Gas Fuel Flexibility in Dry Low Emissions Combustion Systems

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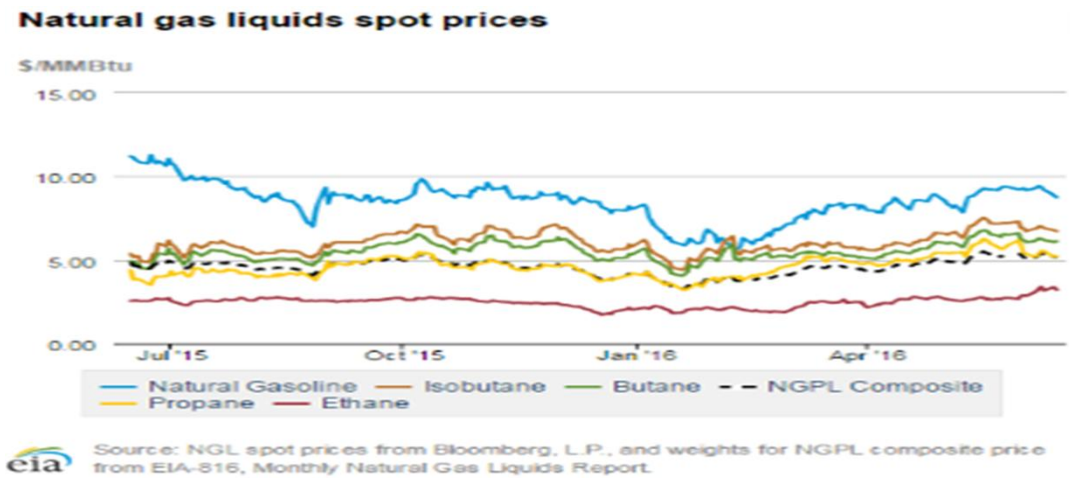
Contents

- Introduction
- Assessing Fuel Suitability
- Performance Impact
- Testing and Operational Experience
- Conclusions

