# Rocky Mountain GPA:
# Fuel Gas Conditioning
# For Remote Reciprocating Engines

## September 2013

DCL America Inc.

Global Leader In Emission Control Systems

# Agenda

- About DCL
- Fuel Gas Issues
- Existing Products
- DCL Concept & Data
- Summary

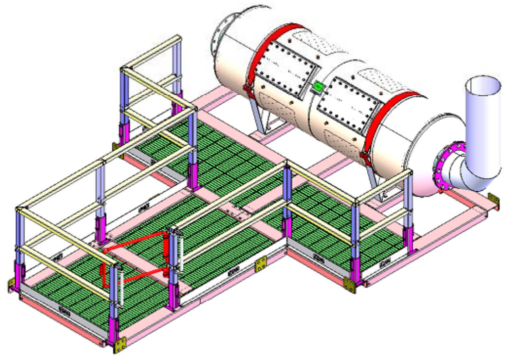
# Who We Are

**$50 million specialized designer and manufacturer of catalytic materials and integrated steel assemblies, in operation for 27 years**

- 175 employees across 5 countries
- >200,000 sq ft manufacturing & 3 US warehouses
- Global customer base in mining, construction, material handling, commercial vehicles, power generation and gas compression
- ISO 9001 registered research, design and manufacturing

# Stationary Markets
# Unique Advantages

- Application optimized catalyst
  - Long term compliance at lower cost
  - Infinite ability to adjust catalyst parameters
- Leading Design & Manufacturing
  - Lowest packager integration costs
  - Application specific designs
  - Assembly-line consistency
- Plug in replacement designs
  - Minimum amount of site prep work
  - Close tolerance production
- >1M US Based Inventory



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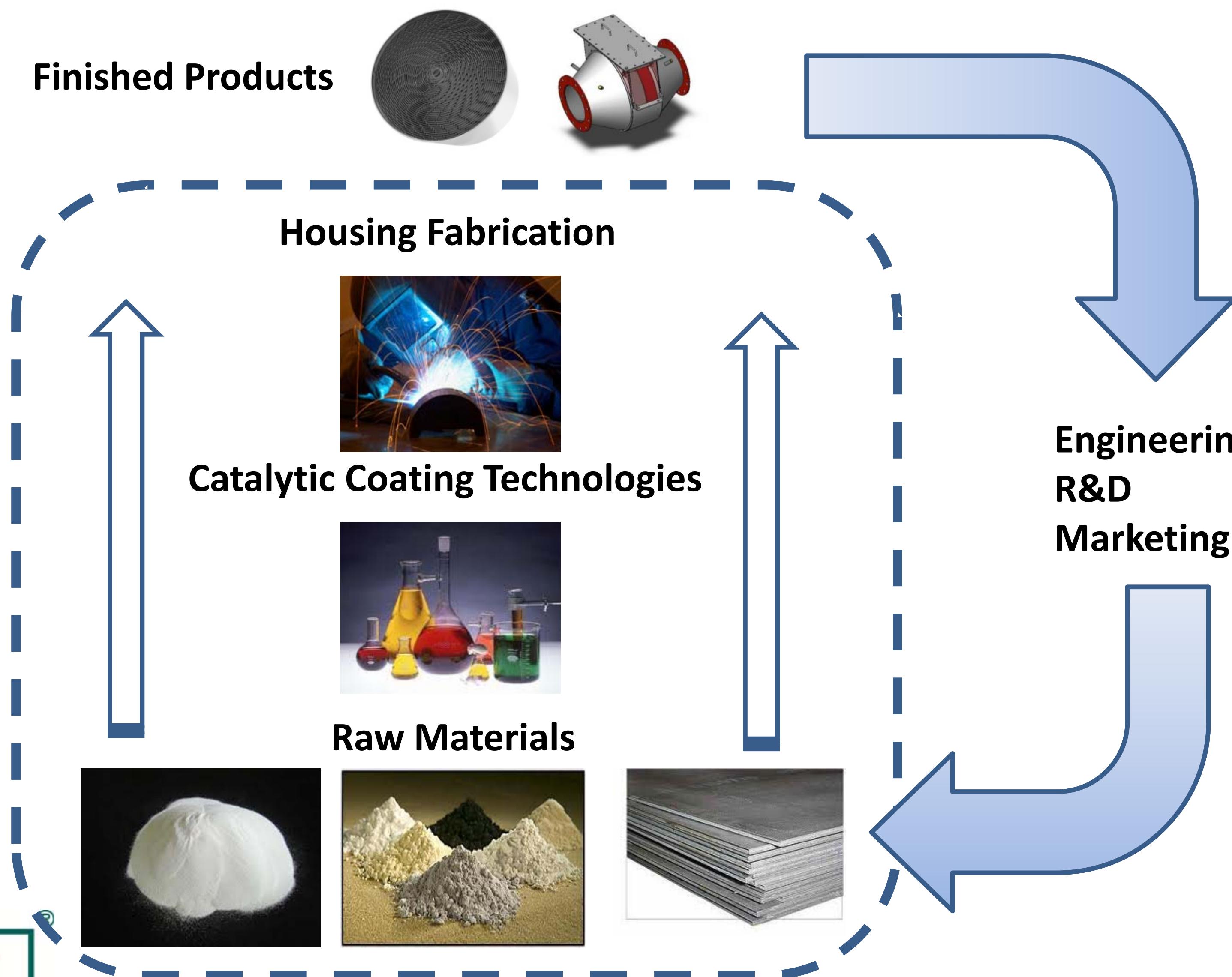
# Vertical Integration



# Field Gas Issues

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# Starting Point:  Challenges

- Varying fuel energy content
- Varying levels of ethane and higher hydrocarbons
- Lower methane number for the fuel

All of the above can result in:

- Engine deration
- Failed emissions tests
- Detonation &/or engine damage

# Existing Solutions

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# Membrane Fuel Filtration

Patented polymer membranes utilize varying molecular size/permeation rates & pressure to separate a percentage of heavier hydrocarbons

- Separated components can be collected for sale
- Fuel pressure of 1000 psig required
- Scalable for fuel flow & relatively compact skid size
- Costs vary from $200K - > $1M
- Some challenges reported with clogging from recirculation (glycol) and hydrates

# Turboexpander/J-T Systems

Cryogenic system with a Joule-Thompson valve is used to separate heavier hydrocarbon components out for resale

- Significant capital investment
- Excellent for separation of >30% ethane and higher
- Broad range of temperatures and pressures to handle across all of the components
- Suitable for processing plant and grouping of reciprocating engines

# DCL's Concept

# Origins

Approximately 18 months ago DCL was approached by many of our customers complaining of issues operating field gathering and booster units

