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Wellhead Flare Mitigation Strategies

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Charles Ely - Dresser-Rand

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The use of words such as “may”, “might”, “will”, “should”, “expect”, “plan”, “outlook”, “anticipate”, “believe”, “estimate", "appear”, “project”, “intend”, “future”, “potential” or “continue”, and other similar expressions are intended to identify forward-looking statements.

All of these forward-looking statements are based on estimates and assumptions by our management that, although we believe to be reasonable, are inherently uncertain. Forward-looking statements involve risks and uncertainties, including, but not limited to, economic, competitive, governmental and technological factors outside of our control, that may cause our business, industry, strategy or actual results to differ materially from the forward-looking statements.

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Agenda

- LNG Safety
- Residual Gas and Flare Mitigation Options
- CNG and LNG
- Best Flare Mitigation Options
- LNG Wellhead Solution for Flare Mitigation
- Commercial Options
- Questions

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Safety Moment - LNG

LNG is natural gas in its liquid state at <-250 ºF

Fire Hazards

- NOT flammable in its liquid state.
- Must be vaporized in order to burn. Very slow burning and difficult fuel to ignite.
- Requires a high temperature ignition source(>1000 ºF) and an appropriate mixture with air (5% – 15% saturation.)

Storage Hazards

- Stored at low pressures such as 30 psi
- Spills vaporize to ATM

Chemical Spill Hazards

- Non-toxic and non-corrosive.
- Requires PPE to handle

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Flaring Is a Problem and Opportunity

- Flaring is the burning of residual / associated gas that cannot be processed or sold economically.

Global Flaring	(5 Tcf/yr)
1. Russia	1320 Bcf/yr
2. Nigeria	520 Bcf/yr
3. Iran	400 Bcf/yr
4. Iraq	330 Bcf/yr
5. USA	250 Bcf/yr

US Associated Gas Flaring	
1. Bakken	350 Mcf/day (2014)
2. Permian	52 Mcf/day
3. Barnett	49 Mcf/day
4. Eagle Ford	30 Mcf/day

Sources: worldbank.org, eia.gov (2011)

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Traditional Associated Gas Mitigation

- Flaring

  Flaring is the burning of gas that can't be processed or sold. It disposes of the gas by burning it in the atmosphere. Flaring reduces the environmental impact of releasing raw gas.

- Gathering by Pipeline

  Small-diameter pipes move natural gas from the wellhead to the gas processing plant or to a larger pipeline.

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Associated Gas as a Replacement Fuel

- Diesel ($29/mmBtu)
- Consumption at Wellhead ($4-$6/mmBtu)

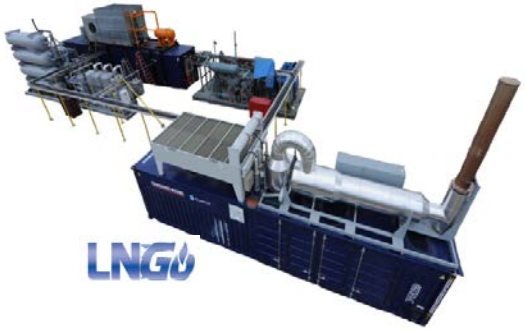
  Using natural gas on site as fuel for uses such as local power generation, heaters, boilers, etc.

- Capture as NGL & CNG ($11-$13/mmBtu)

  Associated gas is captured, treated, and compressed (screw or reciprocating compressor) at the wellhead.

- Capture as NGL & LNG ($13/mmBtu)

  Associated natural gas is captured, treated, and liquefied (LNGo) at the wellhead.



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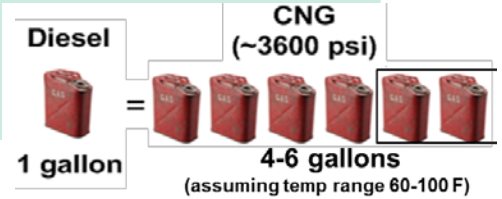
CNG

Residual gas is captured, treated, and compressed (screw or reciprocating compressor) at the wellhead. Compressed Natural Gas (CNG) is stored and distributed at pressures between 2,900 & 3,600 psi.

