LPP = Lean, Premixed & Prevaporized

HARC/EFD Workshop
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Who Is LPP Combustion?

• LPP Combustion, LLC Is a Fuel Technology and Equipment Supplier Providing Clean Energy Solutions
  - Tested and Patented Technology that Converts Liquid Fuels Into A Substitute Natural Gas
  - Applicable For Gas Turbines, Duct and Boiler Burners
• Enables Electric Power for Oil & Gas Sites from Flare Gas & NGL’s

• Spin-Out From Combustion Science & Engineering, Inc.
  - Consulting Services To Global 100 (Caterpillar, GE, Siemens)
  - Consulting Services To U.S. Government (NSF, DOD, NIST)
  - Expertise in Combustion and Fire Science Applications

LPP = Lean, Premixed & Prevaporized
The Problem - Oil Field Flares

**LPP = Lean, Premixed & Prevaporized**

# Typical Bakken Flare Gas Composition

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>MOLE %</th>
<th>GPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>3.00</td>
<td>0.000</td>
</tr>
<tr>
<td>Methane</td>
<td>50.73</td>
<td>0.000</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>0.58</td>
<td>0.000</td>
</tr>
<tr>
<td>Ethane</td>
<td>19.92</td>
<td>5.319</td>
</tr>
<tr>
<td>H2S</td>
<td>0.00</td>
<td>0.000</td>
</tr>
<tr>
<td>Propane</td>
<td>14.83</td>
<td>4.066</td>
</tr>
<tr>
<td>i-Butane</td>
<td>1.82</td>
<td>0.593</td>
</tr>
<tr>
<td>n-Butane</td>
<td>5.00</td>
<td>1.570</td>
</tr>
<tr>
<td>i-Pentane</td>
<td>0.95</td>
<td>0.346</td>
</tr>
<tr>
<td>n-Pentane</td>
<td>1.16</td>
<td>0.418</td>
</tr>
<tr>
<td>Hexanes+</td>
<td>2.01</td>
<td>0.880</td>
</tr>
<tr>
<td>Oxygen/Argon</td>
<td>0.00</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Total: 100.00 13.191

**CALCULATED SPECIFIC GRAVITY** 1.0073 (Air = 1.0000)

**CALCULATED GROSS BTU/ft³** 1627 (Saturated) 1656 (Dry) at 14.73 psi and 60°F

**REMARKS**

$LPP = \textbf{Lean, Premixed & Prevaporized}$

Use low-cost, local fuels to replace expensive diesel fuel at Well Sites

- Replace use of $2.50/gal diesel fuel with flare gas or $0.50/gal Y-grade NGLs

- Produce on-site power for remote locations
- Reduce fuel waste and pollution caused by flaring
- Reduce Engineering & Procurement costs of operators
- Reduce reliance on diesel engines for well-site power
- Reduce the number of diesel trucks on the roads
LPP Benefits

- **Use raw, untreated gas from the well-head for electric power generation**
  - No need to separate liquids from the fuel stream
  - Use total energy content of the available NGLs on-site
  - No need to truck away NGLs
  - Flare gas reduction

- **Accommodate varying fuel-stream composition & heating value**
  - Handles hot-burning higher-hydrocarbons (C2 – C8)

- **Move the portable power systems from well to well**

- **Range of system sizes will power many applications:**
  - Drilling – 2 MW to 10 MW
  - Hydraulic Fracturing – 20 MW to 40 MW
  - Enhanced Oil Recovery (EOR) – 60 Kw to 1000 kW

- **Low emissions power generation with liquid fuels**

- **Produce hot water / steam on-site**

\[ \text{LPP} = \text{Lean, Premixed & Prevaporized} \]
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
The Result

Same Gas Turbine Combustion System as Natural Gas

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 Power Generation Equipment and Infrastructure
• Reduces Equipment Maintenance Cost
• Provides Rapid Customer Payback

Natural Gas Flame

LPP Gas™ Kerosene Flame

LPP = Lean, Premixed & Prevaporized

LPP is Liquid Fuel Agnostic

- Natural Gas Liquids (NGLs)
  - Ethane, Propane, Butane
  - Y-grade
- Wet Gas
  - Natural gas + NGLs
- Natural gasolines
- No. 2 Diesel Fuel Oil
- Naphtha
- Gasoline
- JP-8
- Kerosene
- No. 2 Heating Oil
Trailer Mounted 30 kW LPP System