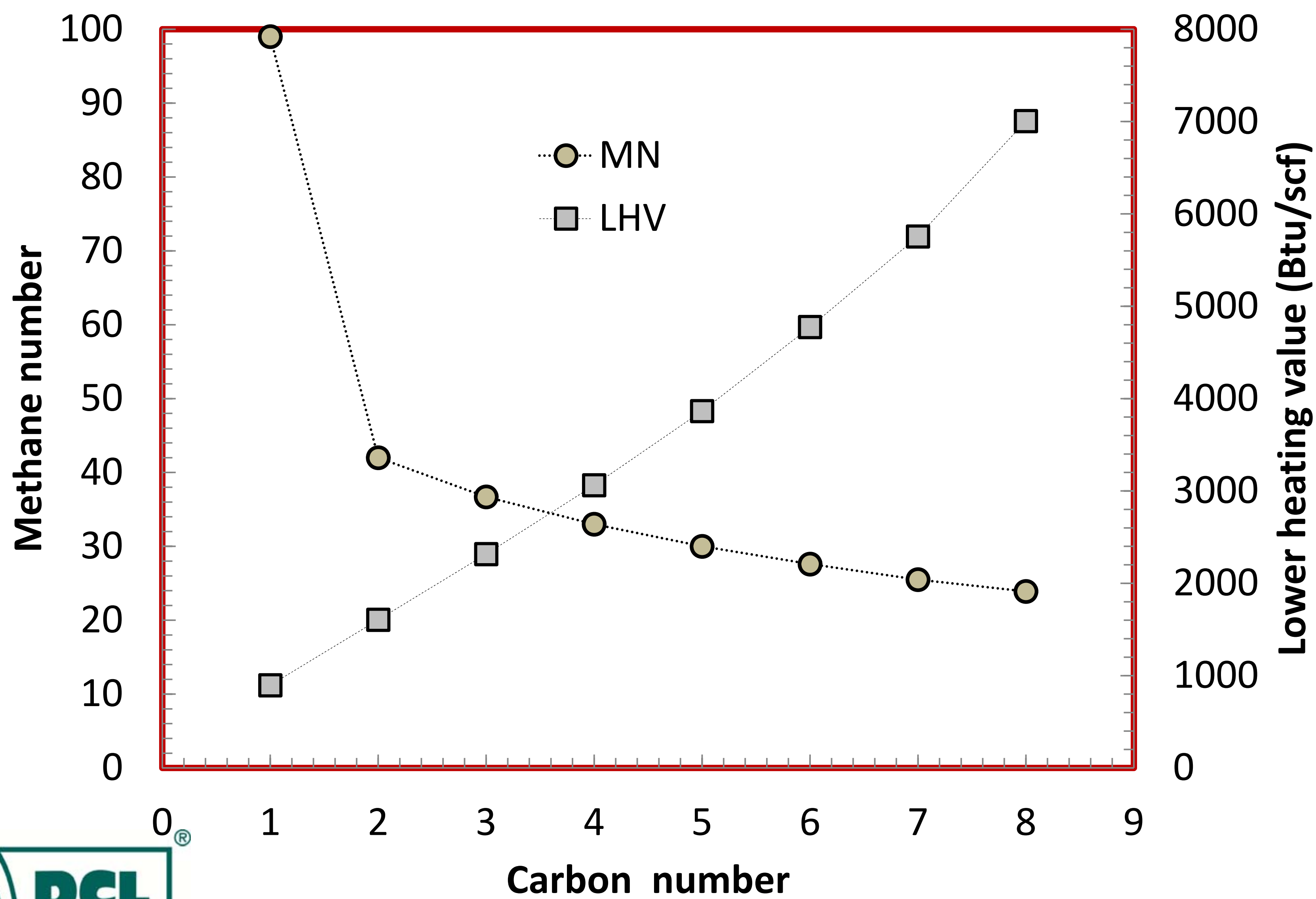
We hypothesized that using our expertise in catalysis it might be possible to change the fuel properties to improve engine operation by raising methane number and lowering the heating value

***While treating simultaneously exhaust emissions ***

# Methane Number

- Analogous to Octane # in gasoline
- Minimum number required for proper engine combustion characteristics
- The more hydrocarbons present in the fuel that are >C1, the lower the MN

# MN and LHV of HCs

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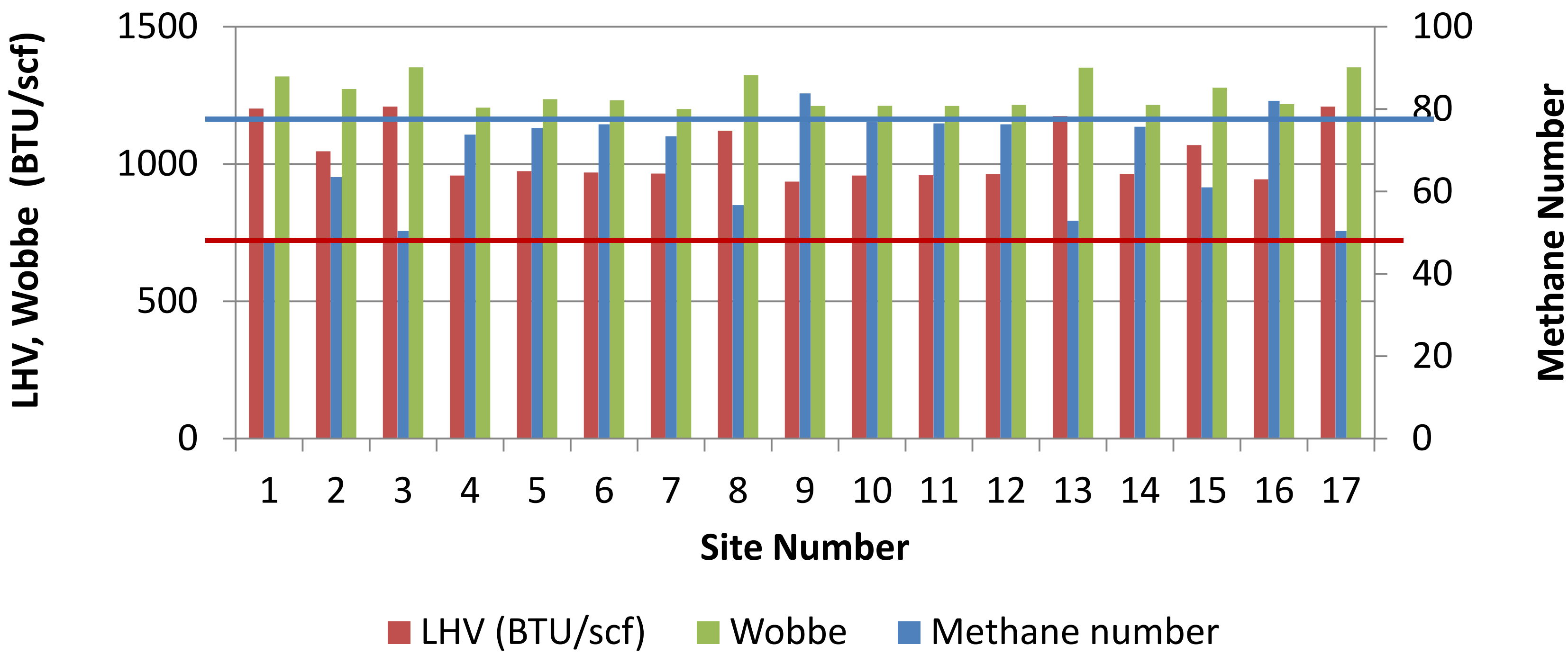
# Step 1: Data Collection



