Gasification-Combustion Technology for utilization of waste renewable fuels

G. Rizeq[a], V. Zamansky*[a], B. Springsteen[b], T. Miles[c], V. Tiangco[d], and P. Sethi[d]
[a]GE Energy and Environmental Research Corporation, 18 Mason, Irvine, CA, USA 92618
Fax: 949-859-3194; grizeq@eercorp.com
[b]EERGC, [c]T.R. Miles, Technical Consultants, Inc., [d]California Energy Commission

Successful development of the biomass power industry greatly depends on the availability and utilization of diverse and low-cost waste renewable fuels. Currently, due to slagging and fouling of boilers' heat transfer surfaces, biomass boilers cannot use a variety of bio-feedstocks with high alkali content. A concept which may reduce NO_x emissions from biomass boilers and utilize low-grade biomass and other waste fuels without slagging and fouling problems is presented. In this concept, entitled Close-Coupled Gasification (CCG), the gasification technology is synergistically combined with reburning methods and with direct combustion of biomass products. The gasified product can be used in existing boilers in cofiring, reburning, and advanced reburning modes, providing up to an estimated 90% reduction in emissions (with advanced reburning) of NO_x and N_2O, a greenhouse gas. CCG can be also used for coal- and oil-fired boilers. Substitution of fossil fuels with renewable fuels results in a reduction of net CO_2 emissions. Predicted composition of the gasified product suggests that it can serve as an effective reburning fuel. Basic and advanced reburning tests with waste fuels have previously demonstrated NO_x control in the range of 60-90%. As an example, one of the potential applications (direct combustion – reburning using gasification products) is shown in Figure 1. This figure shows a variant in which the products of gasification are directed to the reburning zone of a coal-fired boiler.

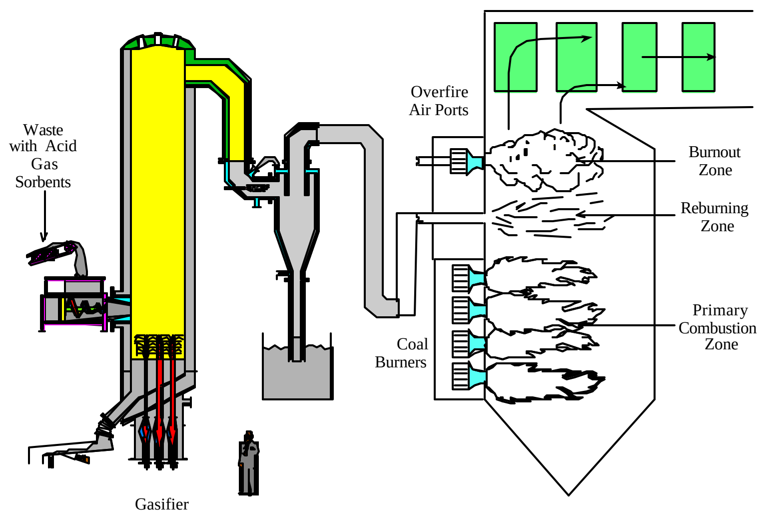

Figure 1. A variant of CCG technology: combination of direct combustion with reburning of waste gasification products.

To evaluate the overall characteristics of the CCG technology, a research and development program funded by the California Energy Commission started in the summer of 1999. The program objectives include: (1) conducting a resource assessment study to select biomass fuels for the experimental program; (2) identifying the most promising feedstocks via laboratory-scale gasification screening tests; (3) optimizing cofiring and reburning performance of gasified products in a pilot-scale combustor simulating conditions of a specific biomass boiler with selected fuels against critical process variables; (4) characterizing flue gas emissions for cofiring and reburning with gasified fuels including CO, SO_2, HCl, dioxins/furans, and trace heavy metals; and (5) quantifying changes in the furnace slagging and convective pass fouling characteristics, if any, under cofiring and reburning conditions with gasified waste fuels. The test program will be followed by detailed economic and engineering evaluation.

