LPP = Lean, Premixed & Prevaporized

LPP Combustion, LLC

Technical Presentation 2012

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The Problem LPP Solves

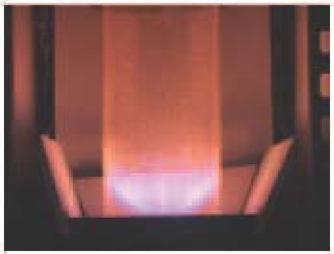
Urgent Need Exists in the Power Industry and Energy Markets to . .

Burn Liquid Fuels at or Below Natural Gas Emission Levels

Conventional Liquid Fuel Flame

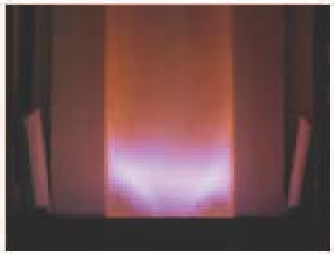
The Problem

Natural Gas Flame



The Goal

Liquid Fuel (Biodiesel) Using the LPP System



The Solution

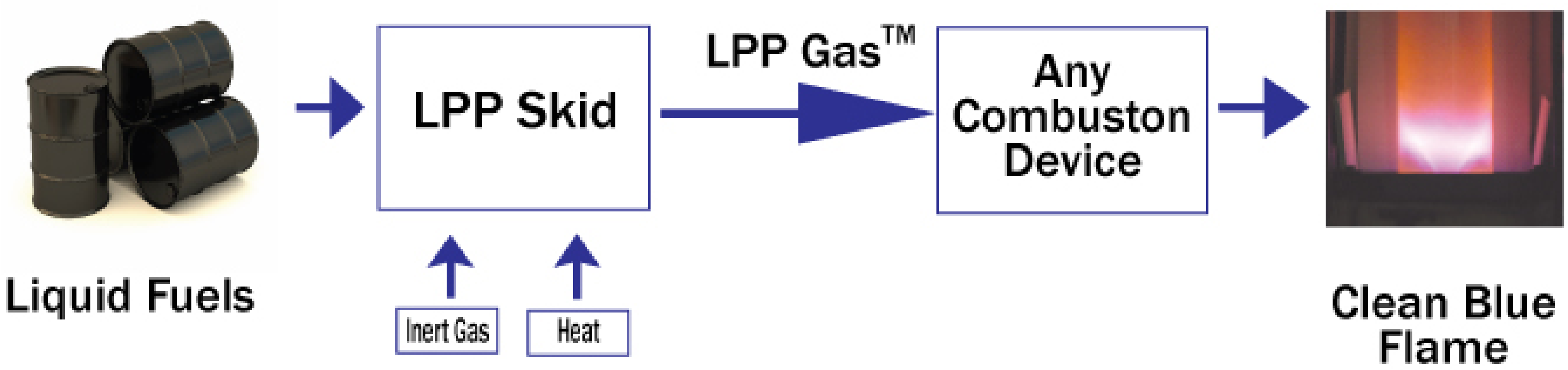
Many firms have attempted to solve the problem of burning liquid fuels cleanly (e.g. GE, Siemens, United Technologies), but have traditionally concentrated on modifying the combustor hardware.

LPP Combustion solved this problem by focusing on modifying the fuel, allowing it to be cleanly burned in combustor hardware designed for burning gaseous fuels.

The Patented Solution

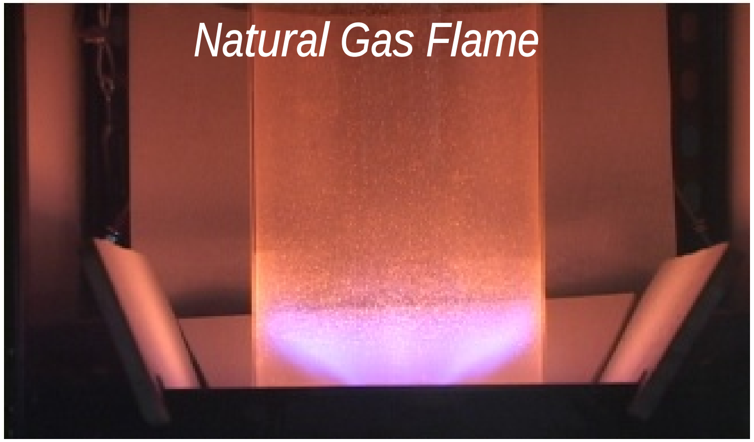
LPP = Lean, Premixed & Prevaporized

- The LPP Combustion System Vaporizes Liquid Fuels And Creates A Substitute Natural Gas (LPP Gas™)
- This LPP Gas™ Can Then Be Burned With Low Emissions In Place Of Natural Gas In Virtually Any Combustion Device
- Burning Biodiesel, The LPP System Creates A Low-Emissions, Renewable Energy Power Plant With No Net CO_2 Gas Emissions



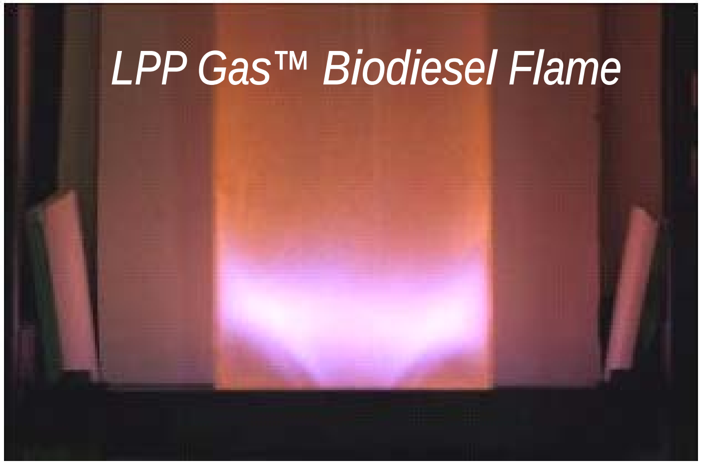
The Result

Same Gas Turbine Combustion System



The LPP System Provides Clean Energy from Liquid Fuels*:*

- **Provides Flexible Liquid Fuel Source While Reducing Emissions, Meeting or Exceeding Environmental Requirements**
- **Process Uses Existing Equipment and Infrastructure**
- **Reduces Equipment Maintenance Cost**
- **Provides Rapid Customer Payback**



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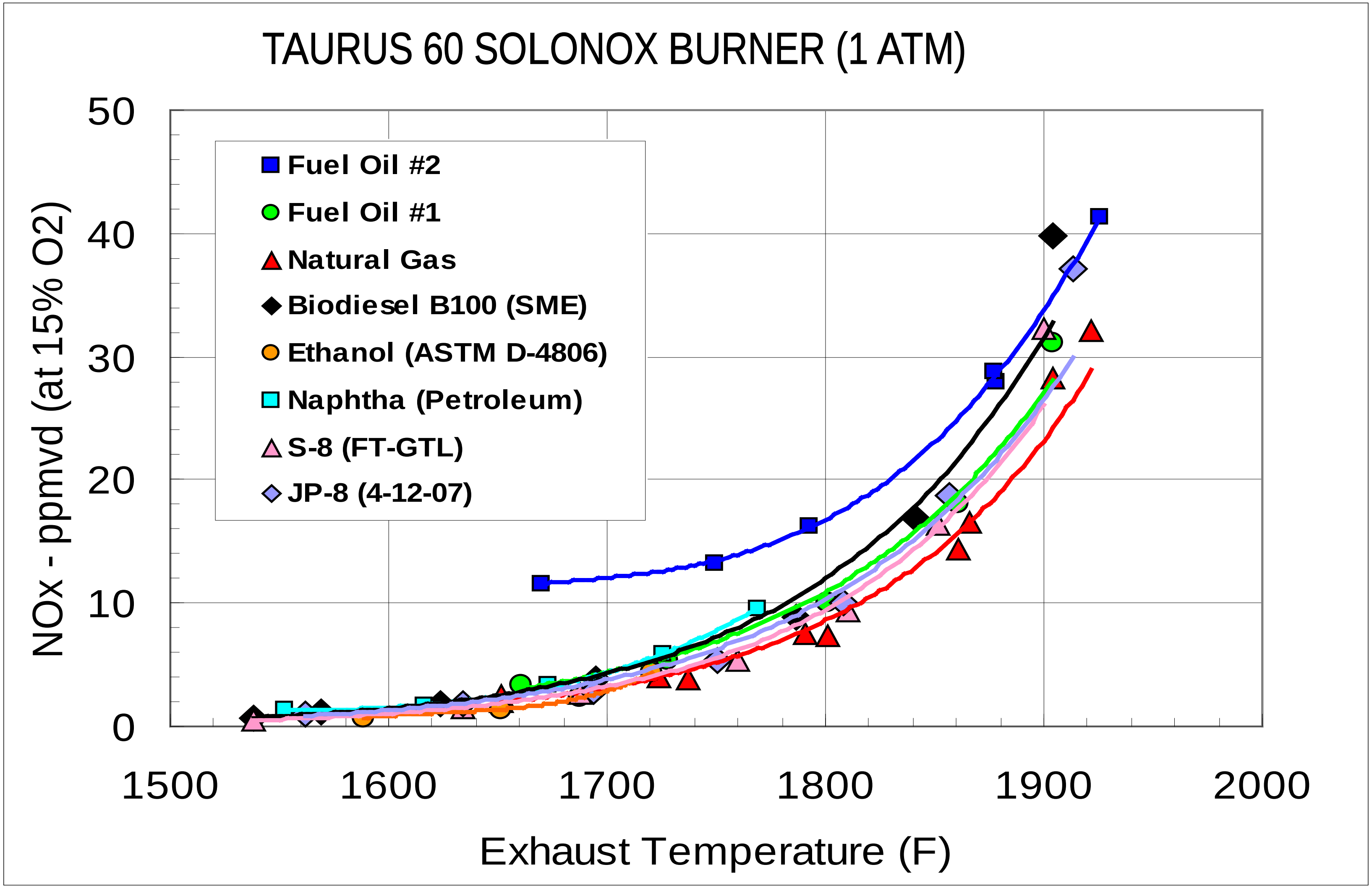
LPP Combustion Technology Development