Pros	Cons
• Reduces environmental impact • Monetizes gas by creating a transportable fuel • Processed at wellhead • Scalable & redeployable • Large potential market in passenger vehicles	• Requires NGL removal/ gas pretreatment • Low energy density fuel compared to diesel or LNG • Competes against pipeline delivered natural gas • Not appropriate in markets requiring energy dense fuel • Medium capital investment



** Energy density/ tank capacity fluctuates with ambient temperature by ±30% assuming 80 F basis (Source: Clean Energy)*

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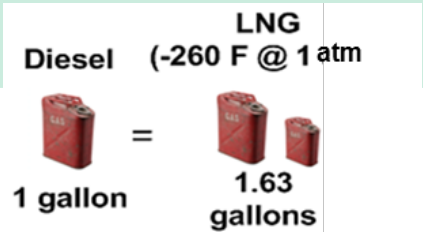
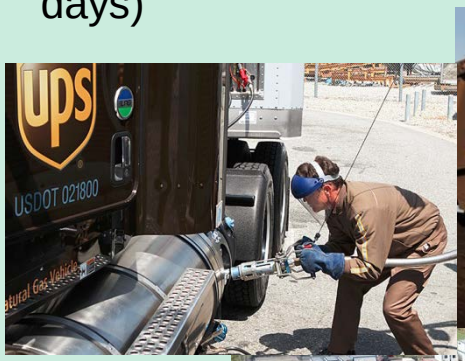
LNG

Residual natural gas is captured, treated, and liquefied (LNGo) at the wellhead. Liquefied natural gas (LNG) is natural gas in a dense liquid form at approximately -260°F and low pressure for easy storage and transportation.

Pros	Cons
• LNGo can operate at wellhead • Monetizes gas by creating dense transportable fuel • Scalable & redeployable • High energy density • Ideal for high horsepower markets requiring energy dense fuel • Easily competes against diesel fuel pricing ($28/mmbtu)	• Requires NGL removal/ gas pretreatment • Medium capital Investment • Short shelf life for LNG (45-300 days)





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Best Flare Mitigation Options

- There is no universal best choice solution
- Flare operators must consider their specific situation to make the best choice
- NGL/LNG is a good option for remote flare and stranded well locations with high horsepower diesel consumers nearby.

	Flare	Pipe	Wellhead	CNG	LNG
Environmental Impact					
Initial Investment					
O&M costs					
Transport cost ($/delivered mile)					
Redeployable					
Energy Density					
Value of Product ($/mmbtu)					
Current Available Off-Take Market					

NA	Poor		Good

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LNG Flare Mitigation Solution for Texas

Raw Flare

Gas IN

NGL Processing
(GTUIT)

Conditioned Gas OUT

Dehydrated Steady flow & pressure Reduced BTU

LNG Production
(Dresser-Rand)