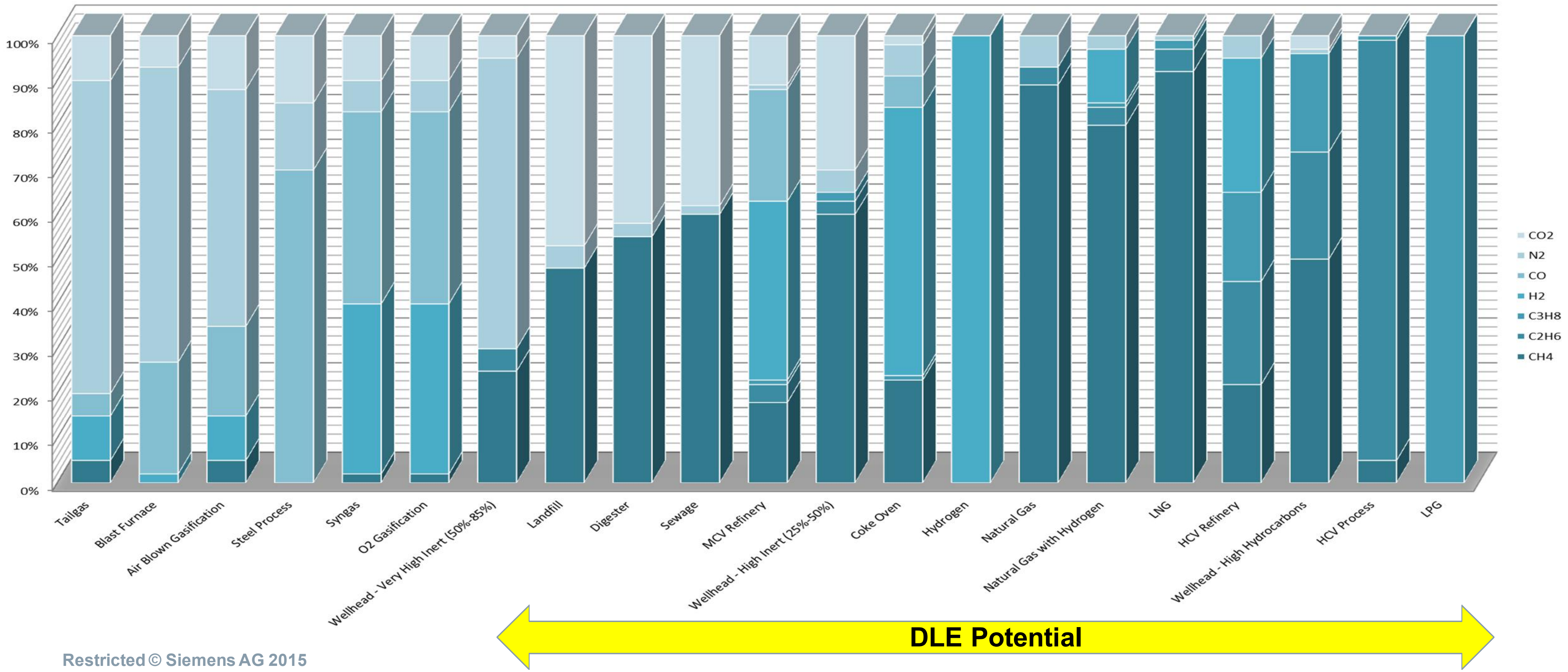
Introduction

Why is Fuel Flexibility important ?

- Local availability / supply constraints
  - Fixed versus interruptible tariffs
  - Non-availability of pipeline quality natural gas
- Cost
  - Opportunity fuels, e.g. process off-gas
  - 50MW class GT: US$0.50 mmbtu cost saving
    → US$2 million/year saving
- Environmental footprint
  - Reduce or eliminate flaring
  - Lower carbon content fuels



Wide variety of gaseous fuels



Assessing Fuel Suitability

What do I need to consider ?

- Fuel volume required
  - Supply volumes available
  - Need for blending
- Fuel Composition
  - Wobbe Index
  - Fuel treatment / blending
  - Auto-ignition
  - Flame speed
  - Emissions
- Supply Temperature & Pressure
  - Dew Point
  - Temperature Corrected Wobbe Index

Assessing Fuel Suitability

Wobbe Index / Temperature Corrected Wobbe Index

$$WI = \frac{LCV}{\sqrt{sg}}$$

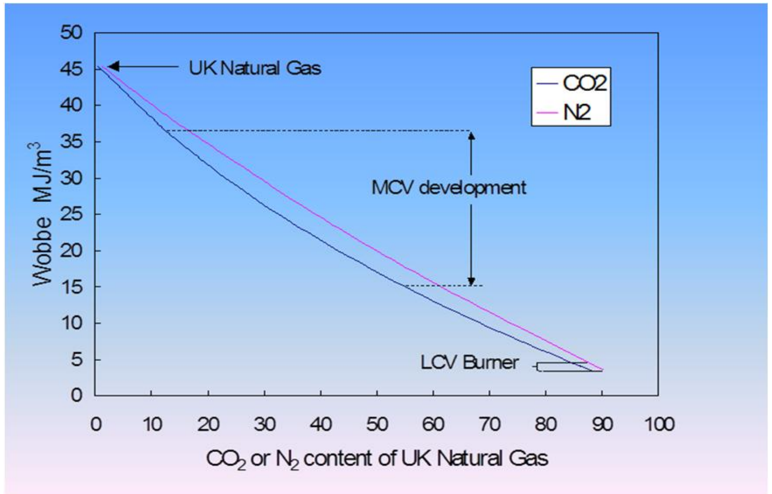
Cv = Net Calorific Value sg = specific gravity