LPP = Lean, Premixed & Prevaporized

Process Flow Diagram

**LPP = Lean, Premixed & Prevaporized**

LPP Combustion Demonstration

**Capstone C30 NOx Emissions**

- Methane (04/20/10)
- Gasoline (10/15/10)
- Naphtha (06/08/10)
- Biodiesel (09/15/10)
- Kerosene (10/20/10)
- JP-8 (11/22/10)
- S-8 (11/26/10)
- DF2 (10/21/10)
- Acetone (11/01/10)
- Iso-Propyl Alcohol (11/02/10)
- Ethanol (08/03/10)
- Toluene (11/02/10)

**Base Load DLN Mode**

**LPP = Lean, Premixed & Prevaporized**

LPP NGL Power Systems

- **Power Generation Capacity**
  - 200 kW  Capstone C200
  - 400 kW  Capstone C200 X 2
  - 600 kW  Capstone C200 X 3
  - 1.0 MW  Capstone C1000
  - 3.4 MW  Solar Turbines Centaur 40
  - 5.2 MW  Siemens SGT100
  - 5.6 MW  Solar Turbines Taurus 60
  - 30 MW  GE TM2500+

- **Fuel Cost**
  - $0 (Flare Gas)
  - $8 - $40/bbl (Y-grade) = $0.20 - $1.00/gallon
    - Y-grade @$8/bbl is half the cost of natural gas
    - $1.50 MBTU (Natural Gas = ~$3.00 Henry Hub + transport costs)

- **Combined Heat and Power (CHP) Configuration**
  - Produce process heat / hot water /steam

*LPP = Lean, Premixed & Prevaporized*
The NGL 200 Power System operates on C1-C8 fuels to provide 200 kW of electric power with natural gas emission levels. The NGL 200 can optionally be configured as a Combined Heat & Power (CHP) system to also produce hot water.

NGL Power Systems use industry standard, robust gas turbines configured to generate power using well-head gas, natural gas, and natural gas liquids (NGLs) ranging from ethane and Y grade to natural gasoline without the need for diesel fuel. The NGL Power Systems can be deployed in stationary applications or truck-mounted for mobile applications and ruggedized for severe weather.

**NGL 200 Turn-Key Power System**

**System features include:**
- Up to 200 kW continuous electric power
- Combined Heat & Power (CHP) option for hot water
- Capstone C200 Gas Turbine
- Lower maintenance cycles & cost
- High performance
- Rapid load-following
- 100% operation on wellhead gas, NGLs, Y grade
- On-the-fly fuel switching & blending
- No diesel fuel required
- Natural gas level emissions across fuel blends
- Mobile & Stationary installations
- Ruggedized option for severe weather

**LPP = Lean, Premixed & Prevaporized**
200 kW Value Proposition

• Comparison of 200 kW electric power generation
  • 200 kW Caterpillar Diesel Engine
    – Operating on No. 2 diesel fuel @ $2.50/gal delivered versus
  • LPP Combustion-equipped Capstone C200 Gas Turbine
    – Operating on natural gas liquids (NGLs) @ $0.40/gal