The LPP Combustion system development has followed the same path used by OEMs:

- **Testing on bench-top atmospheric burner**
- **Testing on bench-top high pressure burner**
- **Testing on commercial turbine burner at atmospheric pressure**
  - Solar Turbines Taurus 60/70 burner with full temperature air pre-heat
- **Testing on 1/12th sector gas turbine combustor**
  - Tests conducted on commercial test stand at Solar Turbines
  - Taurus 60/70 full pressure, full temperature air pre-heat
  - Data obtained for kerosene and No.2 diesel fuel vs. natural gas
- **Testing on commercial Capstone C-30 gas turbine**
  - 30 kW commercial power generation turbine connected to local BGE grid
  - Over 750 hours of LPP Combustion system operation to date
  - 14 different fuels tested from ethanol and naphtha to DF2 and biodiesel

LPP NO_x Emissions (All Fuels)

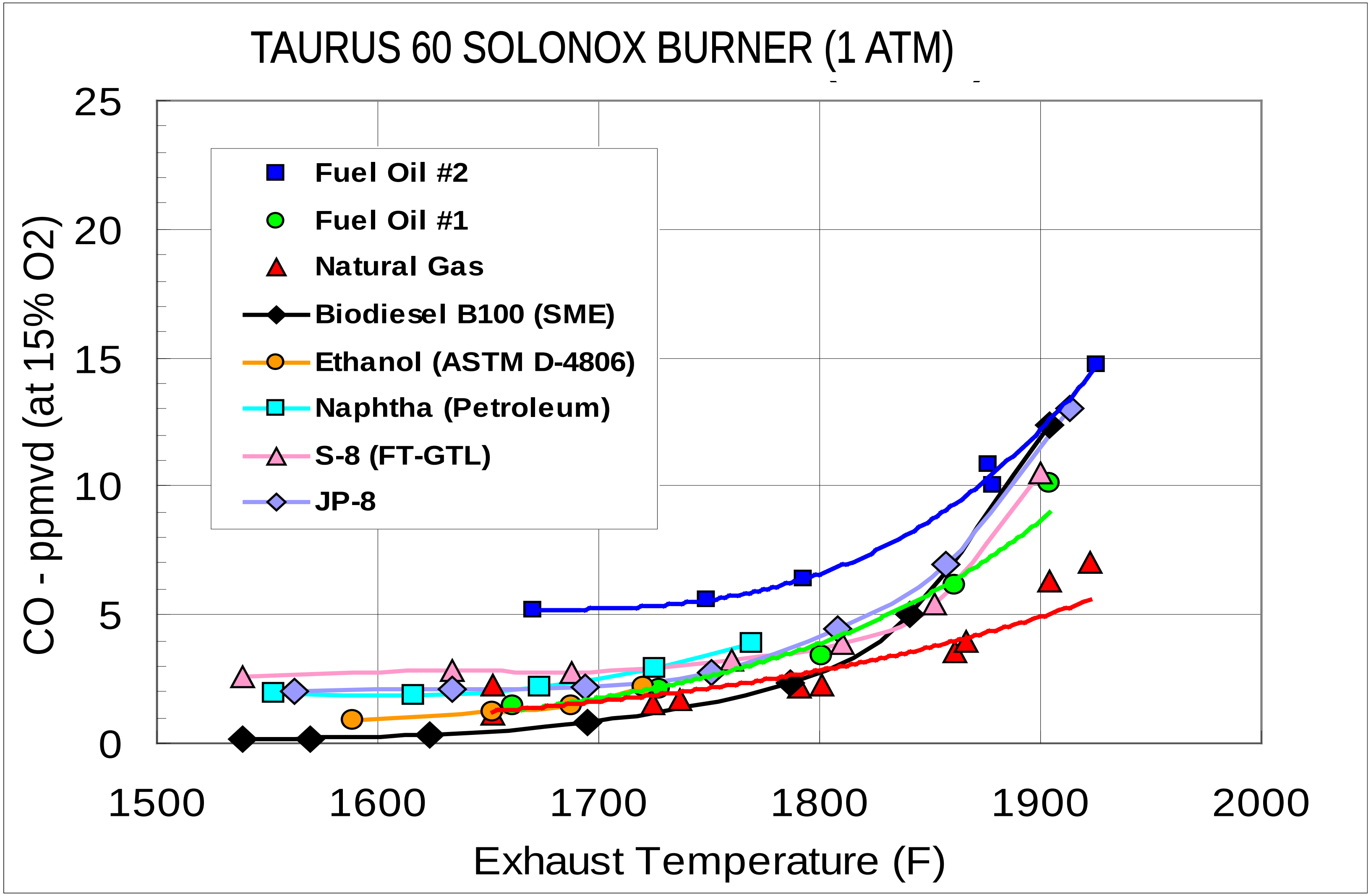


Confidential

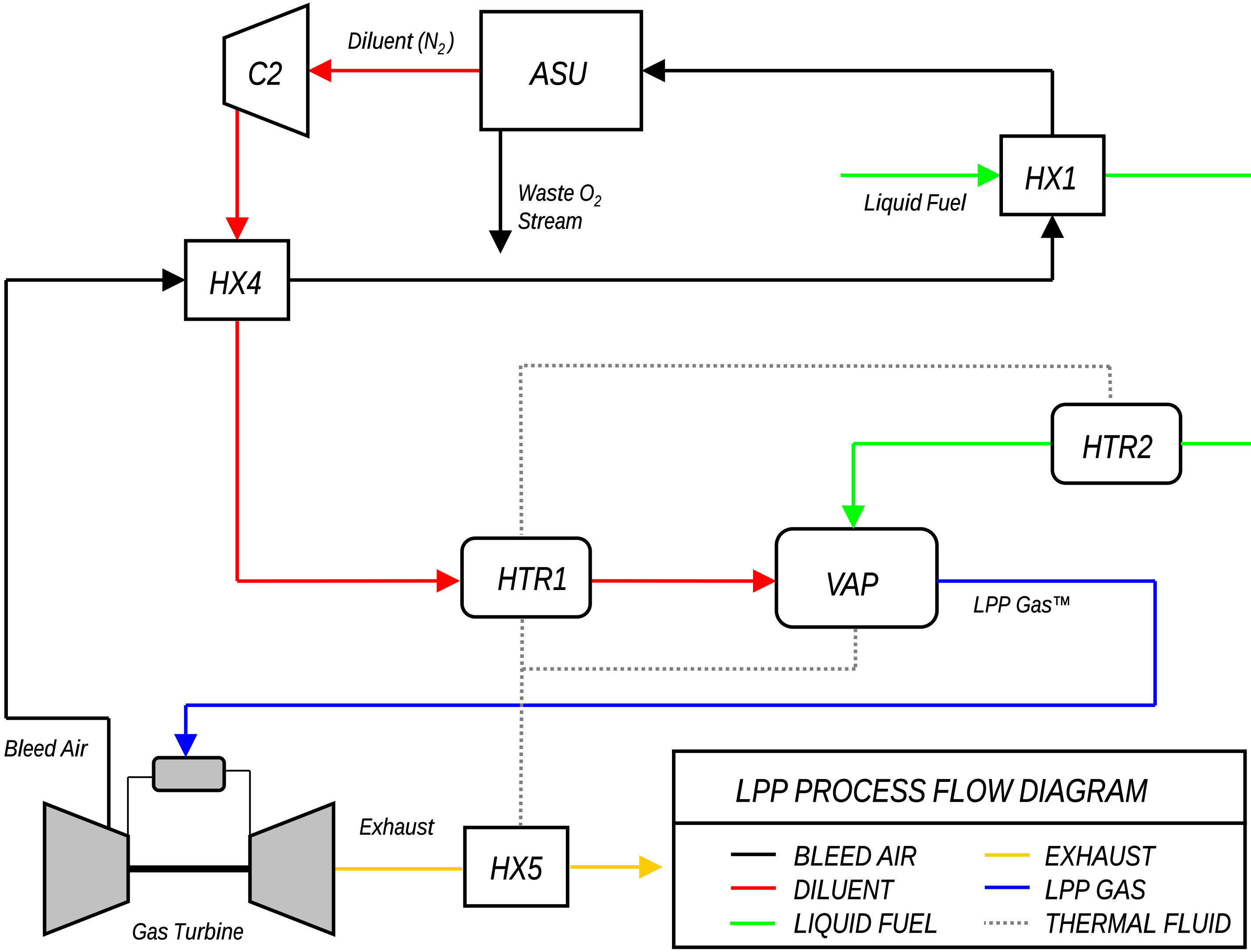
***LPP** = **L**ean, **P**remixed & **P**revaporized*

US Patents: 7,089,745, 7,322,198, 7,770,396. Other Patents Pending.