$$WI_T = WI_{15} * \sqrt{\frac{T_{15}}{T_T}}$$

$$\Rightarrow WI_T = WI_{15} * \sqrt{\frac{288}{T_T}}$$

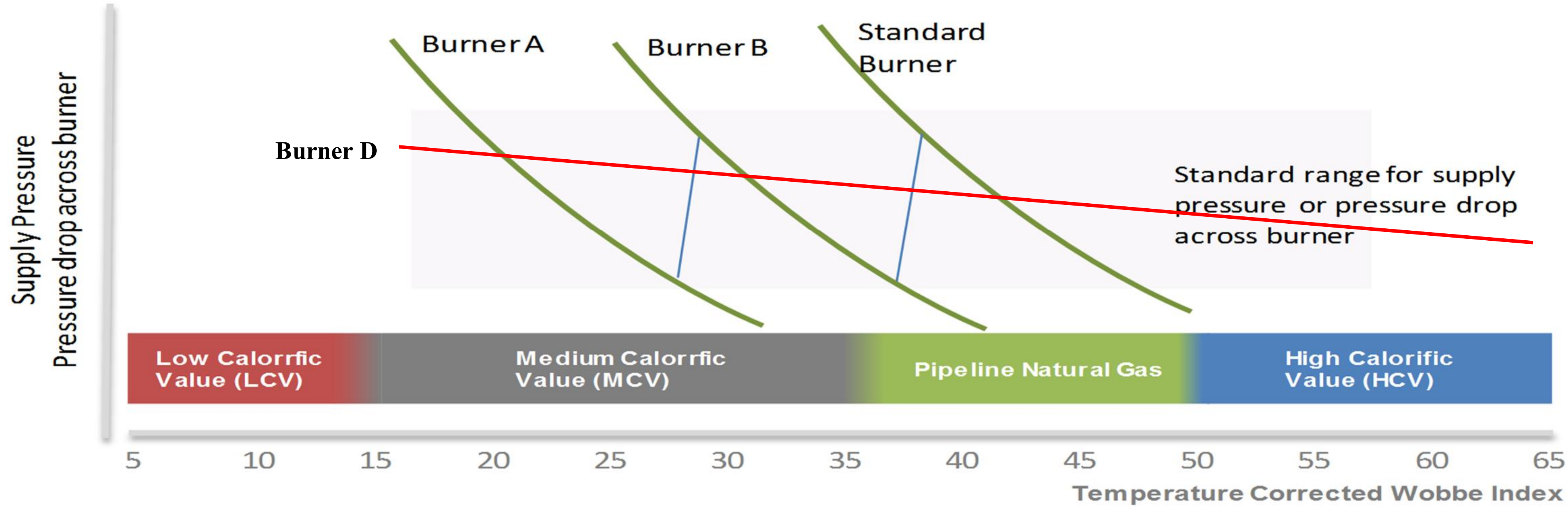
Temp in Kelvin

- Allows direct comparison of different fuels to be made based on heat content
- Determines:
  - Fuel volume required
  - Fuel system and fuel injector design
  - Requirement for blending / treatment
    - Ensure combustion system design parameters are met
    - Fuel switching capabilities using single fuel system