• Baseline Operation assumed at 8760 hours/year

• All Equipment Costs based on Monthly Rental

• Cost Savings for LPP System: ~ $150,000 per year
## LPP NGL 200 Power System

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Diesel</th>
<th>Capstone C200</th>
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<tbody>
<tr>
<td>Generator Type</td>
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<tr>
<td>Electrical Generation Capacity (kWe)</td>
<td>200</td>
<td>200</td>
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<tr>
<td>Fuel Type</td>
<td>DF2</td>
<td>NGLs</td>
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<tr>
<td>Total Operating Period (months)</td>
<td>12</td>
<td>12</td>
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<tr>
<td>Total Operating Hours (8000/yr)</td>
<td>8,760</td>
<td>8,760</td>
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<tr>
<td>Gross Electrical Generation (kWH)</td>
<td>1,752,000</td>
<td>1,752,000</td>
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<tr>
<td>Fuel Usage (gal/hr)</td>
<td>14</td>
<td>18</td>
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<td>Fuel Cost ($/MMBtu HHV)</td>
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<tr>
<td>($/gal HHV)</td>
<td>$2.50</td>
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<td>Total Fuel Cost</td>
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<td>Monthly Fuel Cost</td>
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<td>$243,528</td>
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<td>Generator Cost per month</td>
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<td>$6,000</td>
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<td>Mobilization/Demobilization costs</td>
<td>-</td>
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<tr>
<td>Total Generator Cost</td>
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<td>LPP Combustion Skid Rental Cost (per month)</td>
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<td>Payback period (months)</td>
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<tr>
<td>Cost of Electricity ($/kWH)</td>
<td>$0.18</td>
<td>$0.09</td>
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</table>

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Confidential

LPP NGL 6000 Power System

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

LPP Combustion Fuel Processing Skid
for a Taurus 60 Mobile Gas Turbine s)

LPP = Lean, Premixed & Prevaporized

Confidential
6 MW Value Proposition

• Comparison of 6 MW electric power generation
  • 3 X 2 MW 3516C Caterpillar Diesel Engines
    – Operating on No. 2 diesel fuel @ $2.50/gal delivered
  versus
  • LPP Combustion-equipped Solar Taurus 60 Gas Turbine
    – Operating on natural gas liquids (NGLs) @ $0.40/gal

• Baseline Operation assumed at 8000 hours/year

• All Equipment Costs based on Monthly Rental

• Cost Savings for LPP System: ~ $8.4 million per year
# LPP NGL 6000 Power System

<table>
<thead>
<tr>
<th>Description</th>
<th>3 x Cat 3516C Diesel</th>
<th>Taurus 60 GT</th>
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<tbody>
<tr>
<td>Generator Type</td>
<td>3 x Cat 3516C Diesel</td>
<td>Taurus 60 GT</td>
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<tr>
<td>Electrical Generation Capacity (kWe)</td>
<td>6000</td>
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<tr>
<td>Fuel Type</td>
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<td>NGLs</td>
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<tr>
<td>Total Operating Period (months)</td>
<td>12</td>
<td>12</td>
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<tr>
<td>Total Operating Hours (8000/yr)</td>
<td>8,000</td>
<td>8,000</td>
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<tr>
<td>Gross Electrical Generation (kWH)</td>
<td>48,000,000</td>
<td>48,000,000</td>
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<tr>
<td>Fuel Usage (gal/hr)</td>
<td>435</td>
<td>350</td>
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<tr>
<td>Fuel Cost ($/MMBtu HHV)</td>
<td>$</td>
<td>-</td>
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<tr>
<td>($/gal HHV)</td>
<td>$2.50</td>
<td>$0.40</td>
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<tr>
<td>Total Fuel Cost</td>
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<td>Monthly Fuel Cost</td>
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<td>$(7,580,000)</td>
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<td>Generator Cost per month</td>
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<tr>
<td>Mobilization/Demobilization costs</td>
<td>$-</td>
<td>$400,000</td>
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<tr>
<td>Total Generator Cost</td>
<td>$3,600,000</td>
<td>$1,900,000</td>
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<td>LPP Combustion Skid Rental Cost (per month)</td>
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<tr>
<td>Total LPP Combustion Skid Rental Cost</td>
<td>$900,000</td>
<td>$900,000</td>
</tr>
<tr>
<td>Total Operating Cost</td>
<td>$12,300,000</td>
<td>$3,920,000</td>
</tr>
</tbody>
</table>

| Total LPP Combustion/GT System Savings           | $8,380,000            |
| Pay back period (months)                         | 5.6                   |
| Cost of Electricity ($/kWH)                      | $0.26                 | $0.08        |
Flares to Electricity

Proven gas turbine power generation using Bakken flare gases, Y-grade and other NGLs.

Wellsite power systems available for sale or lease in mobile units from 65 kW to 30 MW.

We can help you turn off the flare and turn on the power

Turning your flares into clean power

Chris Broemmelsiek or Elizabeth Zelley | 410-884-3089 | info@LLPCombustion.com

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Contact

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or
Chris Broemmelsiek
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