



# OVERCOMING TECHNICAL HURDLES TO ECONOMICALLY CAPTURE FLARED ASSOCIATED GAS

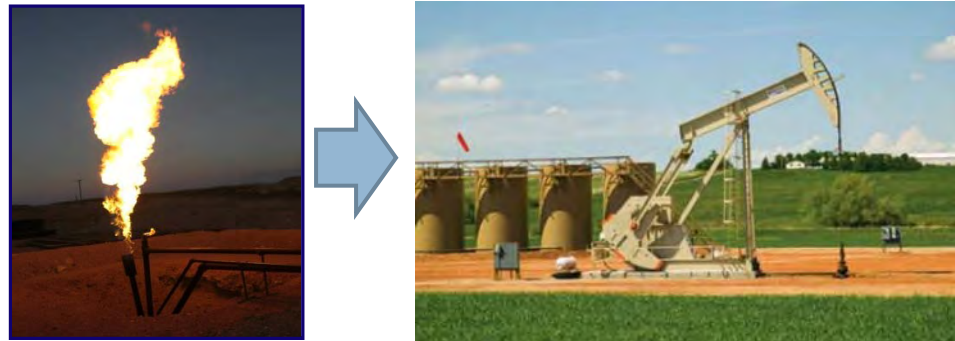
May 2, 2011

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# Benefits To Capturing Flare Gas

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- Reduce flaring & conserve energy
- Monetize wasted gas and liquids
  - ▣ Revenue for Producer, Mineral Owner and Government
    - Gas & NGL represents 20% of total value
  - ▣ Add bookable reserves (20% uplift to oil alone)
- Optimize infrastructure investment timing



# Technical Hurdles

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## □ Capture

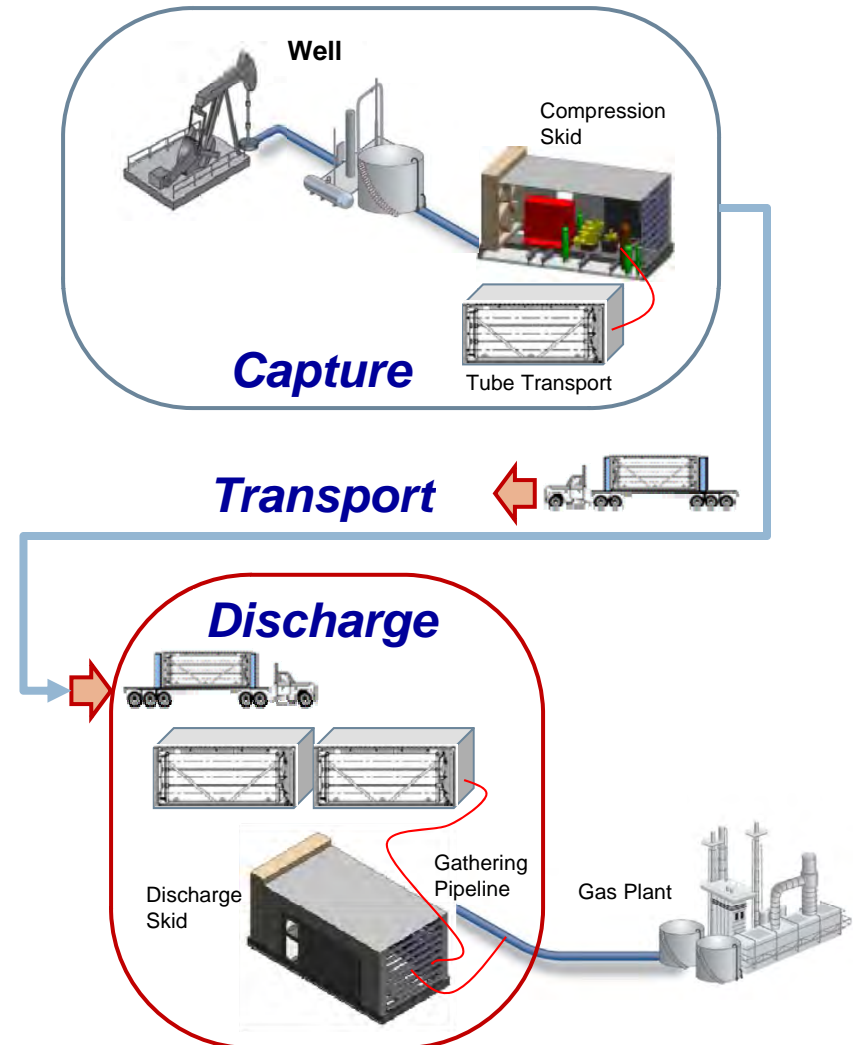
- Compression Capital
- Rich, Saturated Gas
- Cold Ambient Temperatures
- No On-Site Electricity