Assessing Fuel Suitability

Wobbe Index Impact on Burner Architecture

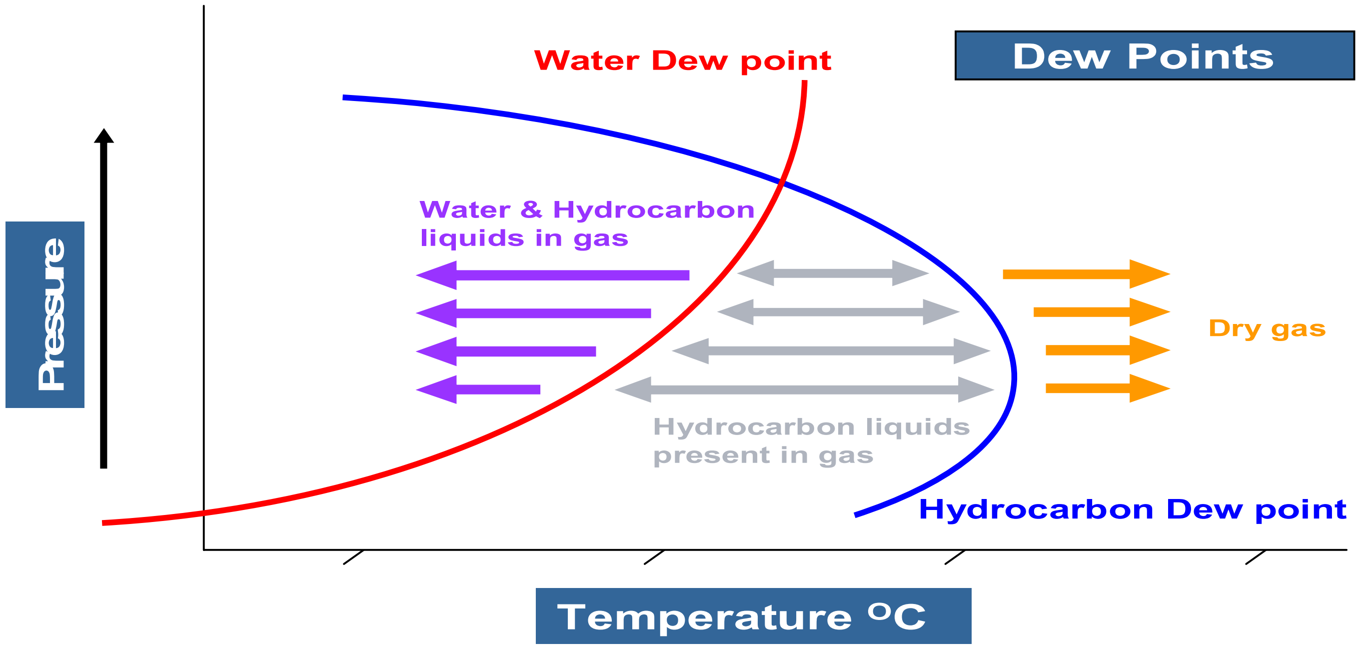


Assessing Fuel Suitability

Dew Point

- Water
- Hydrocarbons
- Superheating

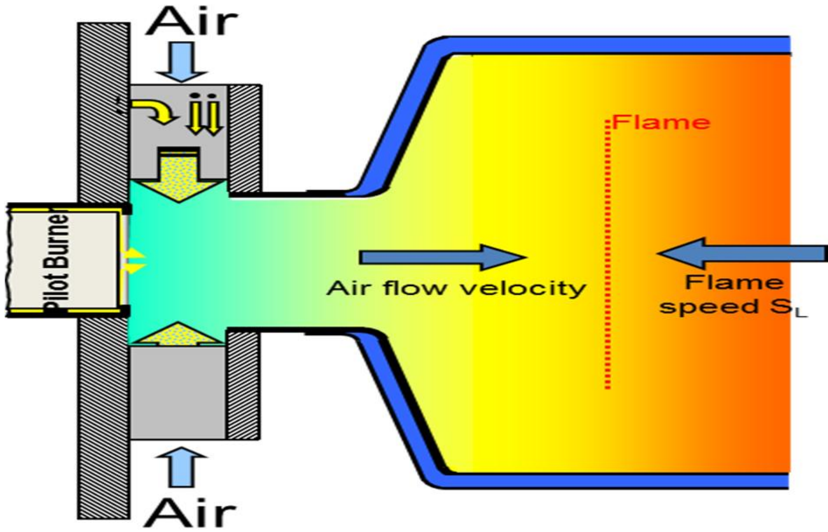
- Unmetered Combustion:
  - **Potential Damages**



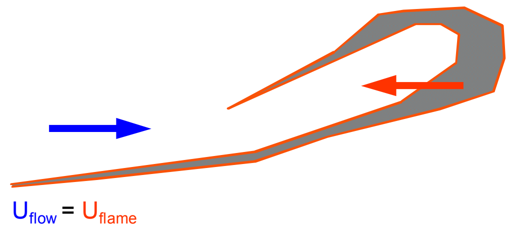
Assessing Fuel Suitability

Flashback

- If the flame speed does not match the flow speed of the reactants, the flame front will move
- If the flame speed is too high, you can get flashback (flame moving upstream towards the fuel injection)
- If the flame speed is too low, you can get blow-off (flame pushed downstream)