CO Emissions (All Fuels)



LPP Process Flow Diagram



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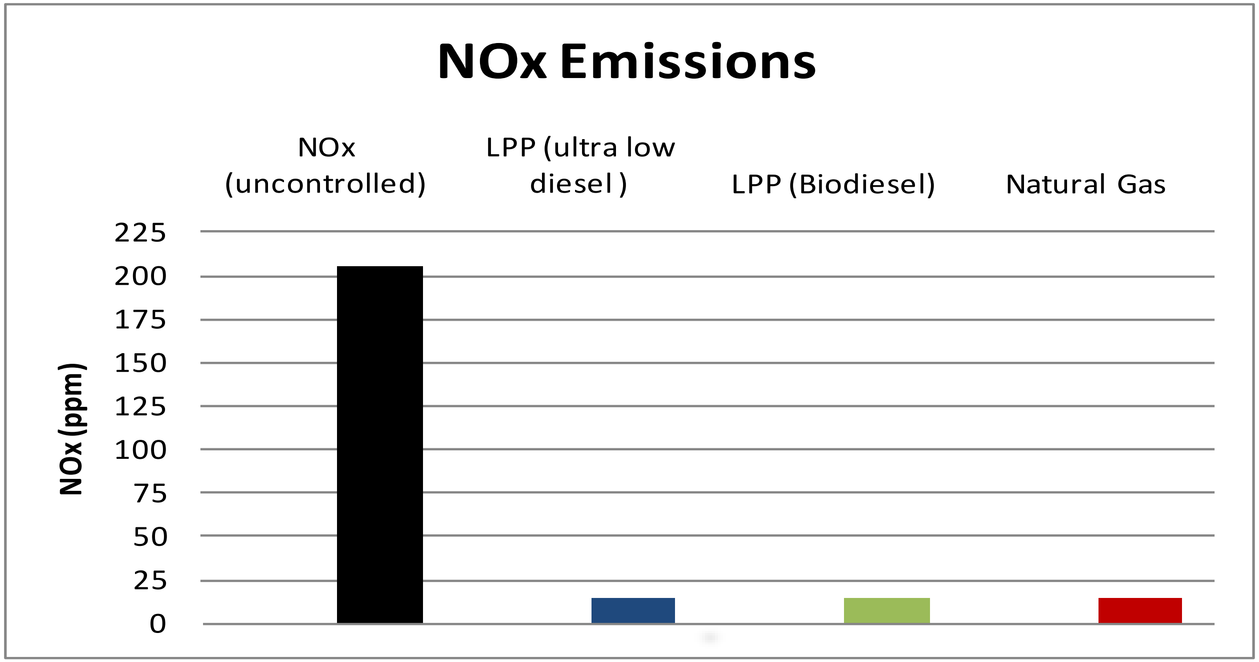
LPP is Liquid Fuel Agnostic

- No. 2 Heating Oil
- No. 2 Diesel Fuel Oil
- Kerosene
- Coal Derived Liquids
- Byproduct Streams
  - Natural gas condensate
  - Naphtha

- Biodiesel
  - ASTM spec
  - Non-ASTM spec
- Bioethanol
  - Anhydrous (<0.5% water)
  - Hydrous (5% water)
- Biobutanol
- Biomass Derived Liquids

LPP Emissions Performance

- *Utilize any light liquid fuel to produce synthetic natural gas*
- *Criteria pollutant emissions (NOx, CO, & PM) reduced by 90%*
- *NOx, CO, SOx, & PM comparable to natural gas emission levels*
- *Use existing natural gas burners w/o combustor hardware modifications*



The LPP System reduces NO_x emissions without increasing CO emissions

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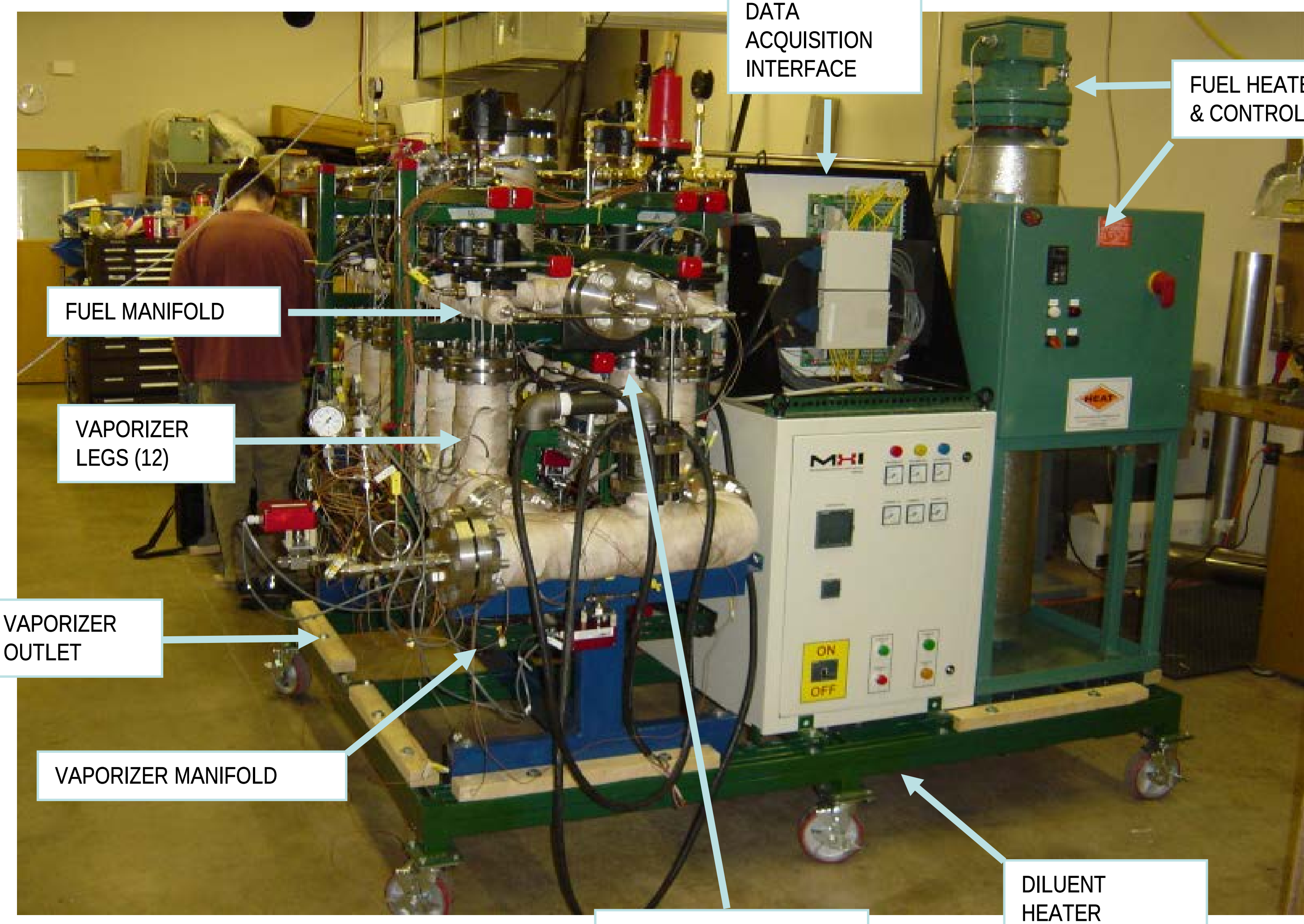
Combustor Rig Testing

Tests Conducted at Solar Turbines

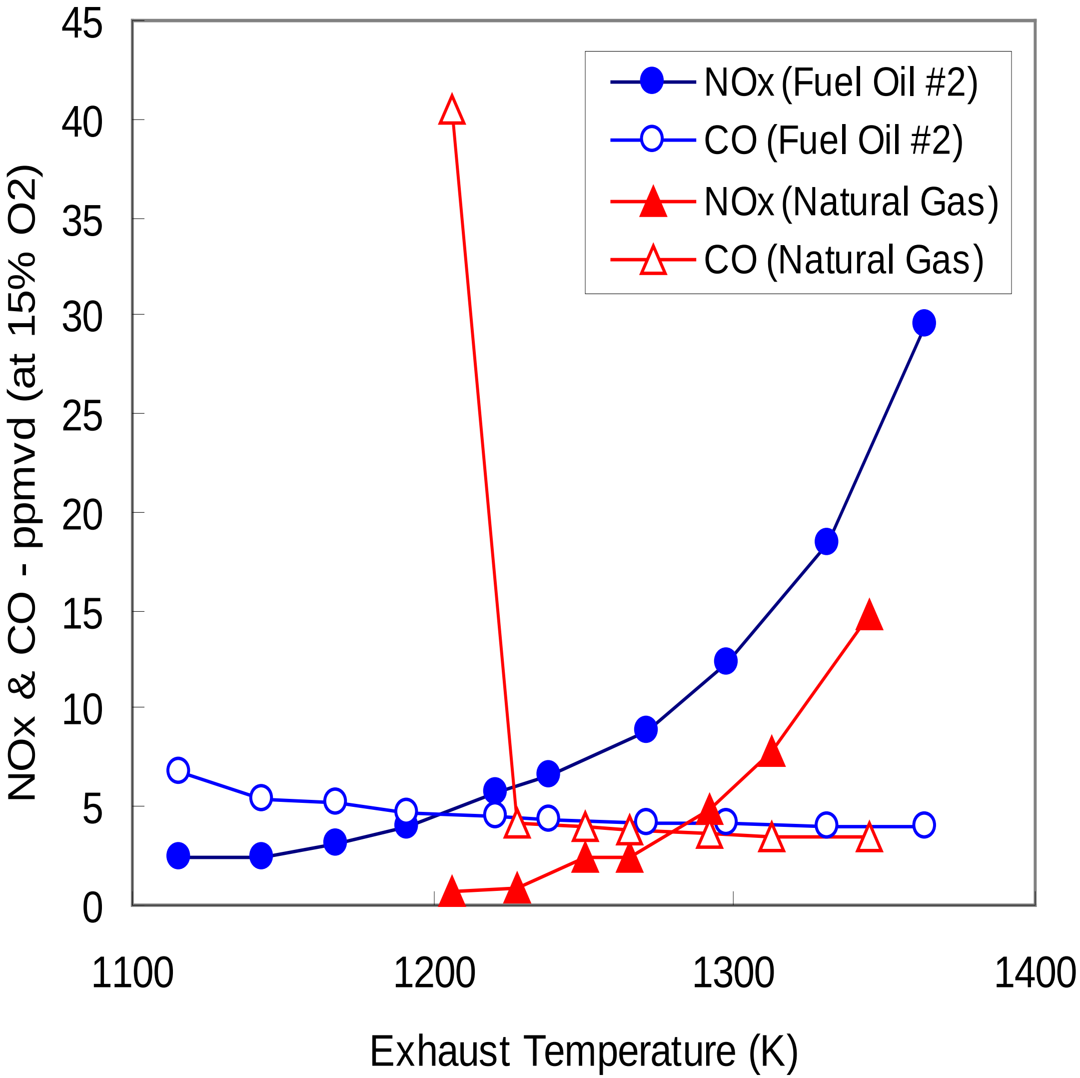
- High-temperature, high-pressure test at Solar using commercial turbine hardware
- LPP Process with kerosene, #2 fuel oil (DF2)
- Measured NOx, CO, LBO – Compared with natural gas
- Tested at 4 turbine combustor inlet conditions, including Taurus 60 and Taurus 70 base load:

	Pressure (psig)	Temperature
T60 50%	100 (7.8 atm)	604 F (318 C)
T60 75%	125 (9.5 atm)	640 F (338 C)
T60 Base Load	165 (12.2 atm)	715 F (379 C)
T70 Base Load	215 (15.6 atm)	810 F (432 C)

Technology Demonstration Unit



NO_x and CO Measurements



DLE 6 MW Turbine
(100% Load Condition)
Single Fuel Nozzle

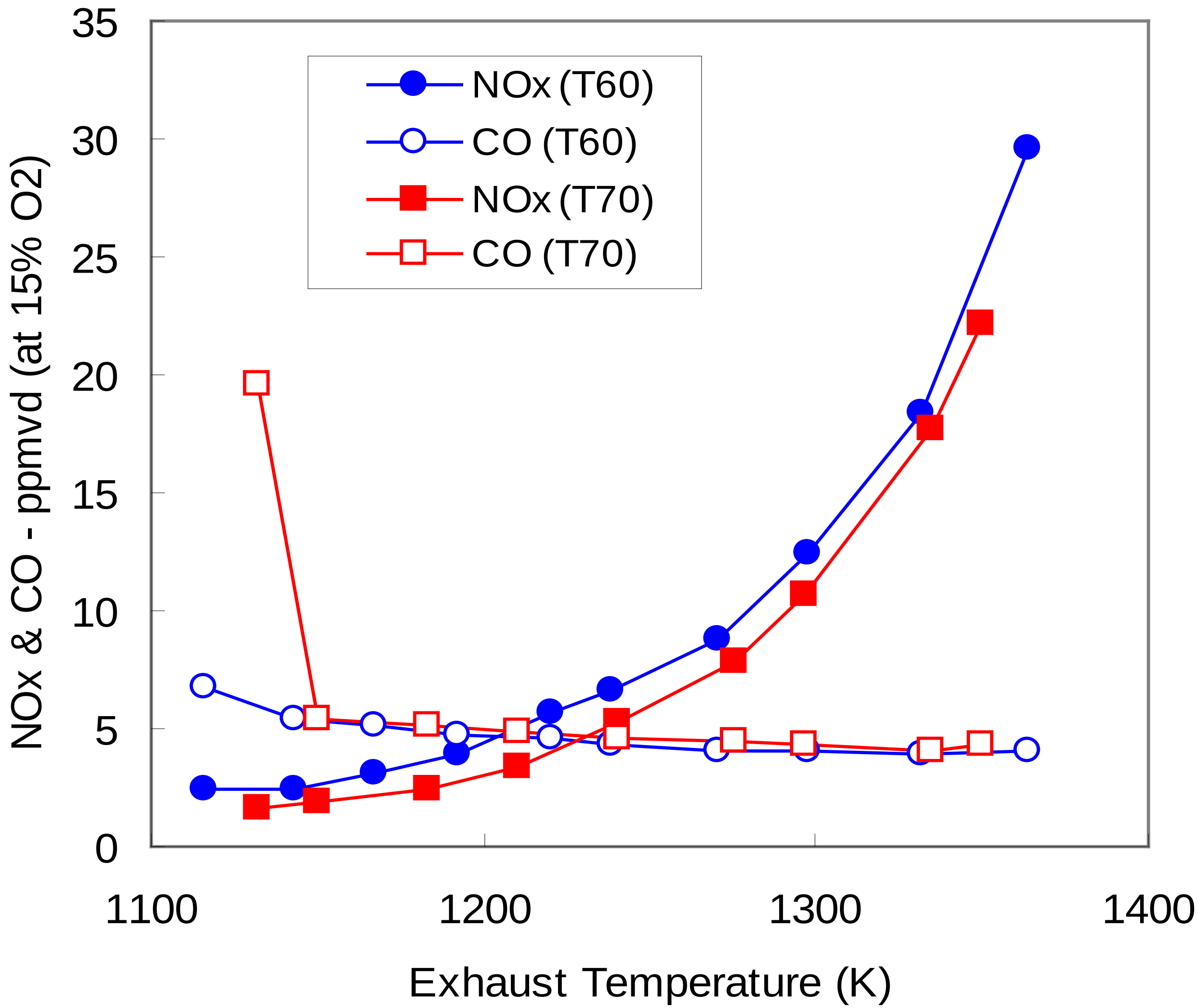
Fuel Oil #2
(0.04 w/o Nitrogen)

Combustion Air Temperature 648 K

Combustor
Pressure = 12.6 atm

Fuel Dilution
5:1 (molar basis)

NO_x and CO Measurements



(100% Load Condition)
Single Fuel Nozzle

Fuel Oil #2
(0.04 w/o Nitrogen)

Combustion Air Temperature
T(60) = 648 K
T(70) = 706 K

Combustor Pressure
T(60) = 12.6 atm
T(70) = 16.2 atm

Fuel Dilution
5:1 (molar basis)

DLE 6 MW (T60)
DLE 7 MW (T70)

Solar Testing Summary

- LPP Process successfully tested on single burner high-pressure/high-temperature test stand using commercial Taurus 60 hardware
- Emissions on liquid fuels were comparable to those from natural gas (NO_x, CO, PM)
- Extended (& smoother) lean blow-off limit
- Dynamics equal to or less than natural gas
- Is 5 ppm NO_x possible on liquid fuels without water addition or SCR?

LPP Combustion Demonstration

- **Currently operating a Capstone C30 gas turbine at LPP Combustion facility in Columbia, MD**
  - **30 kW power generation gas turbine which utilizes diffusion (<65% load) and Dry Low Emission (>65% load) natural gas combustion system**
  - **More than 1000 hours of operation on LPP Combustion system to date including more than 50 "black starts"**

- **Burning a variety of liquid fuels including bio-ethanol, natural gas condensates, naphtha, isopropyl alcohol, acetone, toluene, gasoline, kerosene, JP8, S8, diesel, heating oil, and biodiesel**

- **Generating Green Energy on the local utility (BGE) grid through a "net metering" agreement!**

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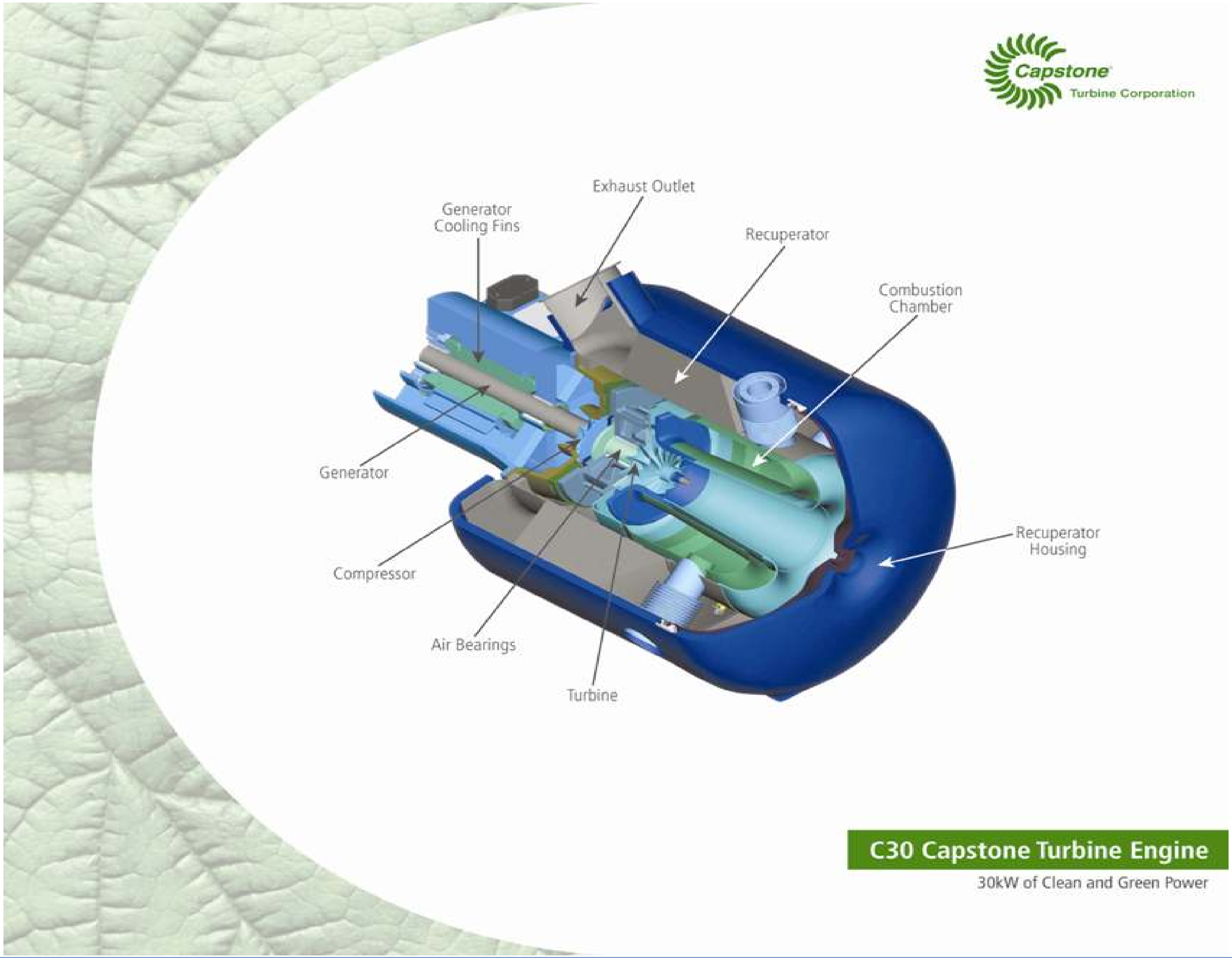
LPP Technology