## □ Transport

- Reduce Round Trip Time
- CNG Tube Trailer Capacity

## □ Discharge

- Speed Up Discharge Time
- Manage Extreme J-T Cooling



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# Compression Capital

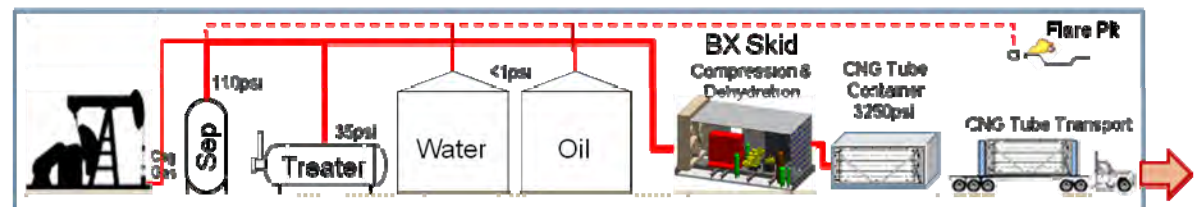
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## □ Hurdles

- Many low volume/high pressure compressors
- Capturing last 10% of stream is expensive

## □ Solutions

- Accept “one size fits all” approach and no H2S
- Use standard component sizes...engine, compressor, dryer, cooler
- Don't capture 100% of gas...return excess to flare



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# Rich, Saturated Gas

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## □ Hurdles

- Bakken gas has ~40% C2+
- CNG requires dehydration to 0.5 #/mmscf

## □ Solutions

- Shift most hydrocarbon liquid recovery from capture skid to discharge skid
- Desiccant dryer using non-electric 'pressure swing absorbent' regeneration

# Cold Ambient & No Electricity

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- Hurdles
  - Unmanned equipment in -40 F ambient
  - During initial well production electricity is usually insufficient or unavailable
- Solutions
  - Remote telemetry and monitoring
  - Enclosure with air flow modeled/optimized
  - High efficiency cooler with low leak/heat loss
  - Natural gas driven engines
  - Engine alternator & battery backup power for PLC

# Reduce Round Trip Time

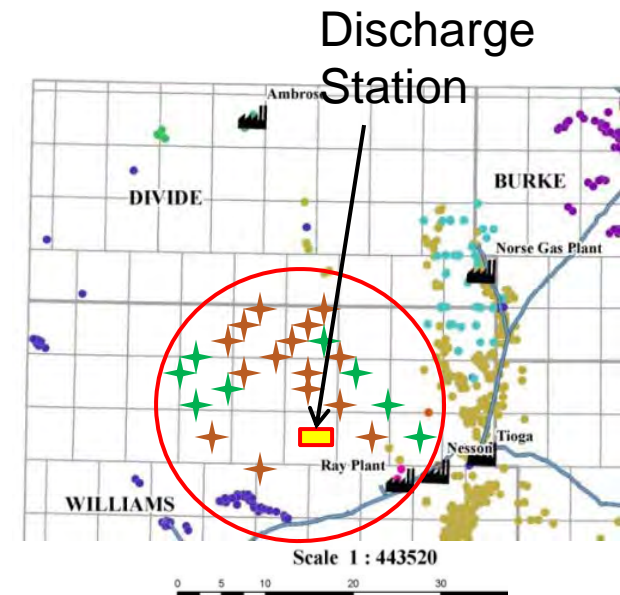
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## □ Hurdles

- Largest operating cost component is truck driving
- Second largest operating cost is diesel fuel

## □ Solutions

- Hub & spoke system and fast swap outs to minimize drive time
- Dual fuel diesel truck engines using captured CNG to reduce fuel expense



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# CNG Tube Trailer Capacity

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## □ Hurdles

- Varied materials used in CNG transport, requiring different CNG specifications
- High capital cost per MCF capacity

## □ Solutions

- Design for most stringent tube specification
- Use hub & spoke system and fast discharge times to minimize number of tube trailers required





