RCL™ System Study for Natural Gas and Coal-Derived Syngas
(Precision Combustion, Inc.)

FACT SHEET (DRAFT 3/17/03)

I. PROJECT PARTICIPANTS

1. Prime Participant: Precision Combustion, Inc. (PCI)
2. Other Participants: General Electric Power Systems, Pratt and Whitney Power Systems, Siemens Westinghouse Power Corporation, American Electric Power, Calpine. ,

II. PROJECT DESCRIPTION

A. Objective(s): The objective of this project is to conduct a system study evaluating the potential impact on power generation turbines of a novel catalytic combustion technology ("Rich Catalytic/Lean burn" or "RCL™" combustion). The study explores the potential for this improved combustion process for elimination of SCR aftertreatment, improved efficiency, reduced combustion dynamics, and reduced O&M costs. This system study will evaluate the applicability to gas turbines of interest to NETL for natural gas and syngas fuels.

B. Background/Relevancy:

Background: Precision Combustion, Inc. (PCI), with DOE and gas turbine manufacturer support, has developed a leapfrog advance in catalytic combustor technology that offers ultra-low emission (NOx<3 ppm) clean and efficient catalytic combustion for gas turbines. Originally developed under DOE's SBIR program, RCL™ technology offers simultaneous improvements in emissions, efficiency, fuel flexibility and component life. The technology has retrofit potential and has been demonstrated operable with multiple fuels. Combustor module tests under large frame gas turbine conditions have demonstrated the robustness of the technology, as well as stable combustion with NOx emissions as low as 2 ppm and low combustion dynamics, in a package sufficiently compact to potentially fit into existing large frame machine combustor volumes. A smaller catalytic pilot version has been developed and tested for minimal modification to existing DLN systems. New catalytic module component cost at commercial volumes for natural gas-fired large frame machines is expected to be in the $3 - $6/kW range, vs present value of avoided costs in the range of $60 - $120/kW. Even for installed machines with operating SCR systems, the RCL technology offers cost reduction that may drive retrofits.

In the RCL™ system, the combustion air stream is split into two parts upstream of the catalyst. One part is mixed with all of the fuel and contacted with the catalyst, while the second part is used to backside cool the catalyst. At the exit of the reactor, the partially oxidized fuel/air stream and the cooling air are rapidly mixed to produce a fuel-lean, reactive mixture prior to final combustion. The reactive mixture provides stability to the downstream flame, extending

lean blowout and enabling the system to run leaner and thus with lower NOx emission. Combustion dynamics are reduced due to improved stability near the lean blowout limit and because gas-phase energy release in the combustor (the driving force for combustion noise) is reduced when a portion of the fuel is catalytically reacted prior to gas-phase combustion. Note that in the RCL™ system, the fuel-rich mixture contacting the catalyst has insufficient oxygen to completely oxidize all of the fuel, thus limiting the extent of catalyst-stage reaction and enabling limitation of the catalyst-stage temperature to a safe value, regardless of the fuel type.

PCI's design offers ultra-low NOx combustion without engine efficiency penalty across a wide turndown range with low combustion dynamics, and the following advances:

- No preburner required – able to operate at existing compressor discharge temperatures, without preburner penalties of increased NOx emissions, space requirements, and cost
- Robust – rich operation and unique reactor design removes concern for catalyst overheating, and enables the reactor to survive substantial fuel/air transients
- Compact - capable of fitting within most existing gas turbine engine envelopes
- High firing temperature operation – <3 ppm NOx with natural gas at "F" class conditions
- Long component life – targeting 16,000 – 24,000 hours following market entry
- Simple control and premixing systems
- Multifuel capability (including natural gas, gasoline, diesel, syngas and low BTU gas)

As such, RCL™ technology has been developed to the extent that a system study assessing its potential impact on power generation turbines is warranted.

Relevancy**:** RCL™ technology offers a near term opportunity to advance DOE objectives by providing an energy-efficient in-engine near-zero emissions solution:

- Eliminating the need for SCR in combined cycle
- Enabling simple cycle and small turbine near-zero emissions, encouraging CHP/distributed power
- Improving efficiency due to the avoidance of SCR and improved combustion stability
- Reducing combustion dynamics, enabling improved RAMD
- Reducing power generation turbine capital and O&M costs
- Retrofittable
- Capable of fuel-flexible operation, including with natural gas/liquid fuels, and applicable to ultra-low NOx syngas combustion

C. Period of Performance: 9/27/02 - 1/31/04

RCL™ System Study for Natural Gas and Coal-Derived Syngas
(Precision Combustion, Inc.)

D. Project Summary: This project will 1) develop a Rich Catalytic Lean burn operating map, 2) assess multi-fuel benefits, and 3) conduct a cost-benefit analysis.

III. PROJECT COSTS

A. DOE Costs:	$239,390
B. Prime Contractor Cost Sharing:	$ 59,847

IV. MAJOR ACCOMPLISHMENTS SINCE THE BEGINNING OF THE PROJECT

Reviewed the RCL™ integration for 3 different gas turbine engine applications. Initiated development of operating map for RCL™. Visited NETL and presented the RCL™ technology status for natural gas and syngas fuels.

V. MAJOR ACCOMPLISHMENTS PLANNED DURING THE NEXT 6 MONTHS

Complete OEM discussion. Complete coal-derived syngas analysis. Complete the technical study and cost-benefit analysis. Hold a technical presentation to NETL personnel.

VI. MAJOR ACCOMPLISHMENTS PLANNED IN OUTYEARS (6 -18 MONTHS)

Finalize the program and provide the final report.

VII. MAJOR MILESTONES FOR ENTIRE PROJECT

1. Compile OEM engine operating data – 1Q2003
2. Generate RCL operating map – 2Q2003
3. Complete cost-benefit analysis – 3Q2003

VIII. ISSUES:

None.

VII. ATTACHMENTS (If Warranted):

None.