This paper presents results from the resource assessment study and preliminary experimental results from the pilot-scale cofiring/reburning tests. Results from the laboratory-scale tests will be described in a separate publication. The resource assessment study involves an evaluation of the availability and delivered cost of potential waste fuels in California. Fuel supply cost curves are presented for three existing biomass boilers targeted for full-scale demonstration of the CCG concept. The outcome of the resource assessment was the selection of six underutilized biomass waste fuels for testing in the program. The selected biomass fuels include rice straw (fresh), almond shell, whole tree chips, Ag prunings, non-recyclable paper, sewage sludge. Quantities of selected fuels suitable for the lab- and pilot-scale experimental programs were collected, processed, and are currently being tested.

The pilot-scale cofiring/reburning experimental program is underway. The pilot-scale system encompasses an air-lock biomass screw feeder, a hybrid fluidized bed (HFB) gasifier (Figure 2), a solid fuel test facility (SFTF, Figure 3) simulating a stoker boiler, and associated continuos emission monitors and control panels. Gasification is performed in the HFB which consists of a bed section, a freeboard region, and auxiliary equipment. The test fuel, in this case biomass waste material, is added to the center of the bed. Combustion tests are performed in the SFTF which is a 1×10^6 Btu/hr pilot-scale research combustor consisting of a horizontal barrel section followed by a vertical controlled temperature tower, sampling pass, and baghouse. Gasification products from the HFB are utilized in the SFTF for cofiring or reburning to reduce NO_x emissions. Various continuous emissions monitors are connected to the gasifier and combustor outputs to measure effluent gases composition including O_2, CO_2, CO, and hydrocarbons.

Operational experience, problems encountered during initial pilot-scale tests, and cofirng/reburning preliminary results are presented. Test results on optimizing cofiring and reburning performance of gasified products against critical process variables, including gasification temperature, residence time, air flow rate to the gasifier, gas composition, injection location, percentage of heat input, and overfire air temperature in the reburning mode are presented. Other effects, including potential bed agglomeration as a function of bed temperature and fuel type, along with fouling deposition in the post flare region, are also discussed.

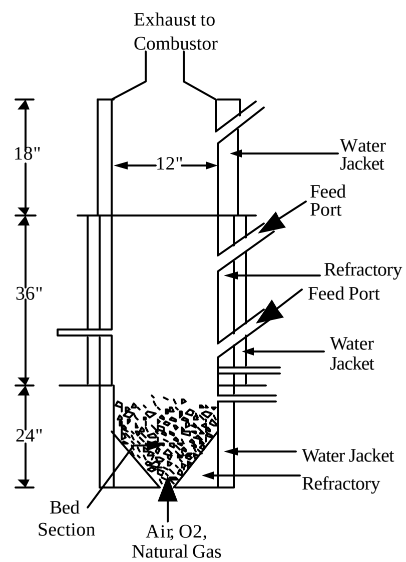

Figure 2. GE-EER Hybrid Fluidized Bed (HFB).

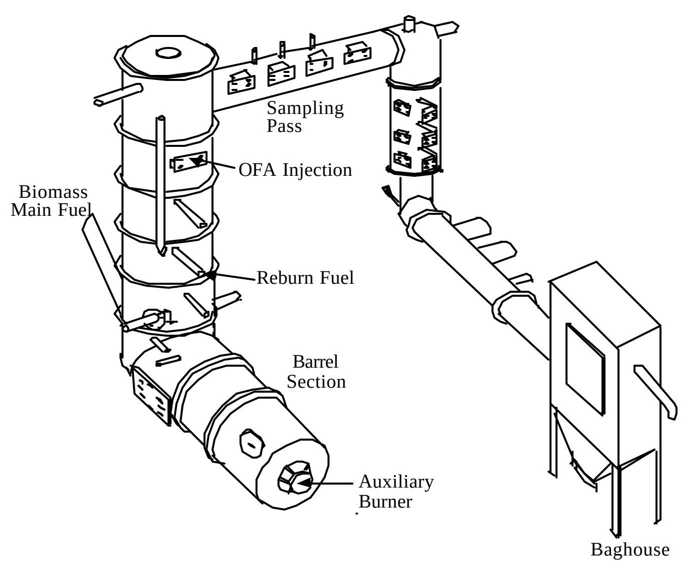

Figure 3. GE-EER Solid Fuel Test Facility (SFTF) - Biomass Boiler Simulator.