Y-Grade NGLs OUT

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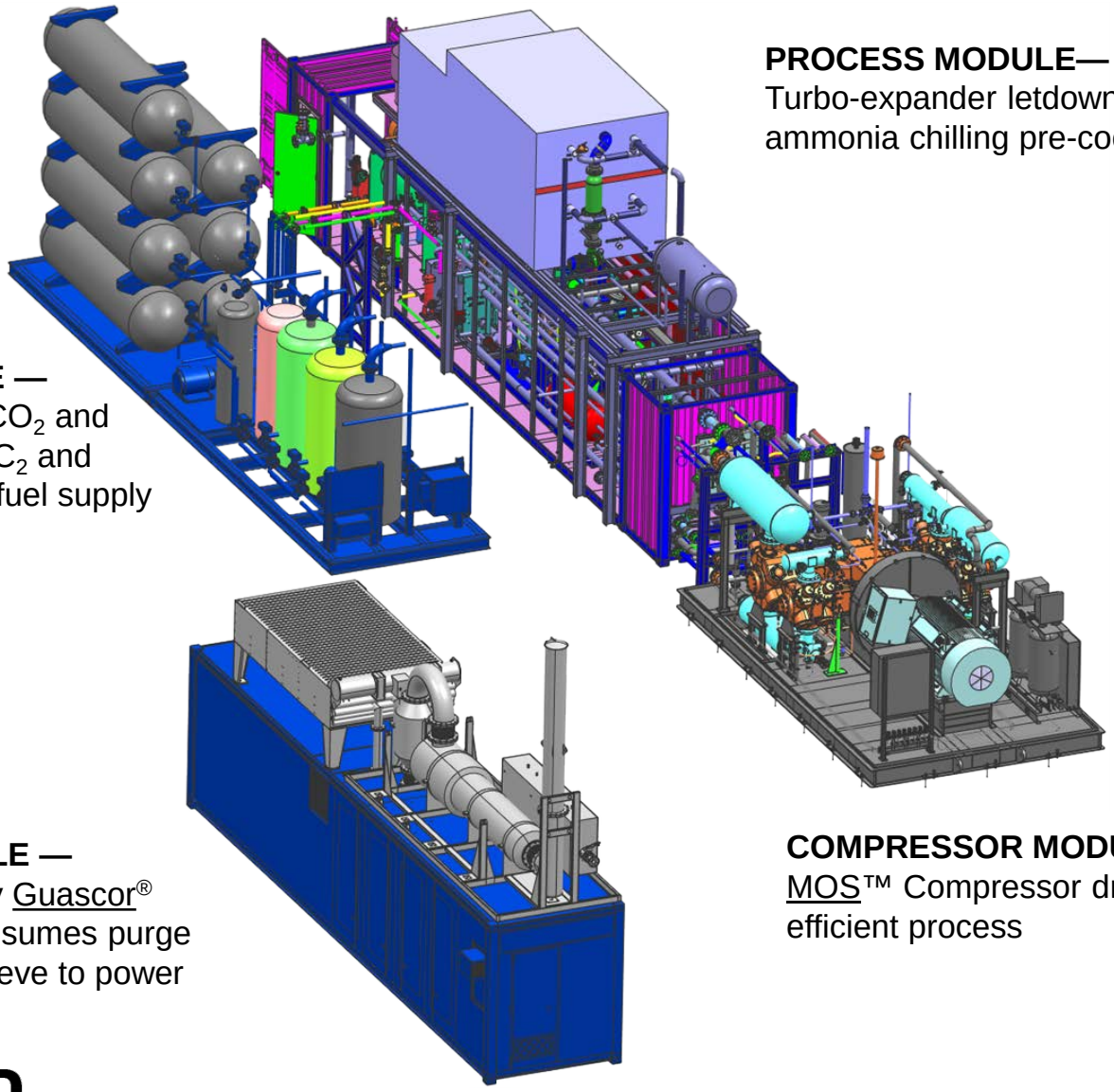
Dresser-Rand LNGo™



PROCESS MODULE—
Turbo-expander letdown and ammonia chilling pre-cool

CONDITIONING MODULE —
Molecular sieve removes CO_2 and H_2O. The purge flow, with C_2 and above, is blended into the fuel supply to the Guascor® engine

POWER MODULE —
Genset driven by Guascor® 1MW engine consumes purge gas from mole sieve to power unit