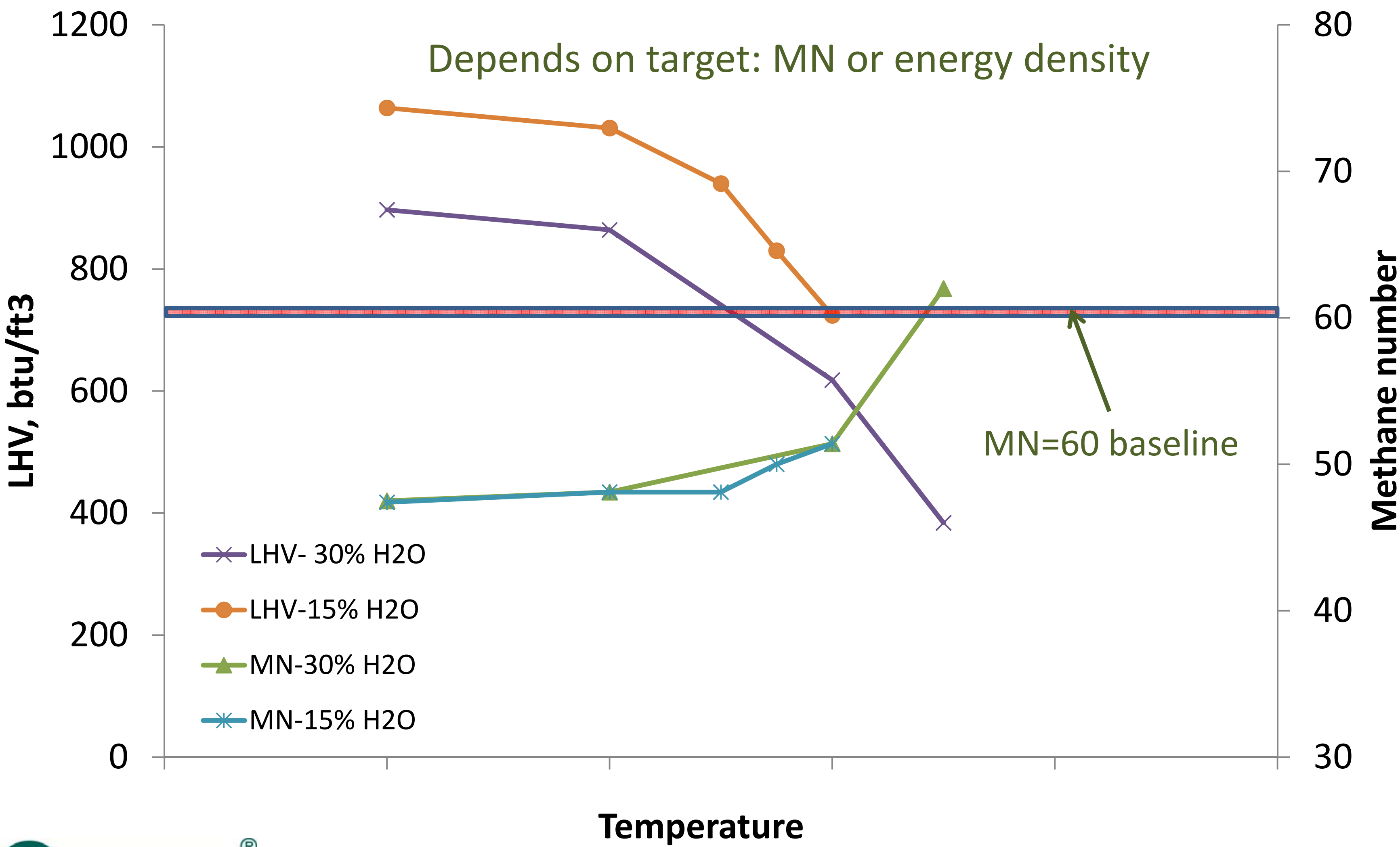

| | Average | Minimum | Maximum |
|---|---|---|---|
| LHV (BTU/SCF) | 1037 | 936 | 1,209 |
| Methane number | 68 | 49 | 84 |
| Wobbe Index | 1259 | 1200 | 1352 |

*Calculated by online tool:*
*https://quickserve.cummins.com/gas_analysis_tool/index.html*
*#combinednew*

# Some options DCL considered...

- Dilution
  - Water injection into feed gas
    - Too much water needed – it will condense in the gas line
  - Exhaust dilution of feed gas
    - High volume of gas required
- Steam reform gas to CO and Hydrogen
- Limit air and Temperature- Reform HHC over catalyst

# Would The Idea Work?

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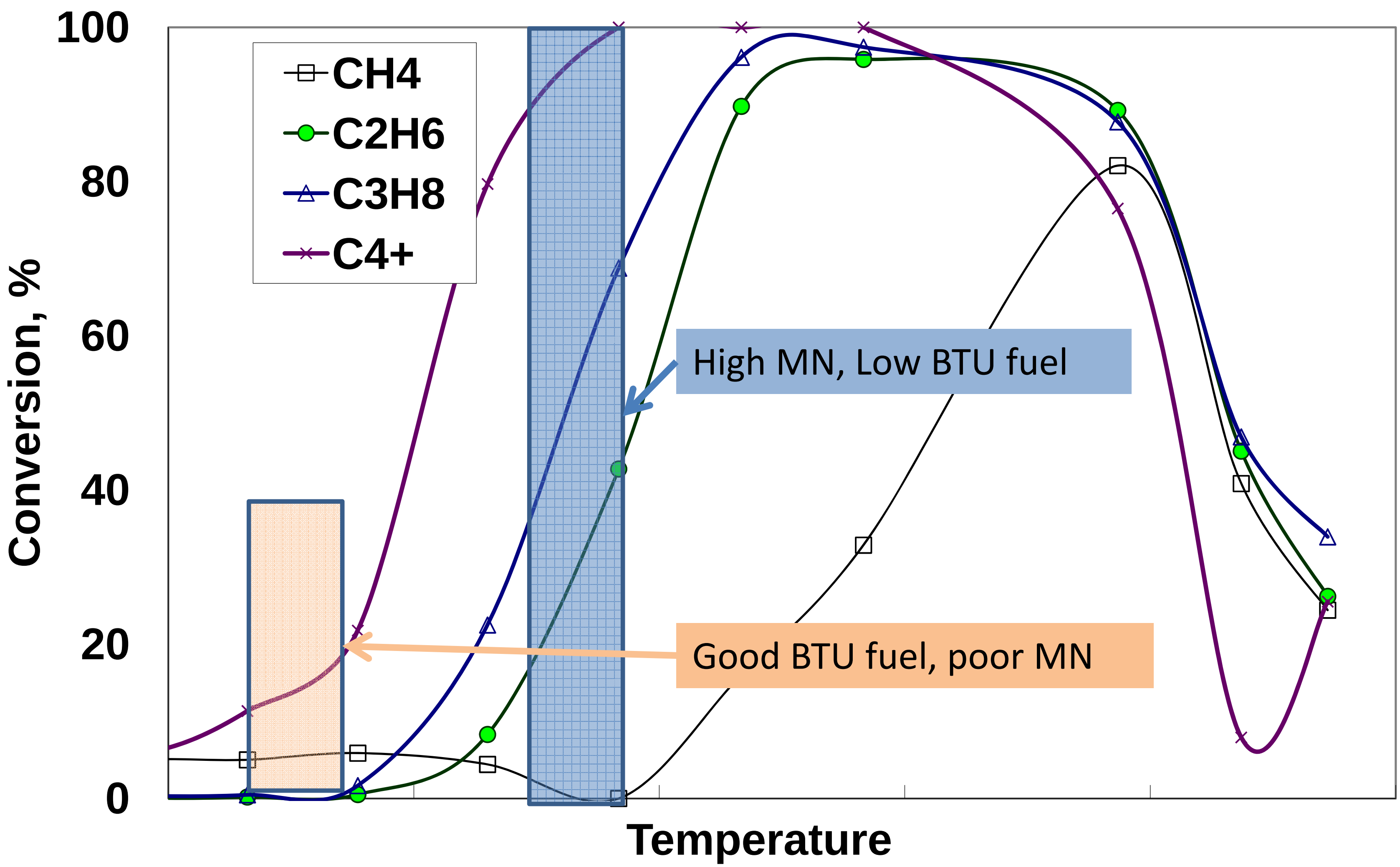
# Preliminary Steam Reforming Results