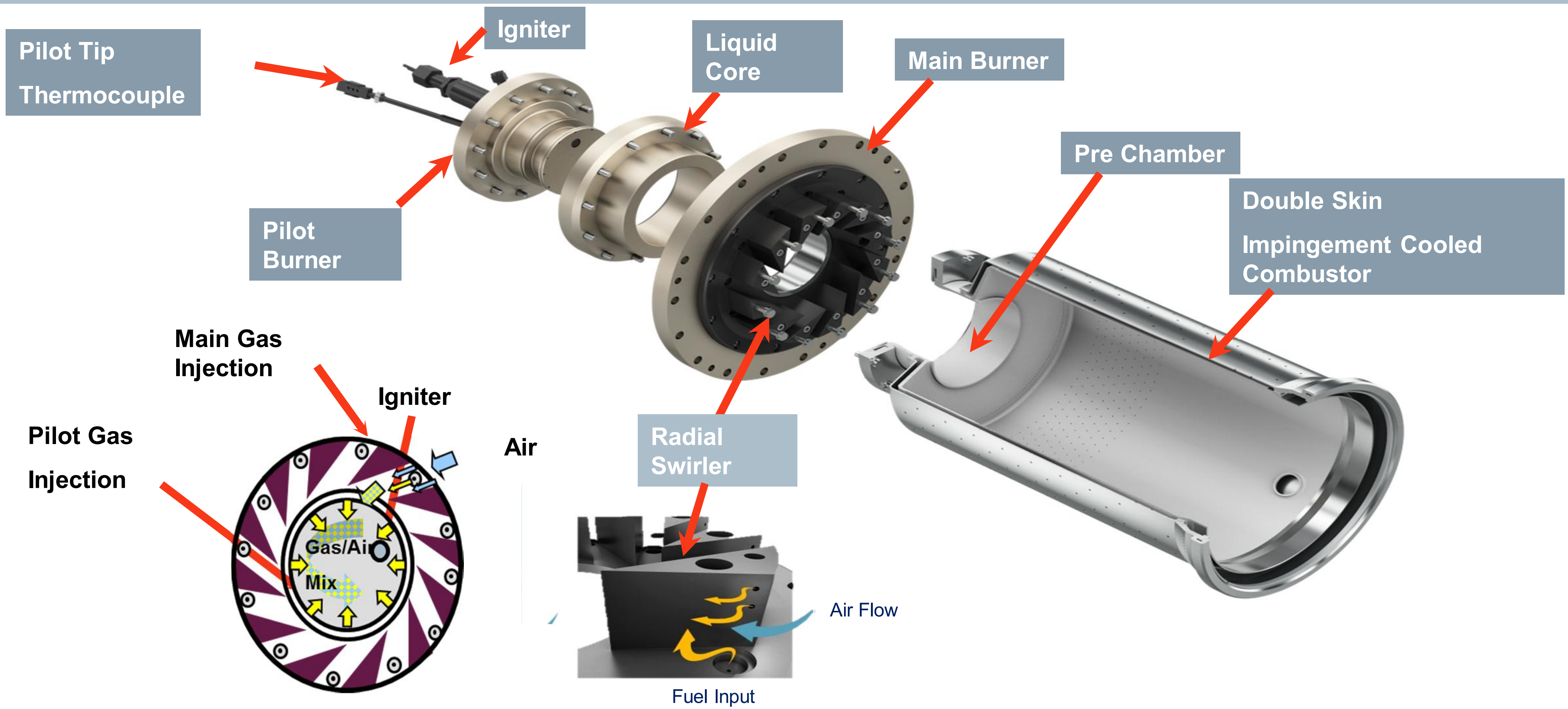
Stable flame



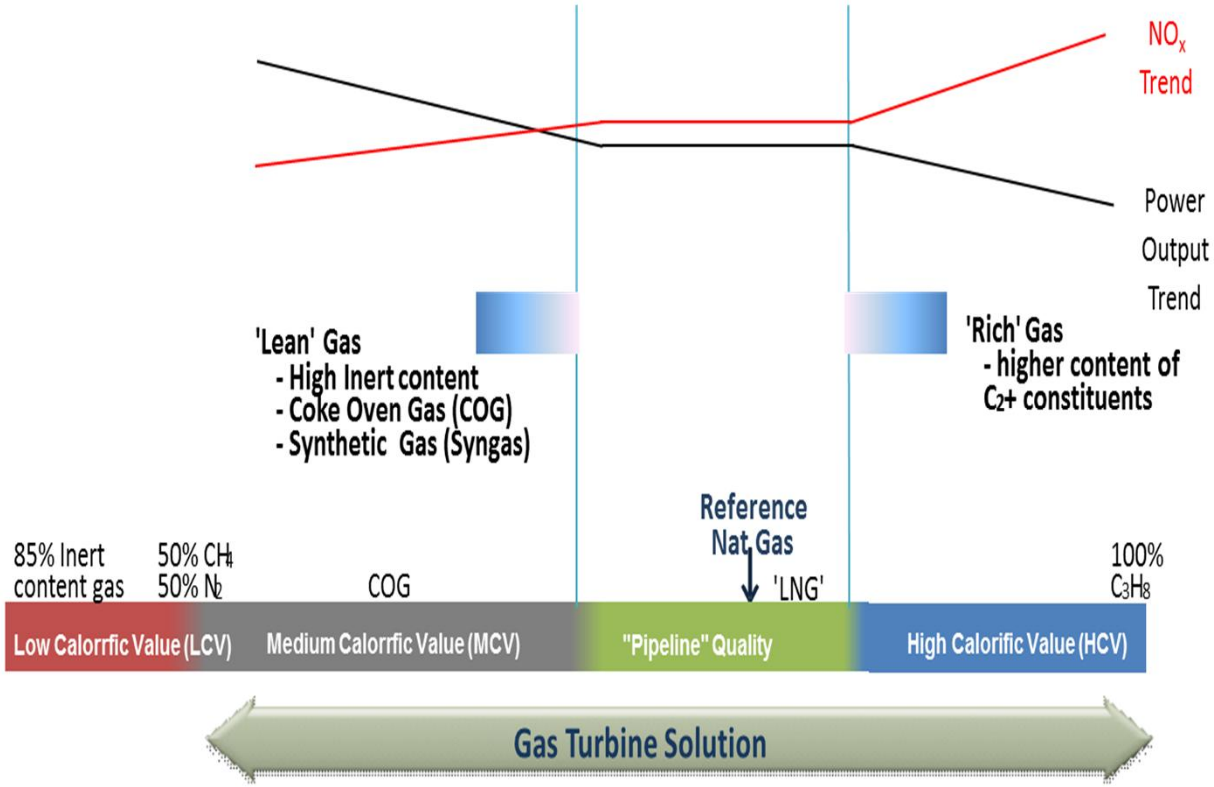
Flame Failure

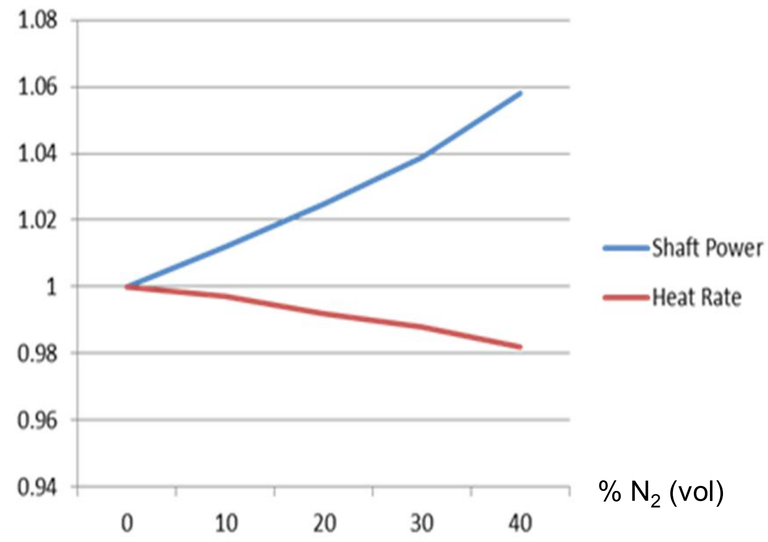
Engine Stop

Example of Standard Combustion System
Lean Pre-Mix



Performance Impact



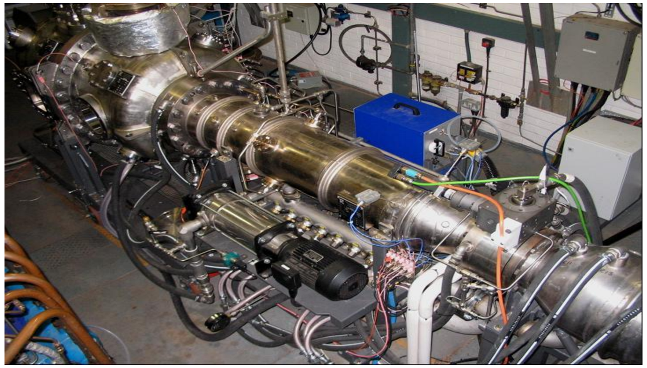


Impact of increasing inert gas content on shaft power output and heat rate of Siemens SGT-700 gas turbine compared to natural gas