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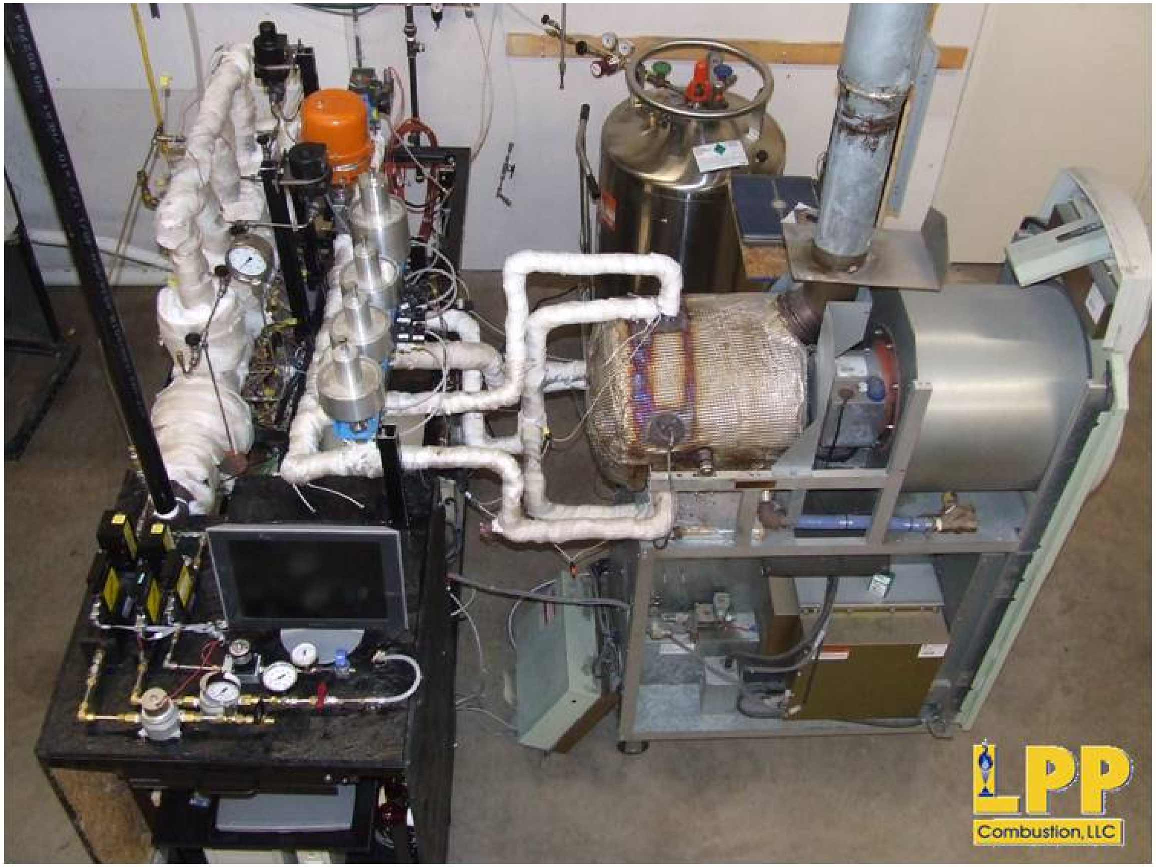
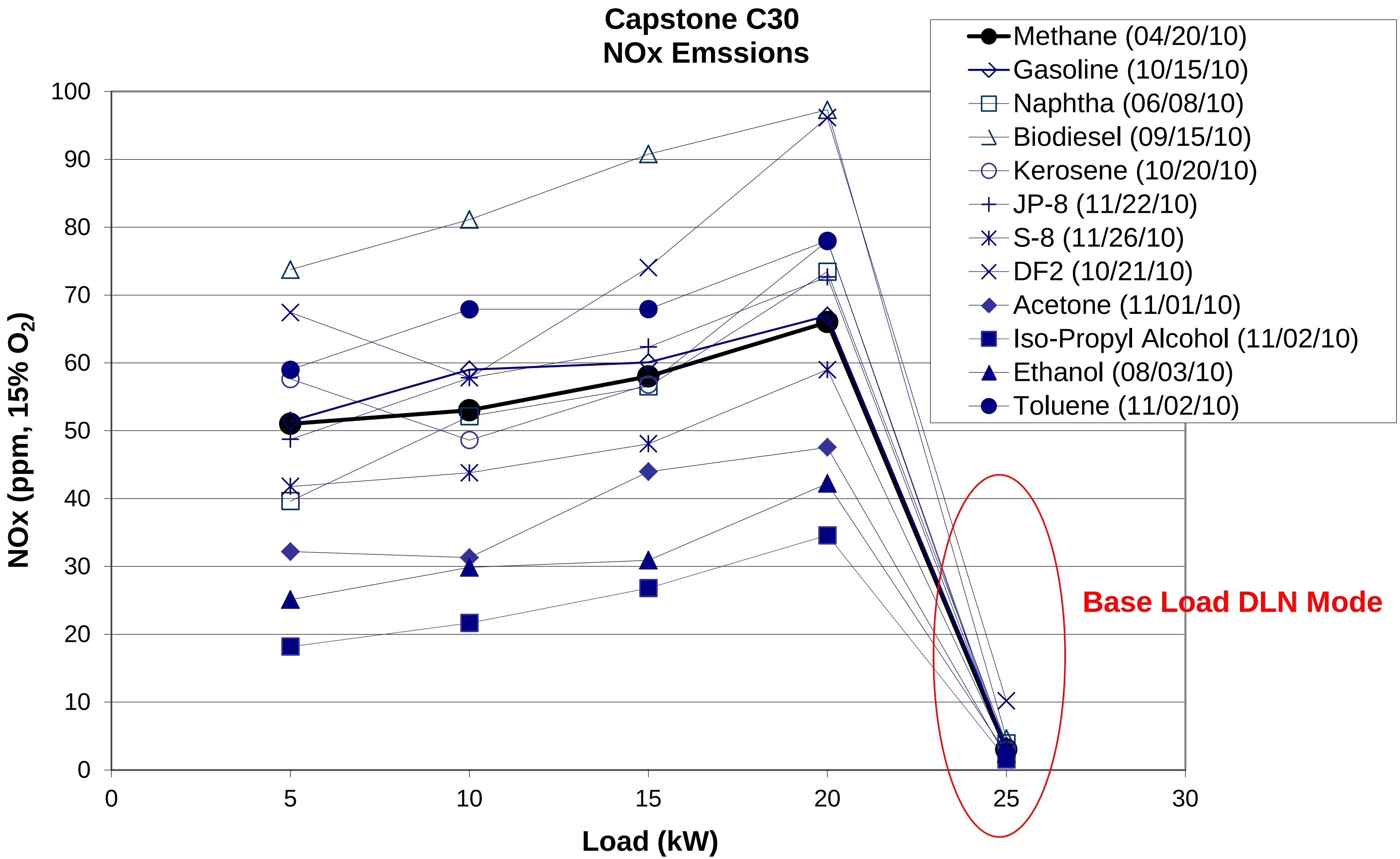
LPP Combustion Demonstration



LPP Combustion Demonstration



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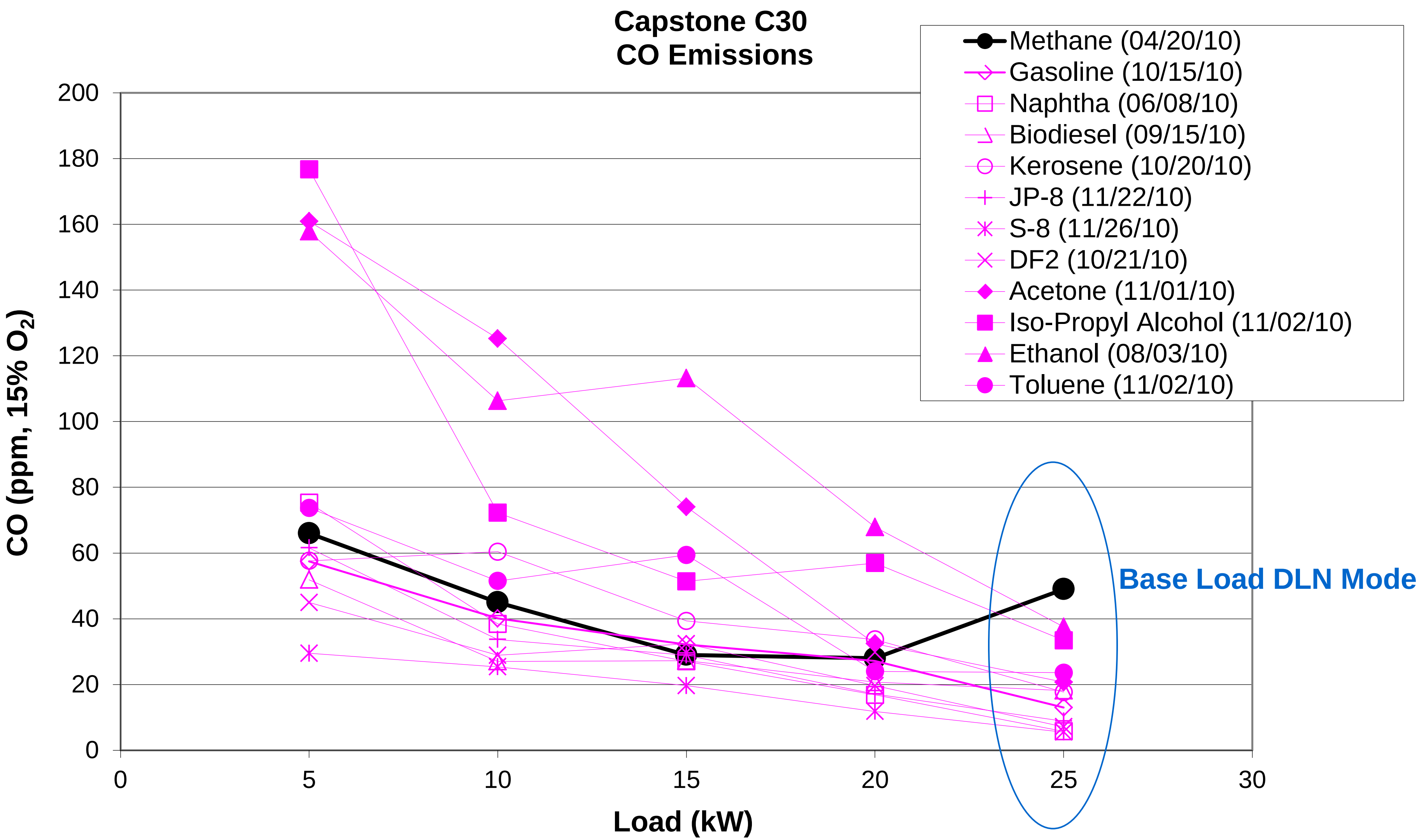
LPP Combustion Demonstration