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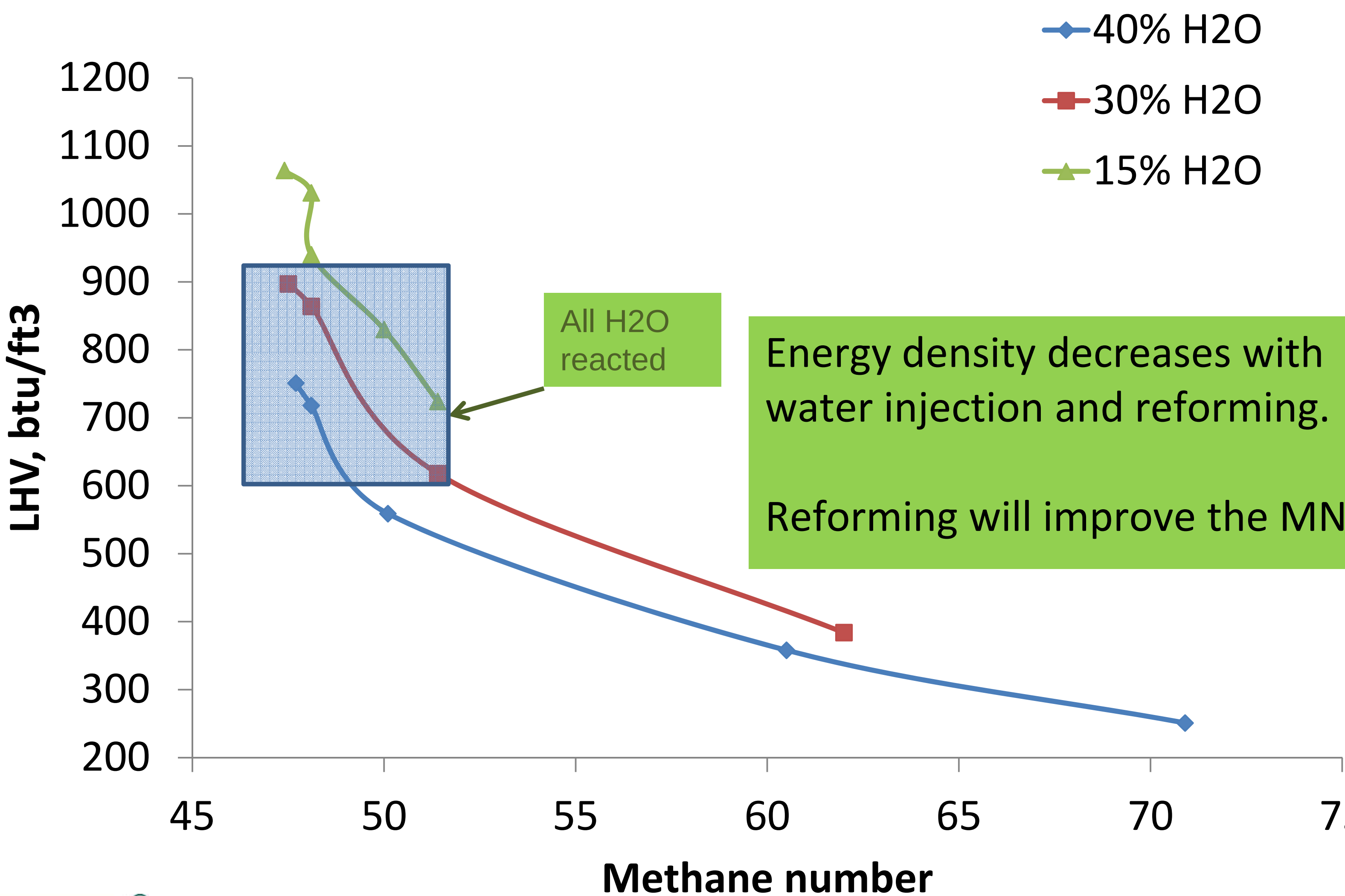
# Energy Density vs. MN




Energy density decreases with water injection and reforming.

Reforming will improve the MN.

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# Market Research

- Potential customers have identified air injection as preferred method
- Reaction temperatures and water consumption proved impractical for operators

However;

- MN calculations are not precise, based on Cummins program which doesn't account for $CO_2$ or $H_2$

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# Example Wellhead Gas Composition

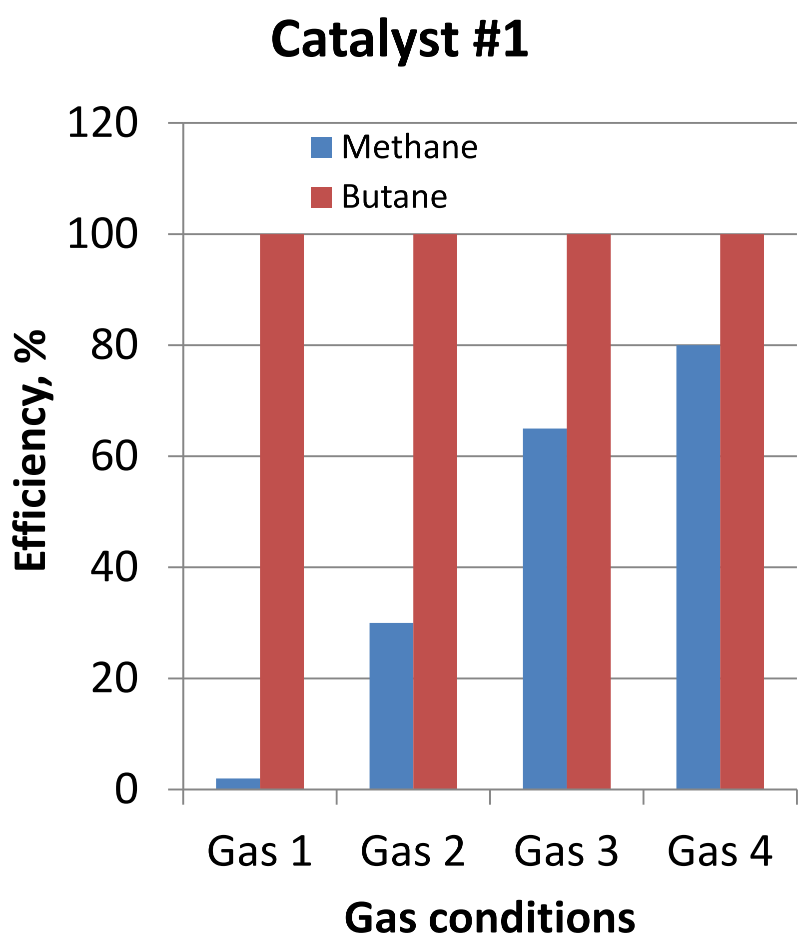
| Component | Mole % |
|---|---|
| Nitrogen | 5.48% |
| CO2 | 0.48% |
| Methane | 65.25% |
| Ethane | 15.25% |
| Propane | 8.18% |
| i-Butane | 0.74% |
| n-Butane | 2.49% |
| i-Pentane | 0.47% |
| n-Pentane | 0.70% |
| C6+* | 0.46% |
| C7+* | 0.36% |
| C8+* | 0.14% |
| C9+* | 0.01% |
| Total | 100.01% |