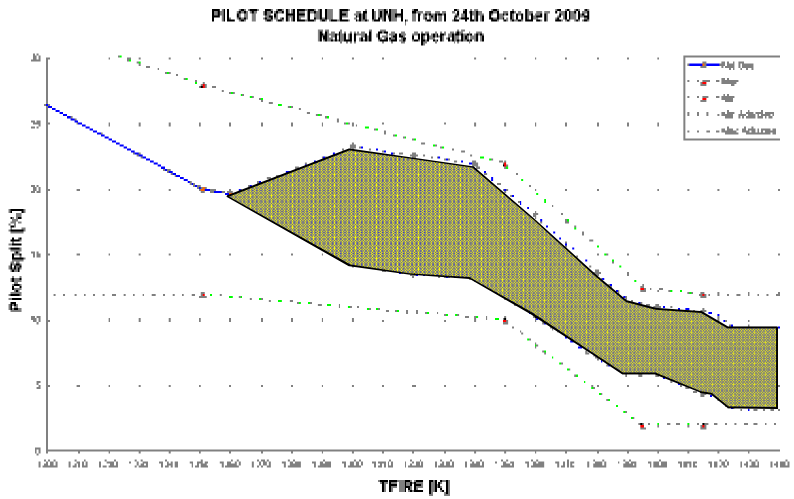
Testing and Operational Experience

- Combustor Rig Testing
- Single Burner Testing
- Full engine tests

- Customer-witnessed combined test
- Developments on DLE burners for variable fuel compositions
  - Intelligent DLE
  - Dual Gas & Tri-Fuel
  - Onshore and Offshore Operational Experience



