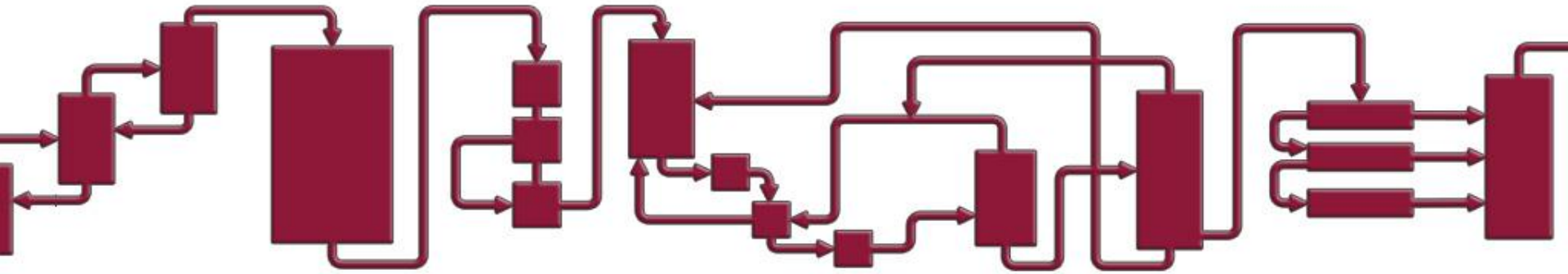

Adjusting Pipeline Gas Composition to Simplify Metrology

Peter Martin

Peter Carnell

Rachel Mansfield

Johnson Matthey
Process Technologies

Composition of Pipeline Gas

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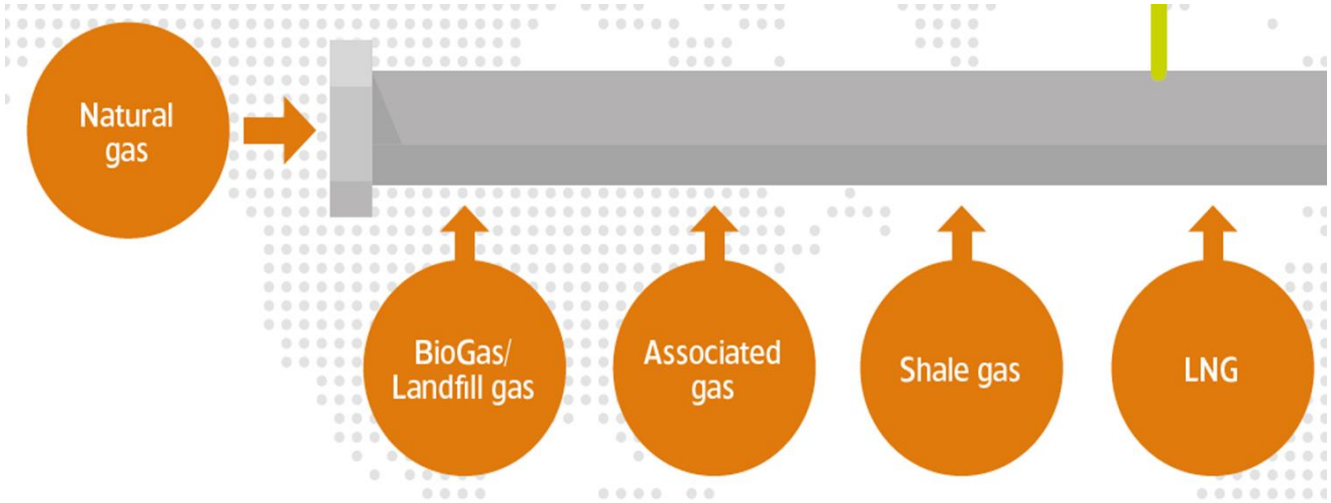
- Mainly methane but also higher hydrocarbons and aromatics
- Carbon dioxide
- Nitrogen
- Oxygen
- Sulphur compounds - Contaminant
- Mercury
- Siloxanes – (ex landfill gas)



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Meeting Pipeline Specifications

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- Gas specifications historically set for domestic market
- Main Criteria
  - Higher Heating Value (HHV)
  - Wobbe Number
- Diverse applications
- Criteria of increasing importance:
  - Chemical Composition