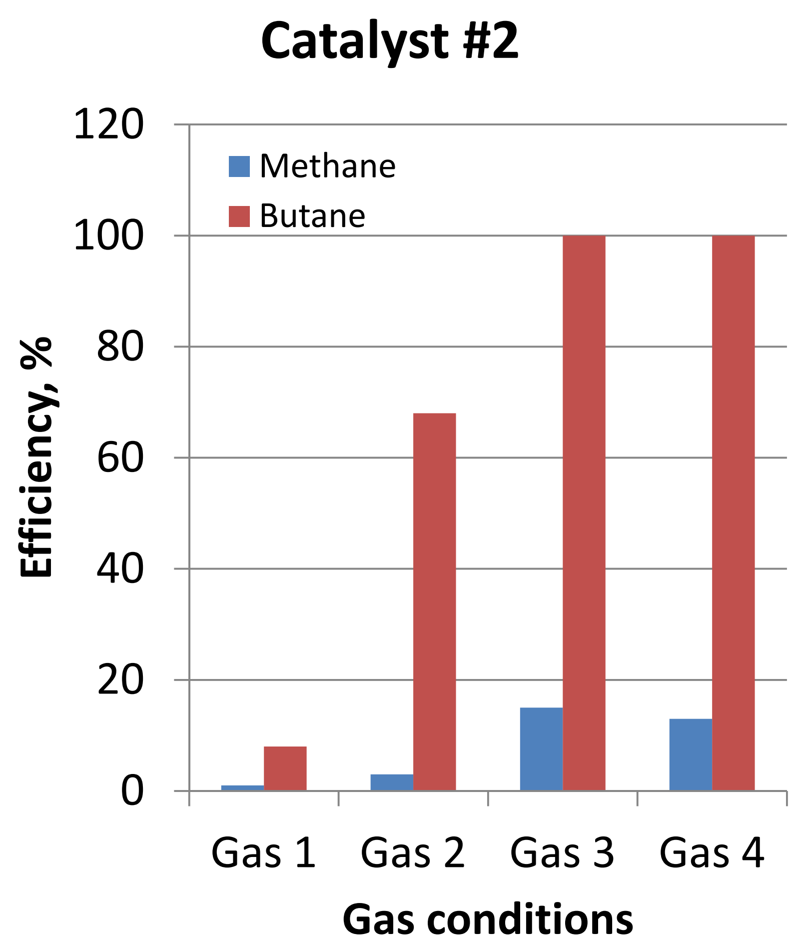
| | This gas | PQNG |
|---|---|---|
| LHV (BTU/scf) | 1200 | 905 |
| Methane Number | 49 | 92 |

Wellhead gas
~ 30% higher LHV than PQNG
~ 47% lower MN than PQNG

On average for gas samples
~ 13% higher LHV than PQNG
~ 26% lower MN than PQNG

# Catalyst and Gas Condition Important

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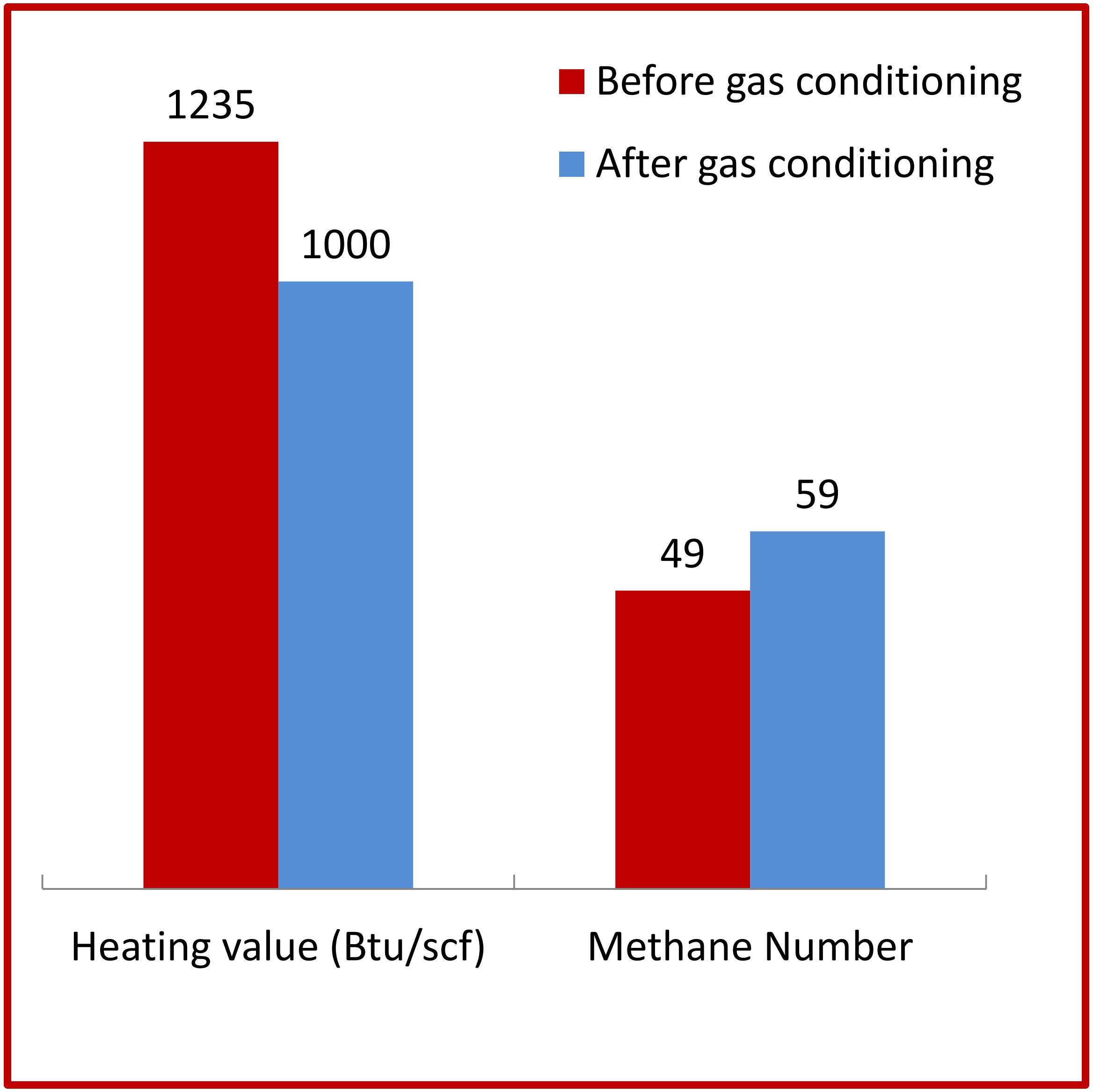
Temperature and space velocity (catalyst volume) constant