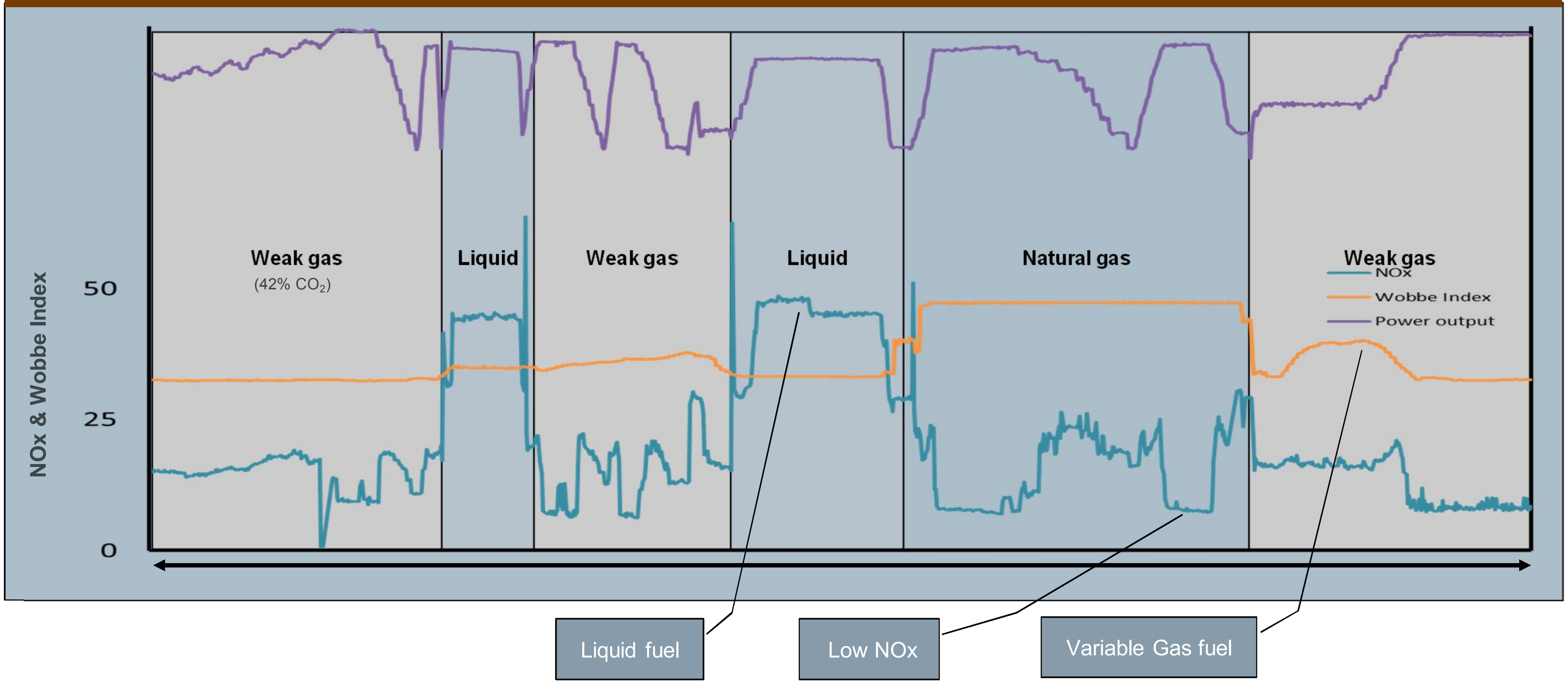
SGT-400
Combustor test rig



Operational Experience: SGT-300-1S, Trigeneration Plant, USA

SGT-300 Typical 24 hour operation – large power swings, auto fuel change overs, low NOx