COMPRESSOR MODULE —
MOS™ Compressor drives efficient process

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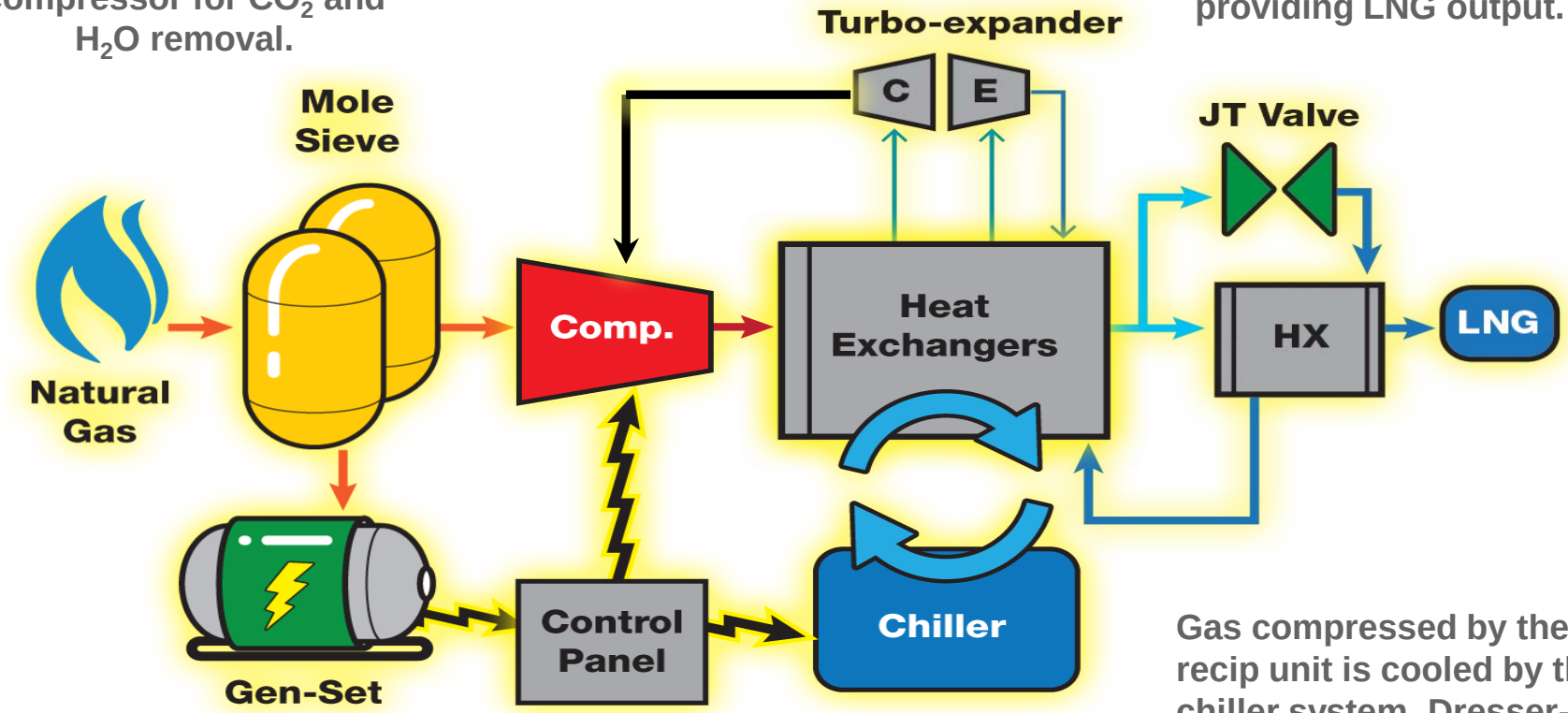
Dresser-Rand LNGo™

Pipeline gas enters the system, directed to mole sieve and the compressor for CO_2 and H_2O removal.

Turbo-expander cools the CNG. Patented heat exchanger arrangement maximizes cooling.

Joules-Thompson (JT) valve combines with a final heat exchanger providing LNG output.



Mole sieve waste gas is blended with pipeline gas to fuel the engine/generator.

Gas compressed by the recip unit is cooled by the chiller system. Dresser-Rand Enginuity® control panel provides automatic control.

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Dresser-Rand LNGo™

- Re-deployable from wellhead to wellhead
- Premier, proven D-R engineered product technologies
- Shortest cycle time (less than 6 months from order to operation)
- Dresser-Rand Worldwide service and support network
- Self-powered (no electric utility required)
- Skid-mounted design and small footprint
- Meets all current U.S. EPA emission regulations
- Modular installation
- Inventory available now

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Thank you for you attention

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BACKUP

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Fuel Comparison – Specifications

	Diesel	CNG	LNG / PLNG	Wellhead
Energy Density	High 1DGE=1gallon	Low 1DGE=4gallons	High 1DGE=1.63 gallons	Low 1DGE=600 gallons
Storage Pressure	1 ATM	3600 psi	30 psi	Not storable
Spill Management	HazMat	Vent to ATM	Vent to ATM	Vent to ATM
Phase of storage	Liquid	Gas	Liquid	Gas
Handling Special Equipment	None	None	Cryogenic Gear	None

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Fuel Comparison

	LNGo	CNG	Diesel
Cost / Pricing			
Net Cost (<150 miles) •<70 F •80 F •100 F	 $12.73/mmBtu $12.73/mmBtu $12.73/mmBtu	 $10.20/mmBtu $11.24/mmBtu $12.80/mmBtu	 $28.88/mmBtu $28.88/mmBtu $28.88/mmBtu
Energy Density (Relative to Diesel)	1.6:1	4.0:1 (70 Deg. F*) 5.7:1 (80 Deg. F*) 7.2:1 (100 Deg. F*)	1:1
Safety	* Spill rises to air * Low pressure * Minimally explosive (Slow flame speed and gas release)	* Spill rises to air * High pressure * Highly explosive (fast flame speed and gas release)	* Spill to ground * Low pressure * Highly explosive (fast flame speed, moderate release)
Infrastructure Costs	2x	5x-8x	1x
Storage Time	~44 days	5+ years	6 Mo – 1 Yr
Well Pad Traffic	1.6x Traffic	4x-7x Traffic	Minimal

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*** Ambient temperature**

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