Contracts are executed for operations and verification work.

Task 3: Prepare Measurements on Gasification Plant. A plan for measurement locations and gas withdrawal will be setup. A protocol for the analysis of gas, liquid, and solid samples will be developed. Gas compression equipment will be acquired and setup to collect gas samples for later use. A measurement and verification protocol will be developed to record the important process parameters of the pilot plant. Systems for feedstock delivery and gas cleanup will be prepared. A Measurement and Analysis Plan will summarize the task.

Task 4: Characterize Raw Gas from Fluidized-bed Gasification for Cleanup and Methanation. The gas composition will be measured during 100 hours of pilot plant operation. This includes online measurement of gases (major gases, H_2S, NH_3) as well as collection of liquid and solid absorption media with absorbed trace contaminants (S, Cl, K). The trace contaminants will be analyzed offline by processing the absorption media. Product gas will be compressed into pressure cylinders for later experiments and analysis. Process parameters of the pilot plant during this operation will be recorded and an energy and mass balance will be generated. Results are presented in a Gasification Test and Analysis Report.

Task 5: Test Gas-Cleanup System. Gas cleanup system components will be designed and setup at the laboratory scale for the removal of critical contaminants from producer gas. The goal is that the gas is clean enough for the long-term stability of a methanation catalyst. For this, three char-coal filter media will be tested: active carbon or micro/meso porous carbon (BrightBlack), biochar from a downdraft gasifier, and char from pilot-plant product gas filter. Gaseous contaminants (NH_3, HCl, alkali) that are soluble in certain liquids can be efficiently reduced by scrubbing. The results will be reported in a Gas-Cleanup Test Report.

Task 6: Test Methanation Catalyst on Cleaned Producer Gas. Acquire a commercial fluidized-bed catalyst that is suitable for methanation and compatible with the contaminant level of the cleaned gas. Design and fabricate a small-scale fluidized-bed methanation experiment in which the catalyst can be tested with the cleaned producer gas and laboratory gas with added contaminants. Confirm that the catalyst is able to retain its activity for 300 hours of operation on laboratory gases and for 100 hours on the cleaned producer gas with analysis of the catalyst for physical and chemical change. The results will be summarized in a Methanation Test Report.

Task 7: Evaluation of Project Benefits. Based on the measured effectiveness of the gas cleanup, costs for larger scale gas cleaning will be estimated. The resulting measured values of trace contaminants in the cleaned gas will allow a projection of catalyst life-time and cost. The benefits of extending the catalyst lifetime can be calculated which translate into cost savings at the commercial scale. These will be evaluated to address the costs and risks for a future commercial project producing 60 MW of RNG for the natural gas pipeline.

Task 8: Technology Transfer Activities: Activities include presentations at conferences and scientific journal publication. They also include the suggested Initial Fact Sheet, Final Project Fact Sheet. A Technology/Knowledge Transfer Report documents these activities.

Task 9: Production Readiness Plan: A production readiness plan will be developed based on the information gathered at the pilot and laboratory scale, combined with the information available from other operating plants of similar technology and regional information on biomass availability. The Production Readiness Plan will be developed together with SMUD for a future commercial scale demonstration project to produce 60 MW of RNG.

5. **Agreement management description:** The project will be managed by the University of California using standard practices, protocols and terms for a research program.