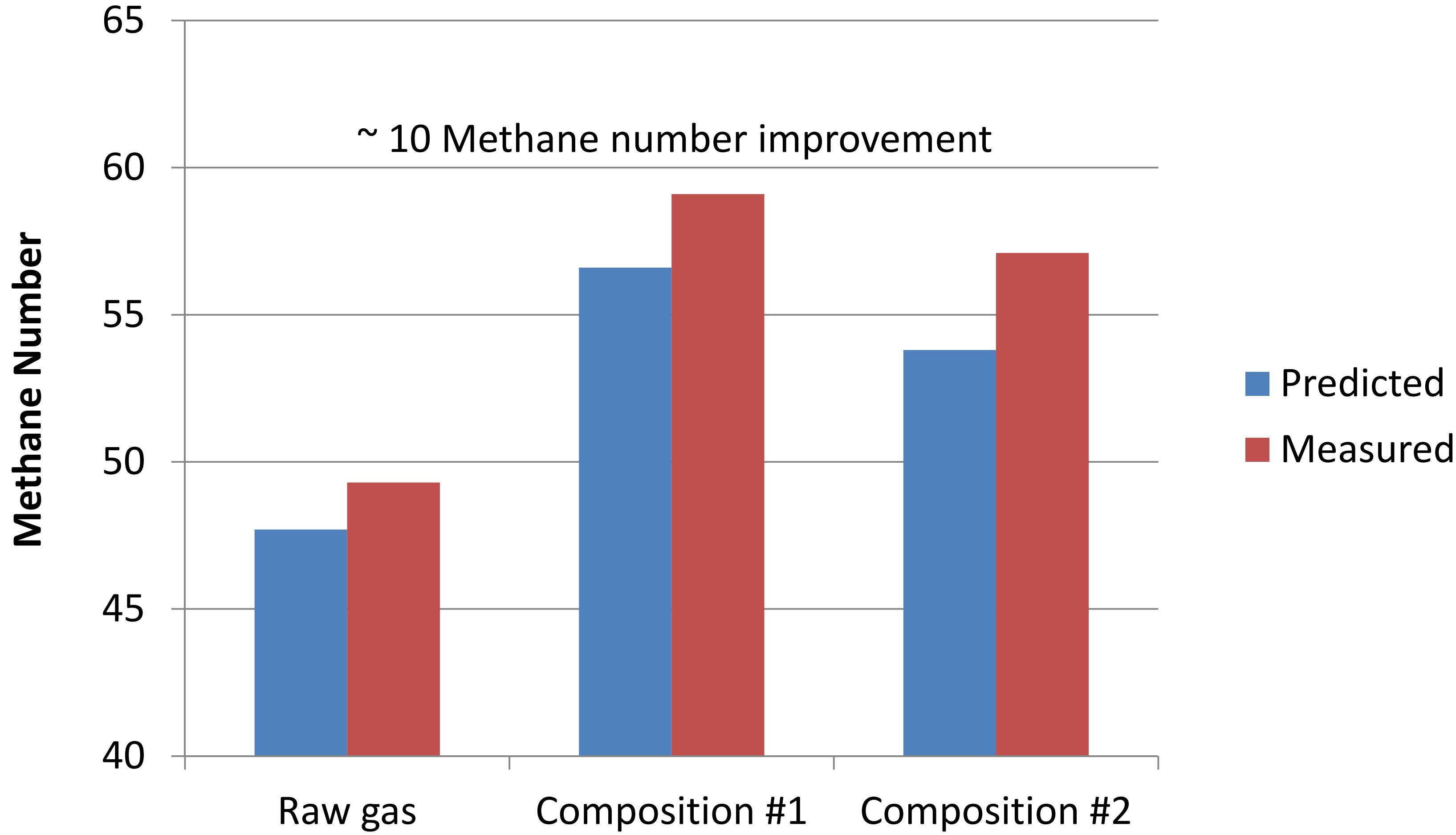
# Project Objective / Target



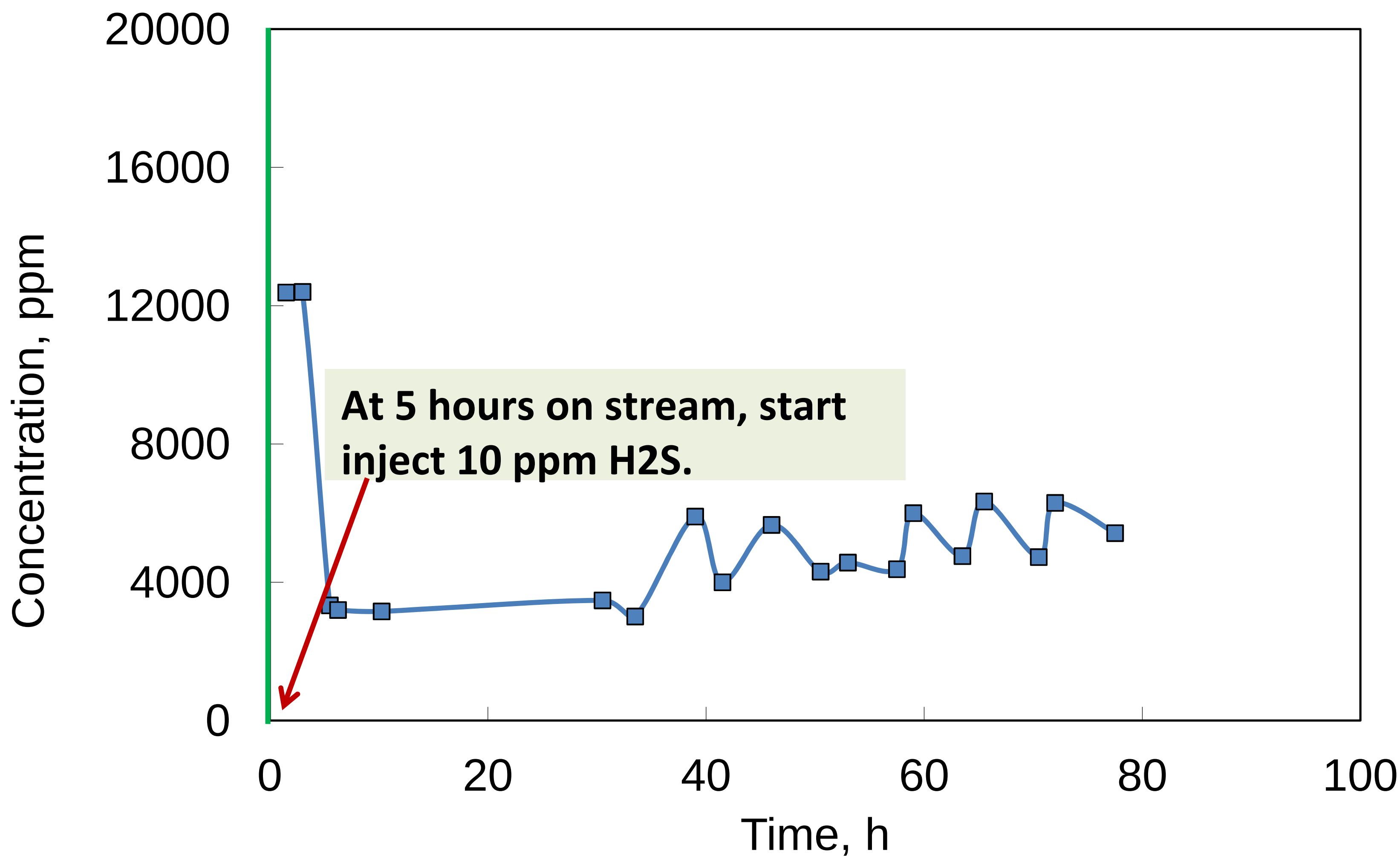
# Research Validation

- CSU was contracted Spring 2013 to confirm actual MN results from several examples of DCL conditioned fuel
- Further steps have confirmed the stability of the catalyst from degradation due to H2S or carbon deposition
- Data presented on subsequent slides