# Speed Up Discharge Time

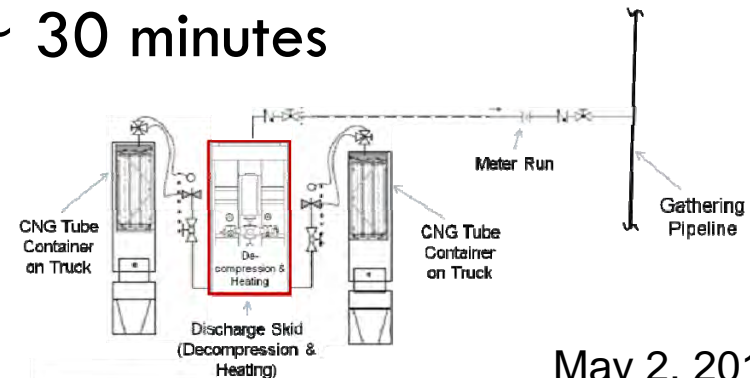
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## □ Hurdles

- Typical CNG industry tube trailer discharge times exceed 2-4 hours

## □ Solutions

- Specify manifolds, connectors and fittings for high capacity discharge
- Manage variable J-T effect during discharge cycle to maximize overall flowrate ~ 30 minutes



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# Manage Extreme J-T Cooling

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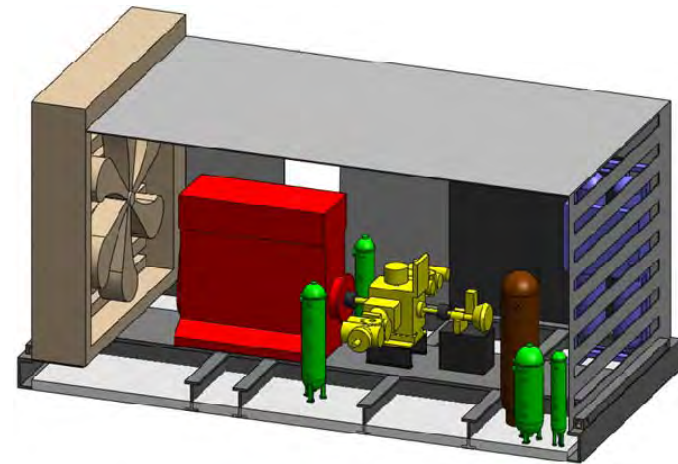
- Hurdles
  - ▣ Expansion causes temperature drop of -150 F
- Solutions
  - ▣ Developed two Discharge Station options:
    - Low pressure gathering systems (variable BTU rate catalytic heater)
    - High pressure pipelines (compressor heat exchanger)
  - ▣ Utilize J-T cooling to separate lean gas (C1 /C2) from liquids (C3+)

# Key Technologies

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## □ CNG Compressors

- Leveraged standardized CNG fill stations, but toughened them up for remote oil field sites.



## □ Desiccant Dryers

- Remove water as low as 0.5 lb/mmcf for tube transport.



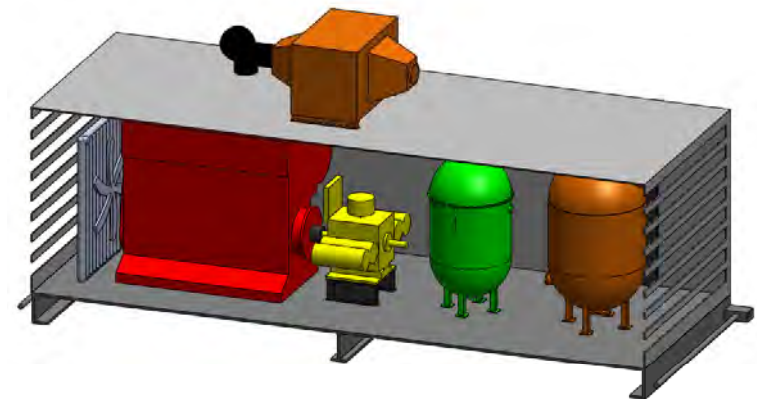
# Key Technologies

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- CNG Tube Transport
  - ▣ Extensive testing before DOT approval.
  - ▣ Long history in CNG industry.



- De-Compression
  - ▣ Manage extreme cooling (-150 F) during rapid discharge.
  - ▣ Enable capture of natural gas liquids for dry gas pipelines.



# Summary

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- Overcame Technical Hurdles
  - ▣ Gas Capture
  - ▣ Gas Transport
  - ▣ Gas Discharge
- Economic Results
  - ▣ Able to capture stranded gas for under \$2/mcf to capture gas during the first year or so of production (while waiting for infrastructure)