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Customer Value Proposition

- **Urgent Need to Generate Clean Energy While Improving Fuel Efficiency**
  - Tightening Emissions Requirements >>> Domestic and International
  - Pressing Need to Reliably Accommodate Alternative/Renewable Liquid Fuels as Energy Suppliers Seek Fossil Fuel Independence
- **LPP Generated Gas Uses Existing Equipment and Infrastructure**
- **Reduces Equipment Maintenance Cost**
- **Provides Flexible Liquid Fuel Source While Reducing Emissions, Meeting or Exceeding Environmental Requirements**
- **Rapid Customer Payback**

LPP Gas™ (Heating Oil) vs. Heating Oil

LPP Provides Fuel Flexibility And Savings for Power Suppliers

		2008 (Present)	
		Heating Oil (LPP)	Heating Oil
Gas Turbine Data	Electrical Generation Capacity (MW)	126	126
	Heat Rate (Btu/kWh (LHV))	7,544	7,719
	Operating Hours	8,040	8,040
	Fuel Usage (MMBtu/year (HHV))	8,121,935	8,310,871
	Net Electrical Generation (MWH)	1,012,236	1,012,236
Fuel Costs	Fuel Cost ($/gal.)	$1.65	$1.65
	Annual Fuel Cost	$96,550,386	$98,796,374
Equipment Maintenance & Operational Costs	Equipment Maintenance Cost	$1,000,500	$3,600,000
	Pollution Cleanup Operating Cost		$1,993,175
Capital Expenditure	Equipment Cost	$10,050,000	$7,915,635
	Net Equipment Cost	$2,134,365	
Production Cost Comparison Summary	Total Power Production Costs per Year	$97,550,886	$104,389,549
	Net Power Production Savings per Year	$6,838,663	
Payback Period for the LPP System vs. the Alternative		0.31 years	

Customer Value Proposition

Fuel Processing Skid provides $6MM savings per year for 126MW Combined Cycle Power Plant through:

- **Fuel Flexibility**
  - Same emissions and performance for a range of liquid fuels
- **Clean Use of Liquid Bio-Fuels**
  - Natural gas level emissions from bio-ethanol and biodiesel
- **Increased Plant Efficiency**
  - 1%-3% improvement in heat rate means 1%-3% reduction in fuel costs
- **Reduced Equipment Maintenance Costs**
  - 2.5 to 4 times less maintenance from lower flame luminosity and elimination of water addition
- **Reduced Exhaust Emissions Costs**
  - Natural gas level emissions w/o water addition or SCR
- **Rapid Customer Payback**
  - 4-6 months for a new plant: 18 months for retrofit

Renewable Market Opportunities

LPP Combustion Enables “Dispatchable” Renewable Energy

- **As electric power demand changes over a 24-hr period, power plants stand-by to “dispatch” power to the grid on demand**
- **Gas turbine power plants can be “dispatched” to provide power to the grid on short notice based on demand from the grid**
- **Because of variations in weather, wind and solar power are not always available to the electric power grid on demand**
  - **Wind and solar power are not “dispatchable”**
- **Gas Turbines equipped with an LPP Combustion system can burn biofuels as cleanly as natural gas to provide on-demand, clean, “dispatchable” power generation to the grid**
- **“Dispatchable” renewable power from gas turbines can compliment the intermittent power from wind and solar generation**

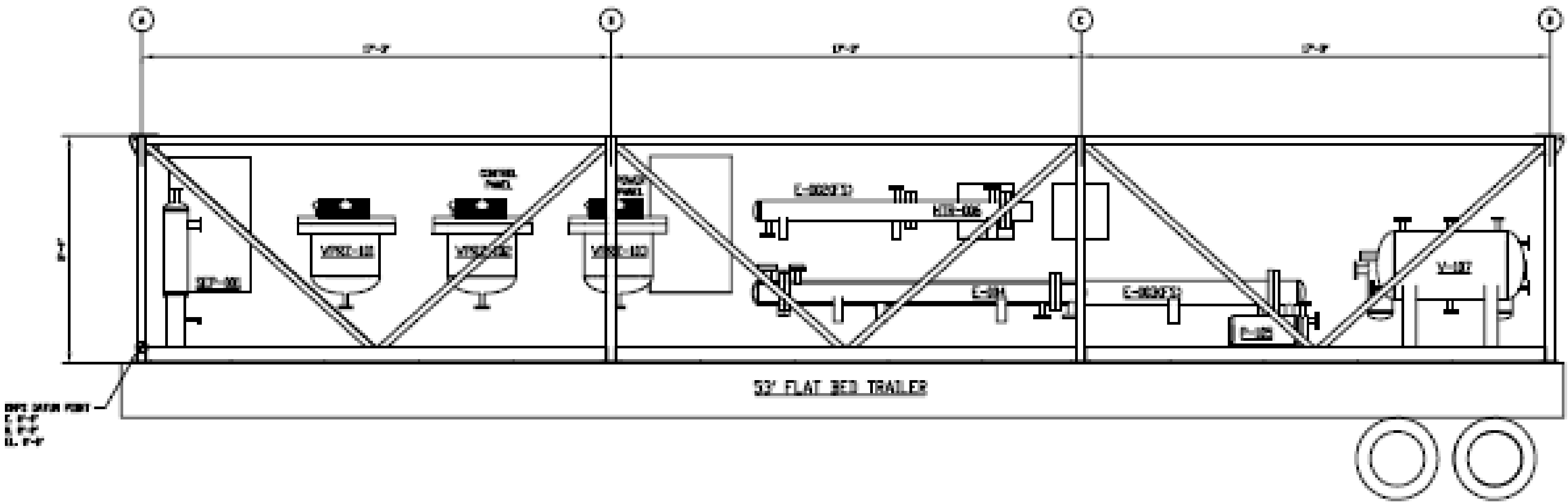
Scaling of LPP Technology

- LPP Technology Demonstrated Over Four Orders of Magnitude
- LPP is a Fuel Technology that is Inherently Scalable
- Modular Design Easily Expandable
- No Technical Barriers to Scaling of LPP System to Larger Applications
- System Can Be Sized for:
  30 kW (microturbine) to
  230 MW (Utility turbine)
- Pricing will vary with scale: $100 (large system) - $300/kW (small system)

Solar Turbines Taurus 60 Mobile Gas Turbine System
(Photo courtesy of Solar Turbines)

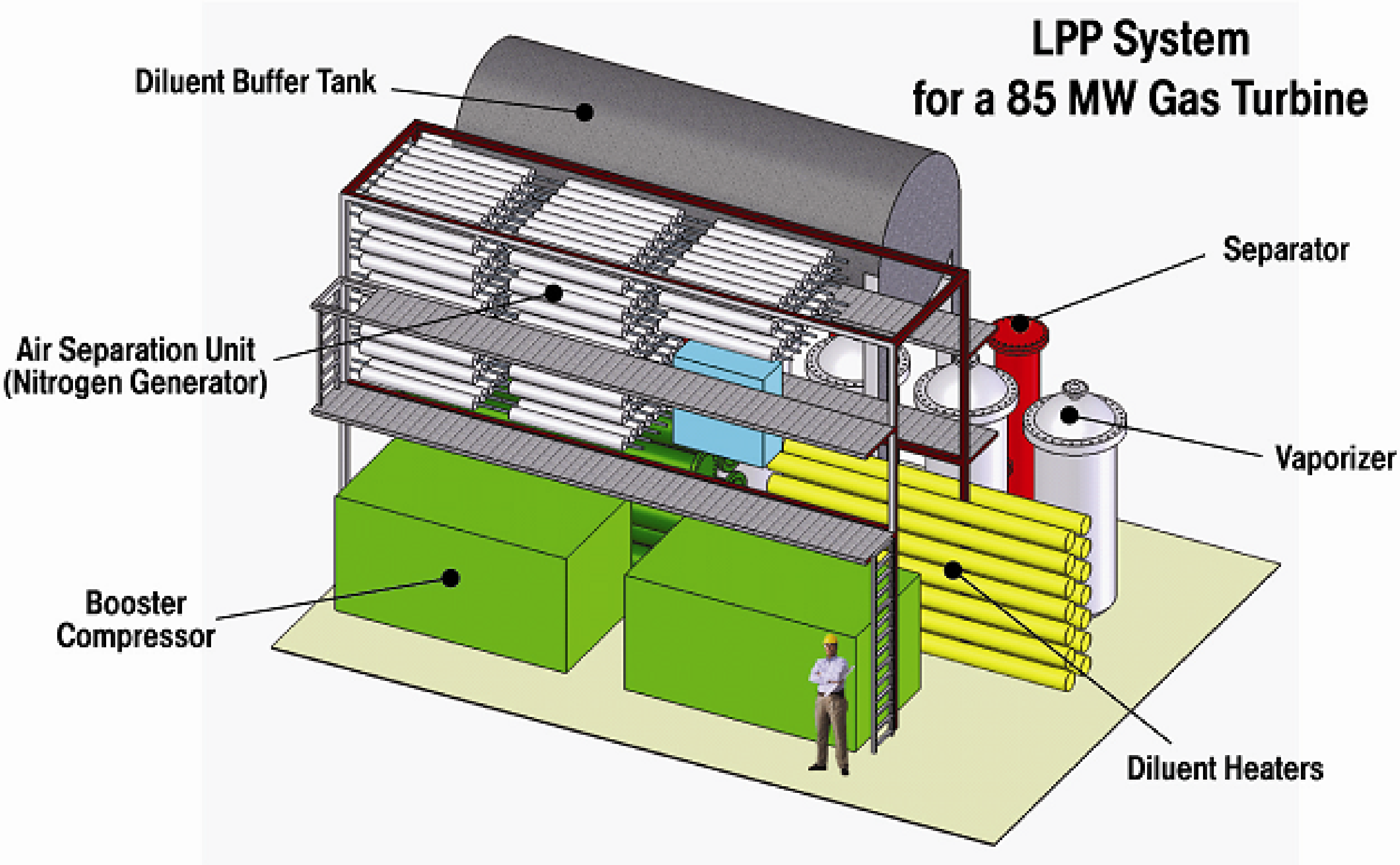
LPP Skid Schematic

LPP Combustion fuel preparation skid for a Solar Taurus 60/70



ELEVATION VIEW

LPP Technology



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LPP Combustion Business Description