# CSU Test Data



# The catalyst is stable

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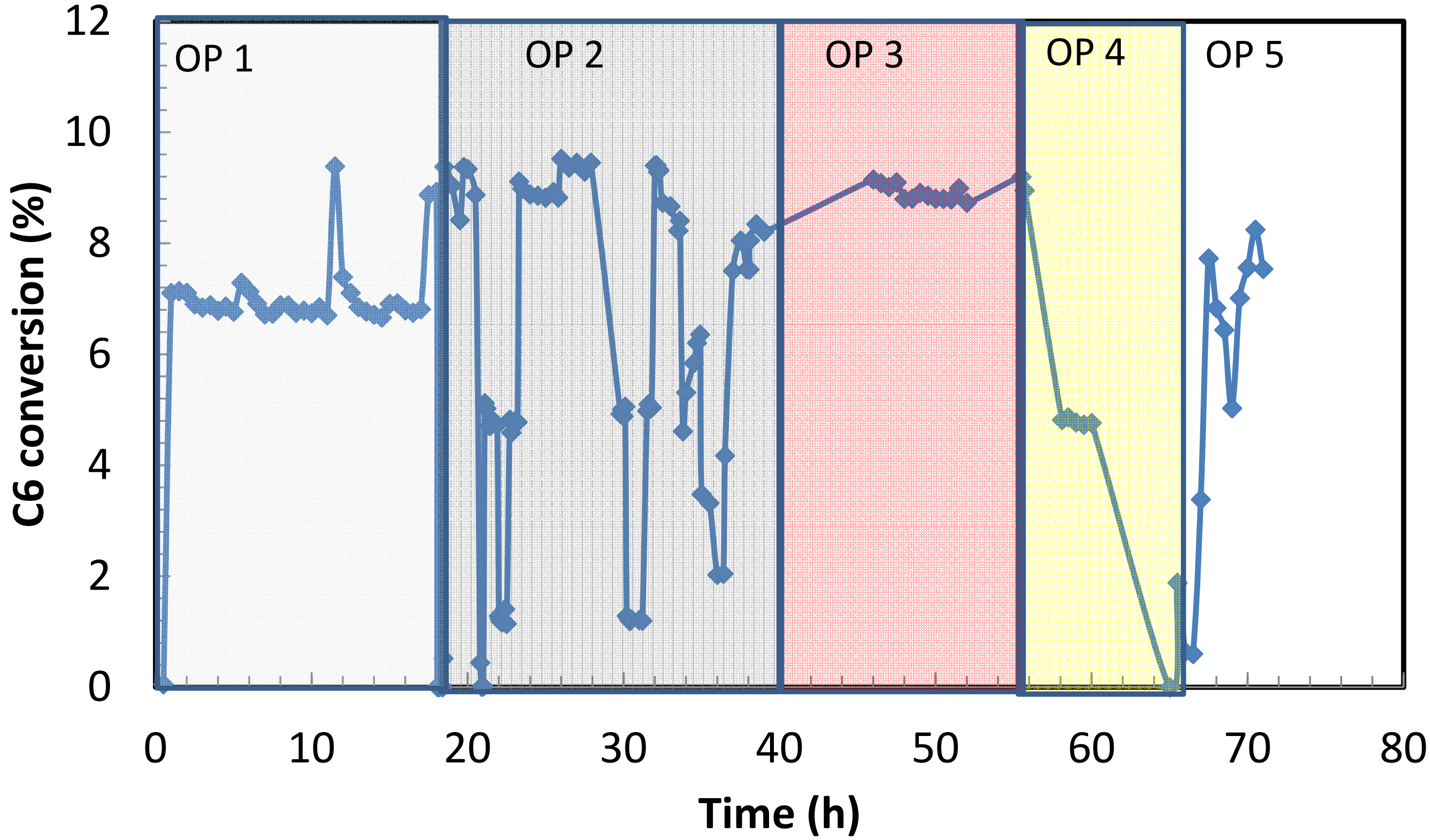
# Long-term activity (Hexane/Methane)

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# Further Work

- As with emissions control catalysts, product development follows an iterative process
- Eventual goal of long term (many thousand hrs) durability without service requirements
- Further experimentation will be completed this Fall to test the specificity, H2S sensitivity and susceptibility to contaminants

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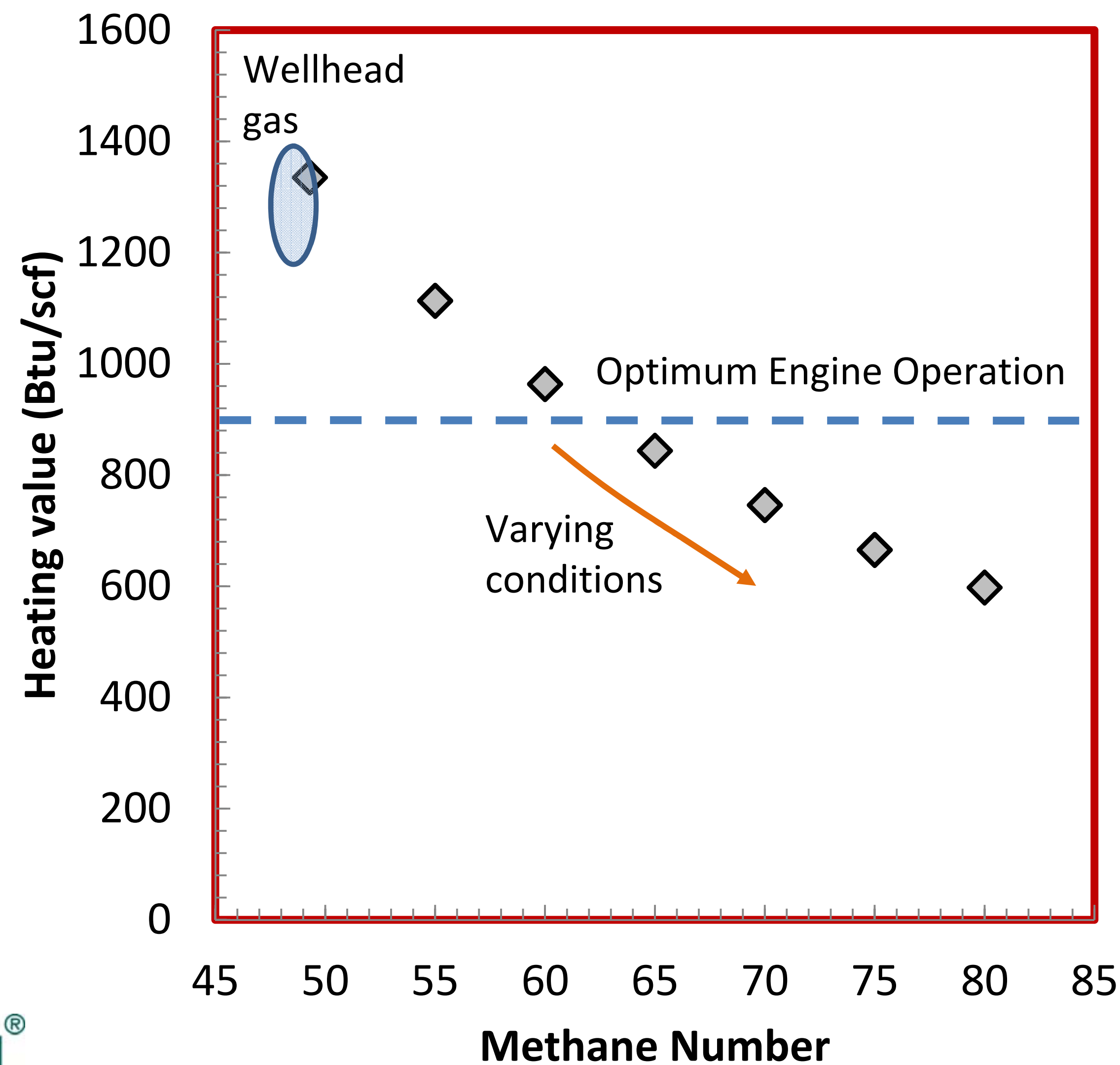
# Optimum Catalyst Performance Curve

