Adapting On-site Electrical Generation Platforms for Producer Gas

Integrating Gasifiers and Reciprocating Engine Generators to Utilize Biomass-Based Fuel

This project integrated a biomass gasifier and a reciprocating engine generator set into a combined platform, enabling electricity generation from waste biomass while reducing diesel fuel consumption and greenhouse gas (GHG) emissions.

Introduction

Internal combustion reciprocating engine generators (gensets) are regularly deployed at distribution centers, small municipal utilities, and public institutions to provide on-site electricity generation.

The diesel that fuels these gensets contributes a large portion of their total operating costs and also, as a fossil fuel, releases carbon dioxide (CO_2) during combustion.

Driven by a desire to reduce fuel costs and greenhouse gas emissions, efforts are growing to utilize biomass-based fuels as alternatives to fossil fuels.

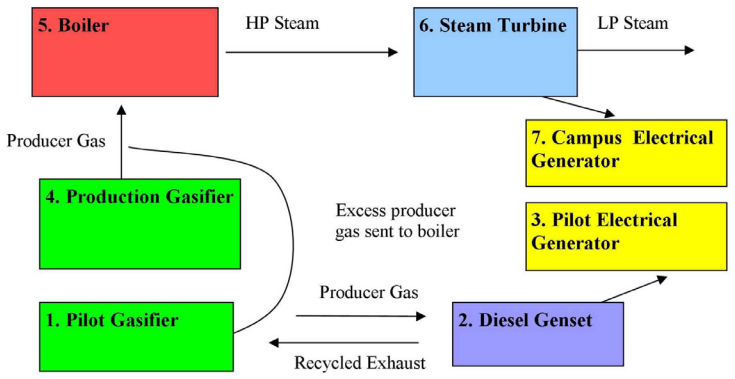
One of these alternative fuels, also known as opportunity fuels, is producer gas, created in a biomass gasifier and composed primarily of hydrogen (H_2), carbon monoxide (CO), CO_2, and nitrogen (N_2). The biomass is often diverted from agricultural, industrial, and municipal waste streams, and its use in gasification reduces waste disposal volumes and costs.

This project integrated commercially available gasification systems and reciprocating engine gensets into a combined platform. Producer gas displaces most diesel fuel consumption using homogenous charge compression ignition (HCCI). A new compressor and cooling system dedicated to handling producer gas and its accompanying, damaging tar deposits was designed and tested. The integrated system was designed to be portable, making it possible that the system could be moved around based on power needs or feedstock availability.

Exhaust from the engine feeds back into the gasifier to preheat biomass for gasification, decreasing emissions from unburned fuel and improving efficiency. The performance of the integrated system was optimized and benchmarked for comparison against other alternatives for on-site electricity generation from biomass-based fuels, such as steam turbines.

Benefits for Our Industry and Our Nation

Implementing combined gasifiers and reciprocating engine gensets, which together provide a renewable, high-efficiency, low-emissions source of electricity, will have major energy, economic, and environmental benefits, including the following:



Energy-flow schematic for use of a producer gas-powered genset.
Illustration courtesy of University of Minnesota Morris

- Reduction or avoidance of waste disposal fees
- Decrease in GHG emissions from the combustion of diesel fuel by substituting renewable fuel sources
- Decrease in CO, NO_x, and soot emissions compared to fossil-fueled generators
- Utilization of inexpensive biomass fuels, a significant and largely untapped energy source
- Reduction in purchased electricity, and in some cases, revenue from sale of surplus electricity back to the grid
- Portability of the integrated system may enable new applications where use of a generator has not been feasible before

Applications in Our Nation's Industry

In its initial commercial deployment, this technology will be marketed toward retail distribution centers, small municipal utilities, and public institutions such as universities.

The ability to utilize biomass as a fuel source will also benefit industries that generate organic waste streams, such as food processing plants, pulp and paper factories, and large farms.

Project Description

This project optimized the integration of biomass gasification systems and internal combustion reciprocating engine gensets. The diesel engine was fueled primarily by producer gas derived from corn cobs and data generated was used to model operations using HCCI mode. The performance of the engine-generator was compared to a boiler and steam turbine generator also operating on producer gas.

Barriers

- Establishing consistent chemical specifications for the variable producer gas created from biomass gasification
- Adapting existing, installed gensets for operation on producer gas
- High cost compared to electricity purchased from a utility

Pathways

The University of Minnesota, Morris conducted research on fuelstock availability and cost measures for its purchase and sale. A fixed bed downdraft gasifier with a multistage, multipoint heat recycling system was incorporated into the system. The University also designed equipment for the cleaning and cooling of producer gas. The campus's biomass plant was used as a testing site of the integrated system, and the university created an economic analysis of the system's performance.

The University of Minnesota Center for Diesel Research provided technical data and analysis related to fumigation and conversion to HCCI operation.

Cummins Power Generation Inc. provided 100 kW diesel genset modified for operation on producer gas, including a redesigned compressor for the gaseous fuel.

Milestones

- Characterization of producer gas quality
- Design of a turbocharged, low-Btu mixing system for fumigating diesel engine
- Development of HCCI control algorithms
- Development of a control scheme for integrated gasifier and genset
- Integration and analysis of the recirculation of exhaust gases into an underfed air supply or gasifier

Accomplishments

- Engine controls were adapted to run the PowerTainer on producer gas.
- A gasifier of sufficient capacity was developed with an innovative heat recovery system that significantly reduced the size, cost, and complexity of needed components, as well as the resulting installation footprint.
- The fully functional PowerTainer was demonstrated and tested successfully.
- Genset performance exceeded expectations; there was no derating of genset capacity when operating on a mixture of 80% producer gas and 20% diesel.

Commercialization

Cummins Power Generation's experience in commercializing power generation equipment in worldwide markets provided essential insight into deploying the new gasifier/genset technology. ALL Power Labs is incorporating the new technologies into its small gasifier/genset product line and utilize its worldwide distribution network to market the products.

The University of Minnesota, Morris designed, built, and now operates an $8.9 million state-of-the-art research and demonstration biomass gasification plant on its campus. The university applied its experience in developing recommendations and guidelines for the effective adoption of on-site gasification and power generation.

Market interest for the PowerTainer has been strong. Specifically, interest is coming from three distinct areas: 1) rural, off-grid remote settings, where access to stable energy is either unavailable or is predicated on the use of volatile-priced carbon-based fuel sources, 2) agricultural materials producers and handlers who have a "ready-made" source of fuel on hand, and 3) grid interconnection to markets with established Feed-In Tariffs.

Project Partners

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