- **Customers Run Gamut From…**
  - Small Combined Heat & Power Users: Manufacturing, Hospitals, Government Complexes, Large Retail, Hotels/Resorts, Military Bases
  - Medium Size LPP Products For Universities & Colleges, Industrial Users
  - Large LPP Products For Utilities, Public Power, and Independent Power Producers
- **LPP Combustion Is Technical And Commercial Center**
  - Manufacturing Out-Sourced to Local Firms
    - Ascension Industries
  - Design, Project Management & Warranty By LPP Combustion

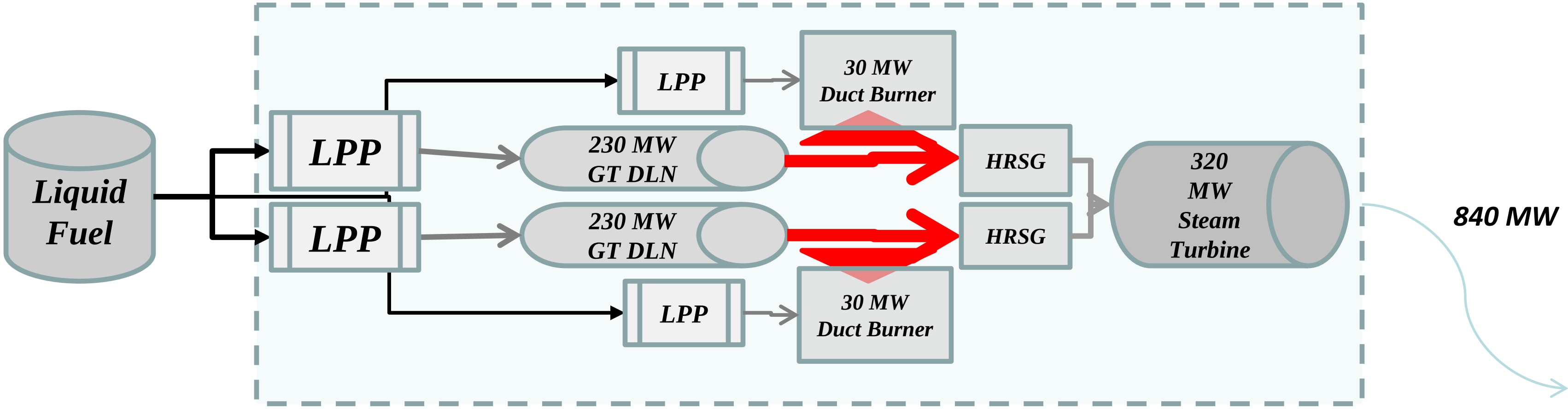
Manufacturing and Installation

- Selection of Modular Design Class Based on GT Size and Fuel(s)
- Site-specific Design Adjustments
  - Development of PFD’s and P&ID’s
- Manufacturing by Third-Party Constructor
  - Multiple Contractors Have Been Pre-Qualified
  - Preferred Vendor: Integrated Flow Solutions, Tyler, TX
- Site Installation
- Acceptance Testing

First Commercial Design

- Argentina Power Plant – operate on #2 oil & biodiesel
- LPP Combustion Design Project - $170K
- 840MW 2-on-1 Combined Cycle Power Plant
- Initial Design for 1-of-2 Duct Burner Systems
  - Developed PFDs and P&IDs
  - Provided Detailed Manufacturing Drawings and Bill of Materials
  - Provided Site Design and Layout
  - Provided Thermodynamic and Economic Analysis of Skid Impact on Plant Operation
  - Provided Detailed Cost Proposal of $6 million

2-on-1 Power Plant



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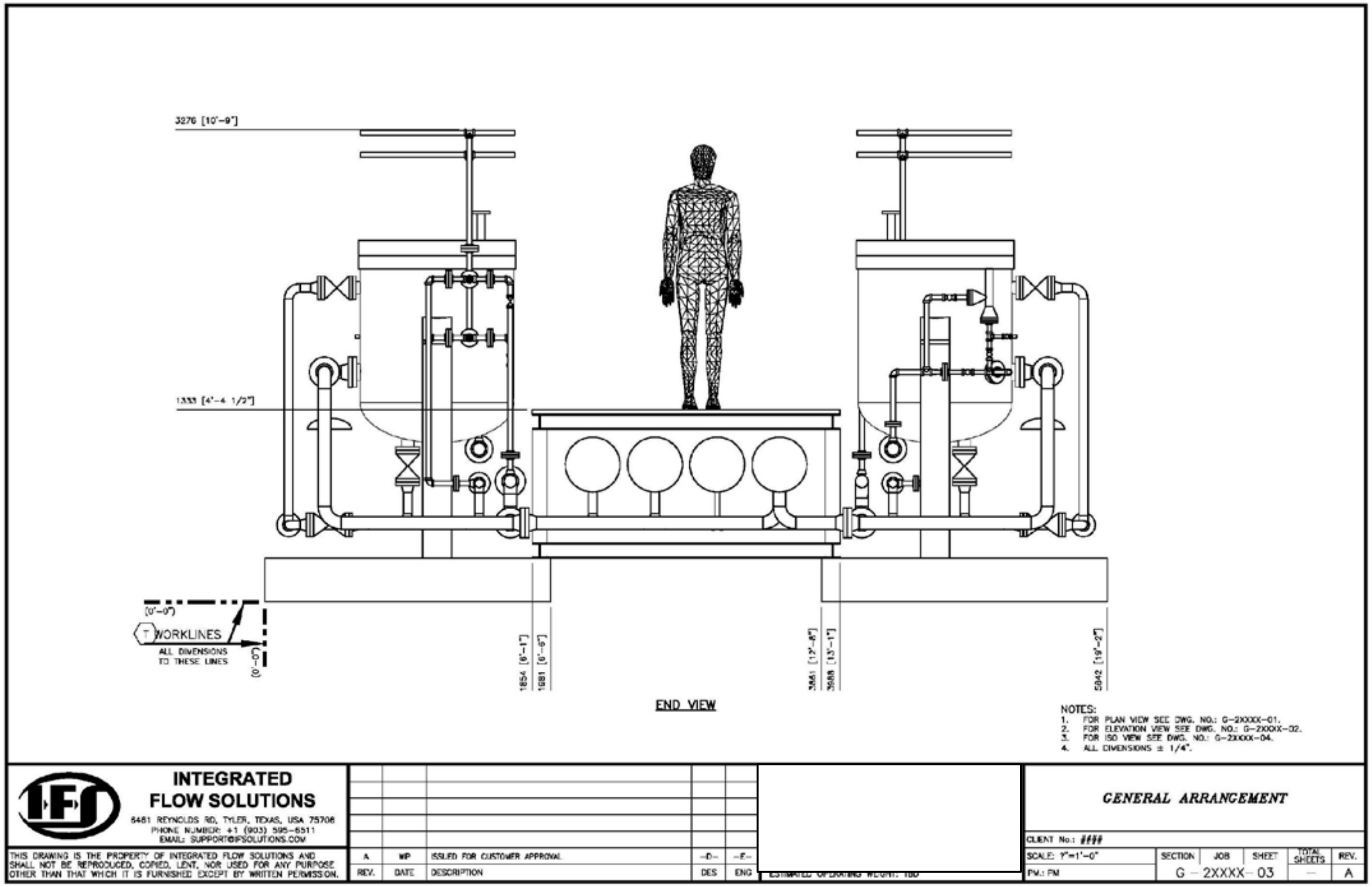
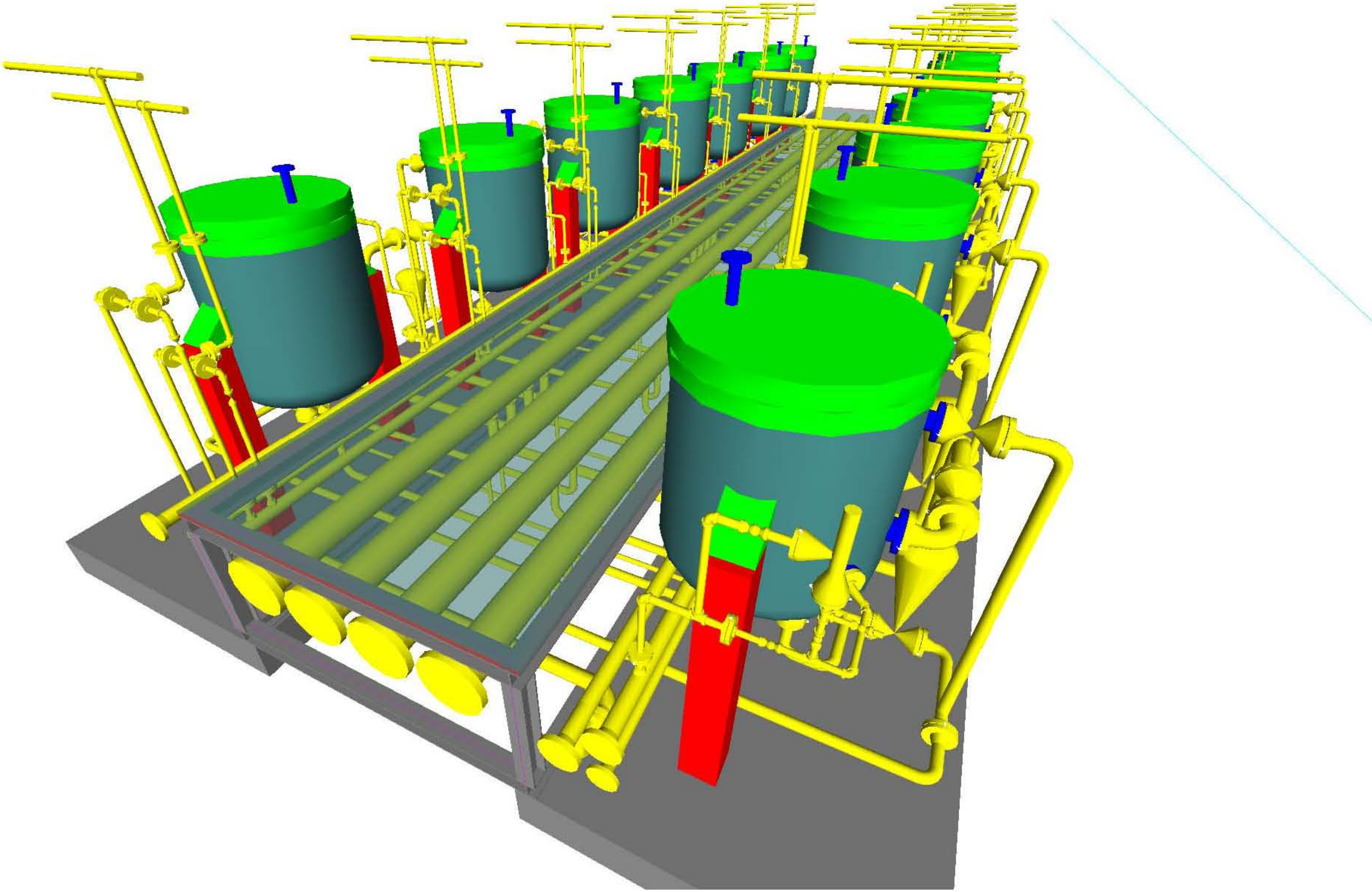
LPP Combustion Vaporizer Skid