AND NO INTERVENTION REQUIRED



Operational Experience: SGT-700 China

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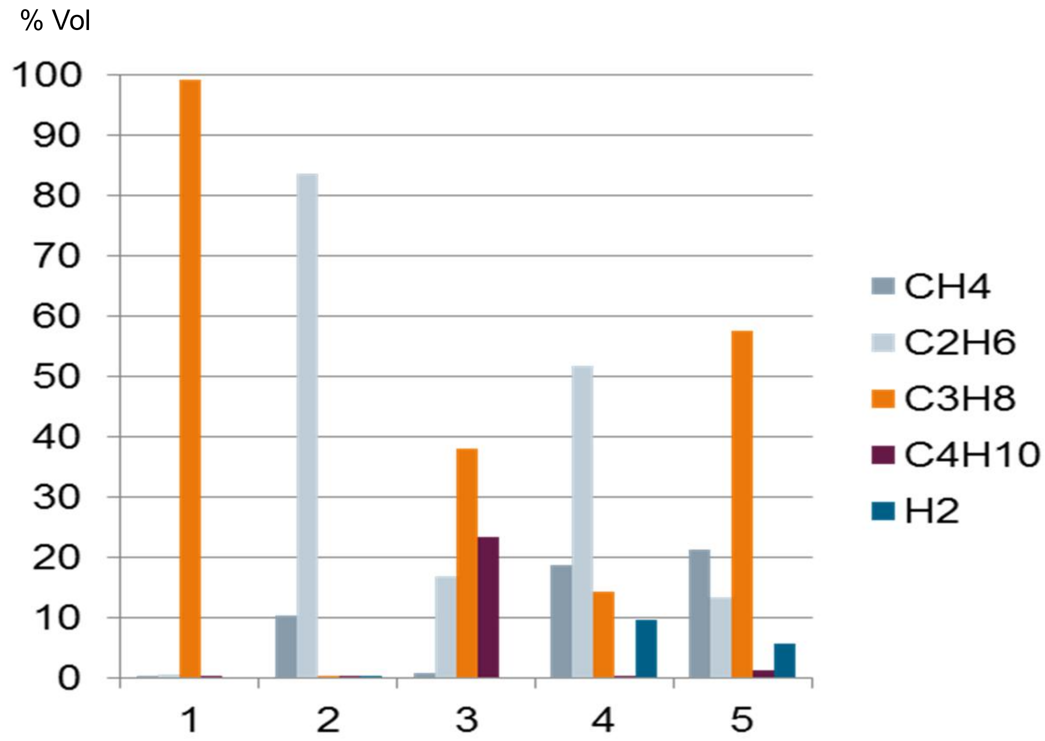
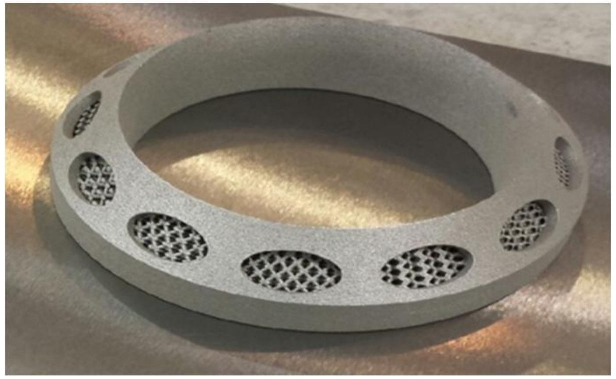
Propane Dehydrogenation Plant (PDH)

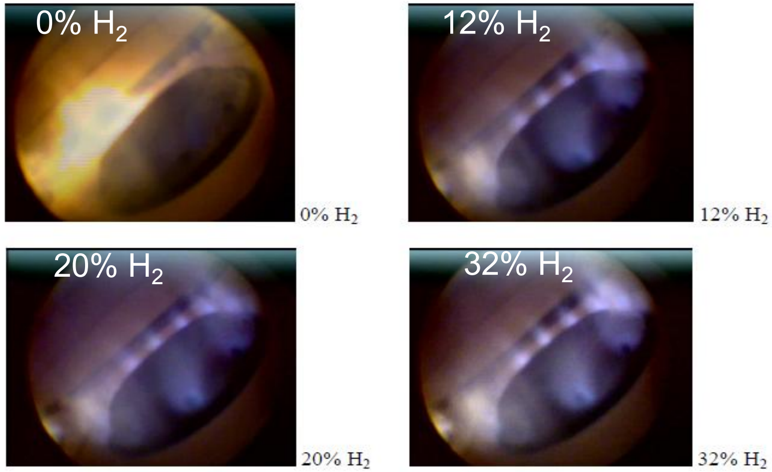
- Single gas fuel system
- DLE Combustor
- Propane used for start-up
- Operation on de-ethanizer off-gas plus other waste gas streams
  - Huge variations in gas composition
  - Fuel gas included C_4 + C_5 and higher
  - Ethylenes, acetylene, dienes and hydrogen
  - Stable operation for more than 8000 hours with < 35ppm NO_x
- 2 additional SGT-700 units on site operate on natural gas with propane as back-up fuel



Example fuel samples over 8 month period

Hydrogen





Single burner high pressure rig testing with increasing H2 content in Natural Gas

Methane / Hydrogen blends can be used in DLE combustors

- Standard DLE burner: up to 20% H_2 (vol)
- SGT-600, SGT-700: up to 40% H_2 (vol)
- SGT-800: up to 30% H2 (vol)

1. http://www.sgc.se/ckfinder/userfiles/files/SGC256(1).pdf
2. http://www.youtube.com/watch?v=zG_yZmwPhIU

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Conclusions

Dry Low Emissions Combustors can operate on a wide variety of gaseous fuels

- Proven operational experience on ‘rich’ and ‘lean’ gases
- Variability of fuel gas can be compensated for without external tuning / shutdown
- Some H_2 content permissible
- Auto-changeover between fuels
- Emissions will differ from ‘pipeline quality’ natural gas
- **Able to demonstrate both economic and environmental benefits**

Thank you for your attention!

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