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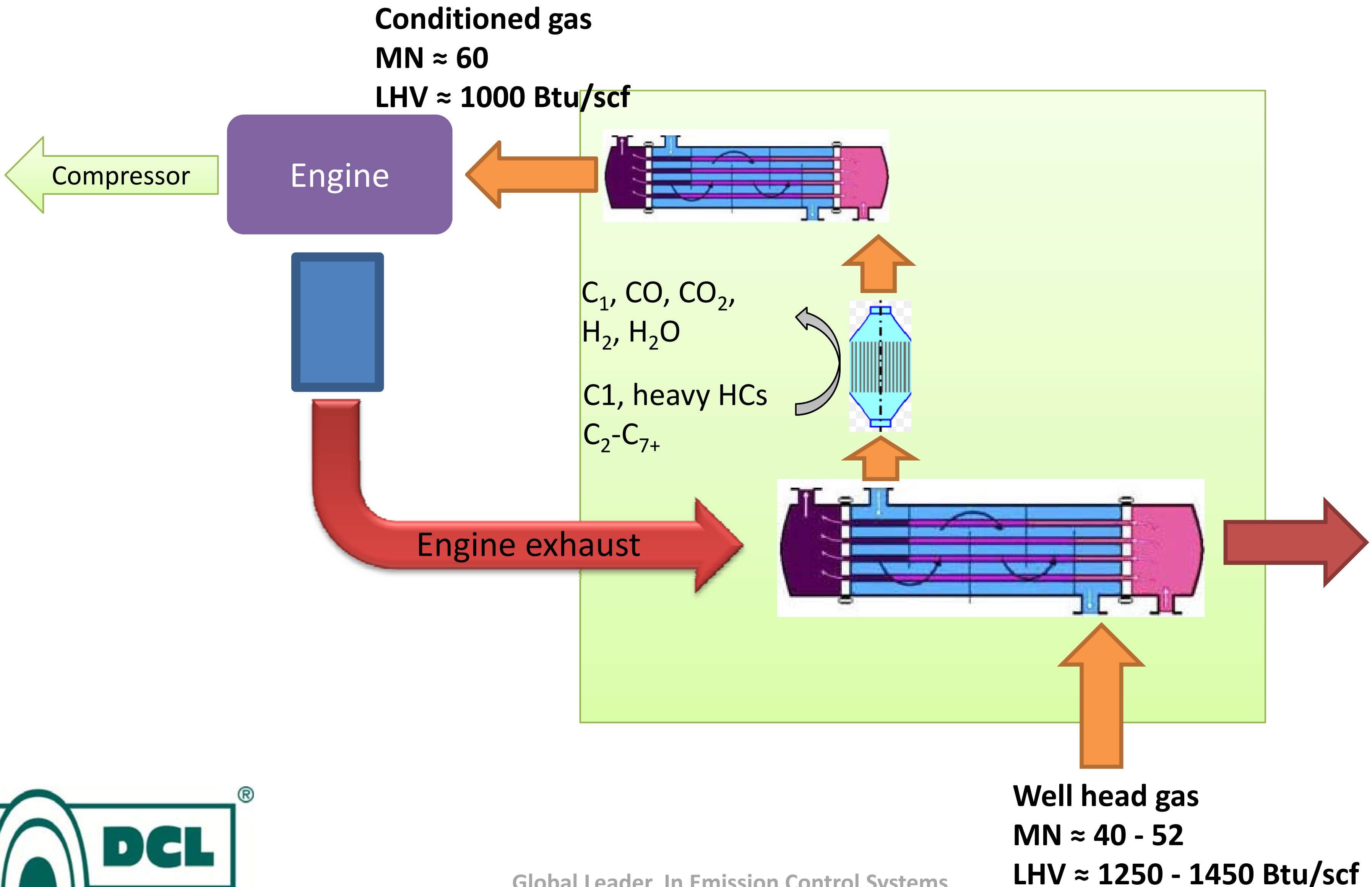
# Proposal

- Reform heavy hydrocarbons in the wellhead gas to CO, $CO_2$ and hydrogen
  - Lower BTU content of gas
  - Increase Methane #
- Accomplish via a simple reactor on the feed line
  - Combined heat exchanger + catalyst system
  - Catalyst will be optimized for site specific conditions

***Constant Fuel Pressure***

# Example Layout

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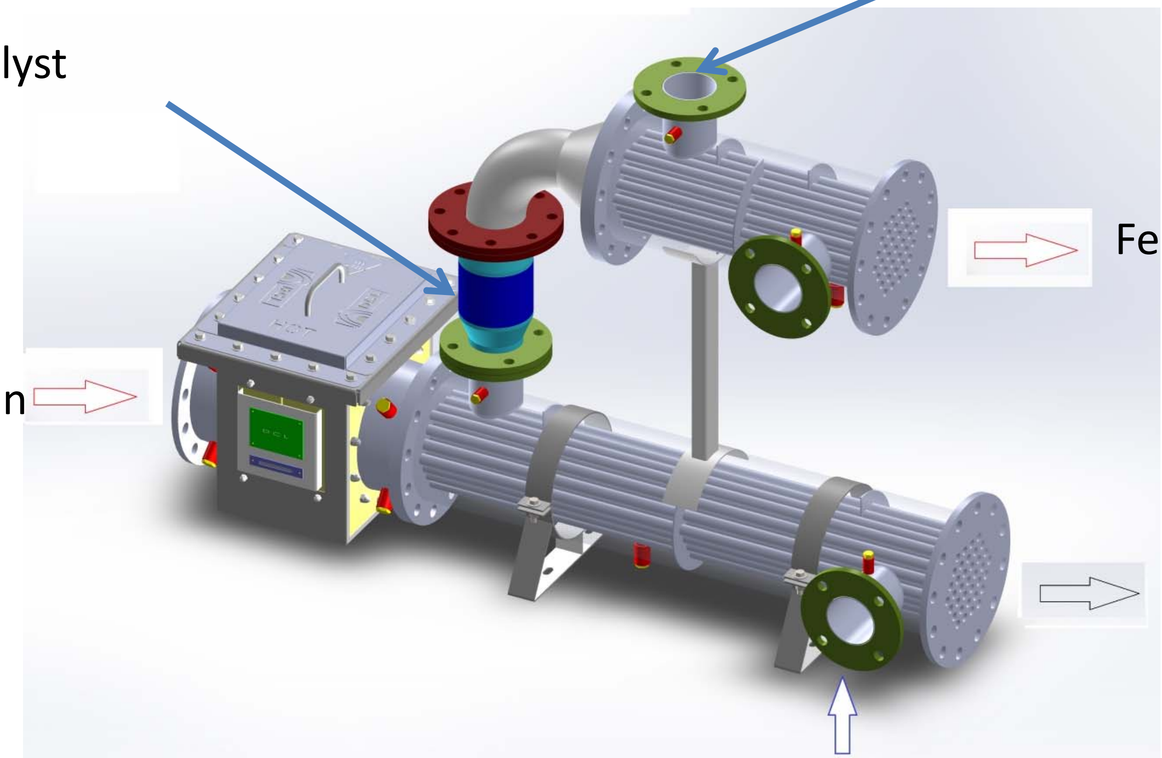
# Proposed Layout

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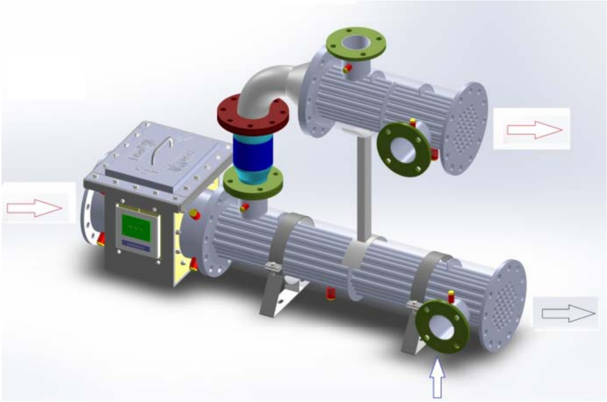
# Market Concept



Target Market:
-remote gathering/booster equipment
-not cost effective for other technologies

Separate skid, Class 1 Div II rated
-scalable for fuel flow/multiple engines
-stand-alone from engine or
combined with exhaust treatment

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# End Product Goal

- Analogous to strong beer (alcohol content is high) same as high levels of Ethane and Propane etc…
- Fuel Conditioner lowers the alcohol content to a light beer for smoother "operation"

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# Next Steps

- Pilot scale system under construction currently
- Test site identified and planned field unit testing later this fall
- Commercial product early 2014

# Questions?

Thank you for your attention

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