Project Status

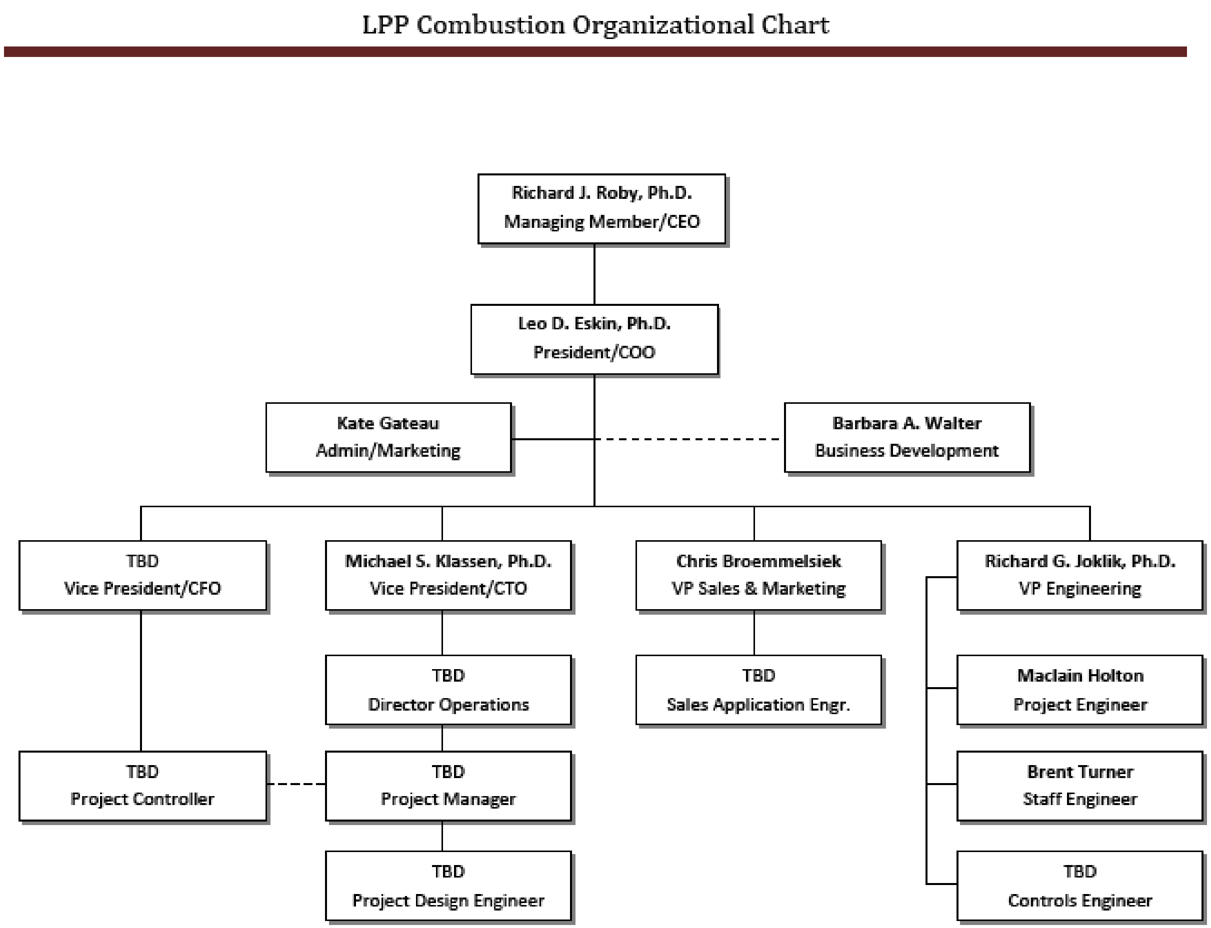
- Detailed Design Presented to Plant Management
- Project has Received Technical Approval
- Project Financing TBD
- LPP Combustion to Begin Manufacturing TBD
- Installation Expected by TBD

- Provided Additional Cost Estimate for:
  - 2nd Duct Burner Skid and 2 Turbine Skids
  - Total Cost Estimate for all Four Skids : ~$75 million

Intellectual Property

- US Patents
  - First US Patent (# 7,089,745) Awarded – August 15, 2006
  - Second US Patent (# 7,322,198) Awarded – January 29, 2008
  - Third US Patent (#7,770,396) Awarded – August 10, 2010
    - > Total of 96 claims allowed (both method & hardware)
- Foreign Patents
  - Awarded: South Africa, China, New Zealand, South Korea, Hong Kong & Australia
  - Pending in 44 countries including: Canada, Mexico, European Union, Norway & Japan
- Broad Protection of LPP System & Technology
- Multiple additional patents under review
- No competing technologies found in patent search

Experienced Management Team



Experienced Management Team

NAME	POSITION	YEARS EXPERIENCE	EXPERIENCE
Richard J. Roby	Chief Executive Officer	30+	• Co-Founder Combustion Science & Engineering (CSE) • Co-Inventor of the LPP Technology • Director of Combustion Research at Hughes Associates, Inc. • Performed Alternative Fuels research at Ford Motor Company • Ph.D. in Mechanical Engineering, Stanford University
Leo D. Eskin	President Chief Operating Officer	30+	• Prior experience as President and CEO of Tech, Inc. a low voltage construction firm • Founded Cogent Science, LLC specializing in numerical modeling of combined cycle gas turbine, coal and nuclear plants • Developed GateCycle software for optimizing power generating plants • Ph.D. in Mechanical Engineering, Stanford University
Michael S. Klassen	Vice President, Chief Technology Officer	20+	• Co-Founder and Principal Research Engineer at CSE • Co-Inventor of the LPP Technology • Consultant to Gas Turbine OEMs and Utilities • Ph.D., Master's in Mechanical Engineering, University of Maryland
Richard G. Joklik	Vice President Engineering	30+	• Principal Engineer at CSE • Co-Founder of LPP Combustion, LLC • Prior experience in combustion and emissions R & D with NIST, Energy & Environmental Research • Ph.D. in Mechanical Engineering, University of California, Berkeley
Christopher R. Broemmelsiek	Vice President, Sales & Marketing	30+	• 10 years experience with GE Power Systems • 10 years experience as VP Sales at ABB Power Generation in the US & Canadian Gas Turbine Combined Cycle market • Previously VP Development & Marketing at Competitive Power Ventures • BS in Mechanical Engineering, Purdue University • Sales of $5B+ Equipment to Power Gen Industry

Executive Summary

- **The LPP System Provides a Technology Solution that Enables the Clean Use of Liquid Fuels in Standard Combustion Devices**
- **Timely Investment Opportunity in the Renewable/Green-Friendly Power Generation and Combined Heat & Power Markets**
- **Strong Customer Economics and Sales Pipeline**
  - Multiple Commercial Demonstration Project Opportunities -> Accelerated Adoption
  - Rapid Payback for Customers – Typically Under 4 Months
  - Supports GHG Reduction Commitment of Universities/Industry/Local Govt
- **Proven and Patented Technology With Strategic Partnerships Creating Further Barriers to Entry**
  - Wide Range of Liquid Fuels Tested: Biodiesel, Ethanol, Biomass Derived Liquids, No.2 Heating Oil and Diesel, Kerosene, Naphtha, Coal Derived Liquids
- **Experienced Management Team with Start-Up Track Record**
- **Compelling Business and Financial Model for Investors**
  - Ability to Scale Rapidly and Achieve Cash Positive Operations Quickly
  - 10 to 12 Times ROI in 5 to 7 years