



The LPP Combustion System: A Breakthrough in Fuel Technology

LPP Combustion, LLC is a Maryland-based company that has developed a unique fuel utilization technology. The patented **Lean, Premixed, Pre-vaporized Combustion System** converts conventional liquid fuels, such as kerosene or #2 fuel oil, as well as alternative fuels, such as biodiesel, coal liquids, and ethanol, into a synthetic natural gas. This LPP Gas can then be burned with low emissions in gas turbines (or other combustion devices) in place of natural gas, producing environmentally friendly power and providing substantial fuel flexibility to power generators.

The LPP System uses a fuel preparation skid to convert the liquid fuel to a synthetic natural gas prior to introduction to the gas turbine through the normal natural gas piping and combustion system. Thus, the LPP System allows for rapid switching between liquid fuels and natural gas, as well as operation on liquid fuels, even for gas turbines that have no current capability to burn liquid fuels. This innovative technology can provide millions of dollars in fuel cost savings per year by allowing power generators to burn oil, gas, or alternative liquid fuels, whichever is cheaper, during seasonal fluctuations in energy prices, while generating similar low emissions on any of these fuels.

Over the last ten years, nearly 1,200 dry low emissions (DLE) natural gas-burning turbines have been installed in North America. These turbines provide extremely low emissions for power generators by burning natural gas in a lean, premixed combustion system. In addition, many thousands of smaller turbines that power industrial complexes, such as refineries and chemical plants, have also been designed to produce low emissions when operating on natural

gas. This combustion technology has not been available for use with liquid fuels because of the long-recognized problem of autoignition when liquid fuels are pre-vaporized prior to premixing.

As a result, operation of turbines on liquid fuels, when permitted, still relies on spray flames with water addition, which produces substantially higher Nitrogen Oxide (NO_x) and Carbon Monoxide (CO) emissions than burning lean, premixed natural gas. Conventional operation on liquid fuels also requires substantially higher maintenance and shorter overhaul intervals. Consequently, even those gas turbines with the capability to burn liquid fuels are, in general, severely restricted on the number of hours per year they can operate on liquid fuels because of significantly higher emissions and maintenance.

The LPP System solves the autoignition problem associated with lean, premixed, pre-vaporized combustion of liquid fuels, thereby allowing operation on liquid fuels while producing low emissions similar to natural gas operation. Thus, turbines using the LPP System will be able to operate for a much higher number of hours per year on liquid fuels.

With the LPP System, the liquid fuel is transformed into LPP Gas on a self-contained hardware skid, consisting of conventional compressors, heat exchangers, vaporizers, piping, valves, control hardware, and passive air separation membranes. The membranes use ambient air to create the diluent that is used to vaporize the liquid fuel. No additional pre-treatment of most liquid fuels is required.

The LPP Technology has been tested on a variety of burners, including commercial turbine hardware. Tests have been completed in a combustor at typical gas turbine temperatures and pressures using a test rig at a turbine manufacturer. The technology has proven viable, allowing stable operation under a variety of conditions while

producing emissions on the same order as natural gas. Testing has also demonstrated that switching from natural gas to LPP Gas is easily accomplished without interrupting normal operations.

The U.S. will benefit from commercialization of this technology because the LPP System will provide a more cost-effective method for utilizing bio-derived fuels and coal liquids to produce clean, reliable electrical power, reducing U.S. dependence on foreign energy sources while helping to protect the environment. LPP Combustion, LLC is pursuing additional investments, as well as partners, to assist in further operational development. At present, we are conducting on-going discussions with utilities, fuel producers, turbine manufacturers, gas turbine operators, and several governmental agencies.

COMPANY MANAGEMENT

Richard J. Roby, P.E., Ph.D., is the CEO and Managing Member and a Co-Inventor of the LPP Technology. Rick also leads Combustion Science & Engineering, Inc. (CSE), an affiliated company, and has 25 years of experience in combustion related to energy, emissions, alternative fuels, and power production.

Leo D. Eskin, Ph.D., serves as President and COO. Leo was the Co-founder, President and CEO of a Washington DC-based, low-voltage construction firm which he led to an annual volume in excess of \$15 million. Leo was also co-founder of a company, now owned by GE, that developed the GateCycle software program for optimizing power-generating plants. Leo has extensive contacts in power plants throughout the U. S. and hands-on turbine testing and operations experience.

Michael S. Klassen, P.E., Ph.D., is a Vice President and Chief Technology Officer and a Co-Inventor of the LPP Technology. Mike has extensive experience performing combustion-related R & D for the power industry, and is a consultant to a task force of utility executives formed by the Edison Electric Institute to study the issues related to LNG quality.

Michael Ramotowski, MSME, Director of Operations for LPP, was instrumental in the development and testing of the LPP System. Mike, a Mechanical Engineer, also has substantial experience with developing new combustion technologies for the marketplace.

Drs. Roby and Klassen in 1998 co-founded CSE, an engineering R & D firm with \$5M in annual revenues.