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Issues

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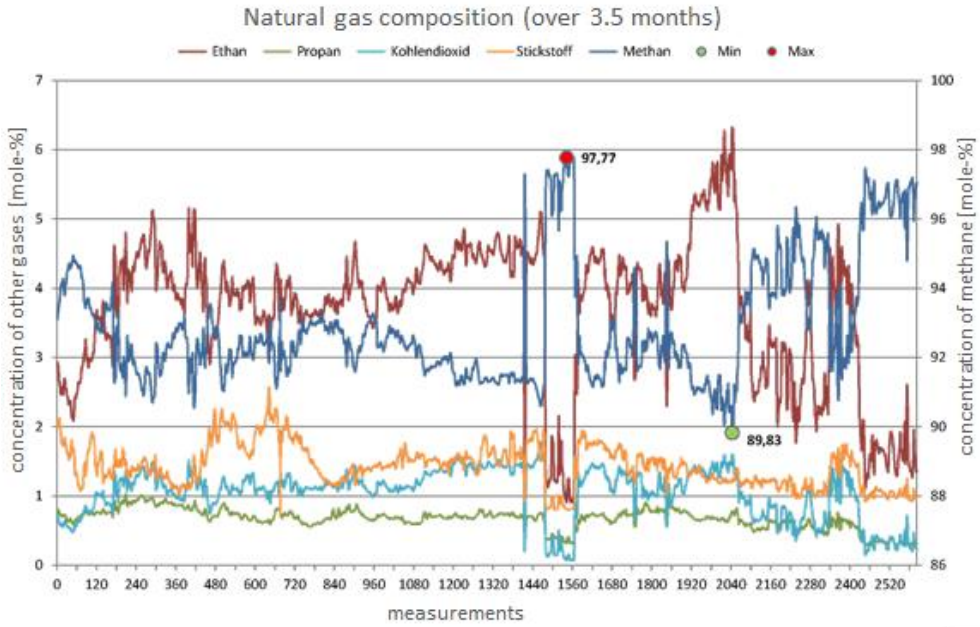
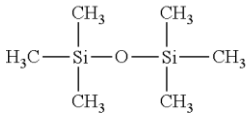
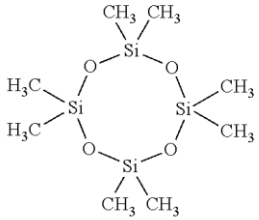




Siloxane "MM"



Siloxane "D4"

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Gas Variability of Pipeline Gas

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Table 1: Typical Composition for Natural Gas Distributed in Germany

Gas Composition	Unit	Russian Group H	North Sea Group H	Danish Group H	Libya LNG (rich)	Nigeria LNG (mean)	Egypt LNG (lean)	Bio-methane	Bio-methane + LPG
Methane	mol%	96.96	88.71	90.07	81.57	91.28	97.70	96.15	90.94
Nitrogen	mol%	0.86	0.82	0.28	0.69	0.08	0.08	0.75	0.69
Carbon Dioxide	mol%	0.18	1.94	0.60	-	-	-	2.90	2.68
Ethane	mol%	1.37	6.93	5.68	13.38	4.62	1.80	-	-
Propane	mol%	0.45	1.25	2.19	3.67	2.62	0.22	-	5.00
n-Butane	mol%	0.15	0.28	0.90	0.69	1.40	0.20	-	0.50
n-Pentane	mol%	0.02	0.05	0.22	-	-	-	-	-
n-Hexane	mol%	0.01	0.02	0.06	-	-	-	-	-
Hydrogen	mol%	-	-	-	-	-	-	-	-
Oxygen	mol%	-	-	-	-	-	-	0.20	0.19
Total		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

- Mainly methane but also some higher hydrocarbons and aromatics
- Carbon dioxide
  - No HHV + Reduction in pipework capacity
  - Can lead to corrosion of in the presence of condensed water
- Nitrogen
  - No HHV + Reduction in pipework capacity
  - Leads to NH3 formation on steam reformers
- Oxygen
  - Can lead to corrosion in the presence of condense water
  - Elemental S formation – fouling of adsorbent beds and instrument tapping points

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Sulphur – H_2S

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- Pipeline specification – Variable around the world
  - 0.25grains/100SCF (3.8ppm v) North American standard
  - 3.3ppm v (5mg/m3) European Standard
  - 1ppm v suggested to avoid black dust formation
- Black dust causes major operational problems in the gas industry
  - Product contamination, erosion, clogging, fouling
  - Health and environmental issues

Images: Review of black powder in gas pipelines e An industrial perspective
Tariq S. Khan, Mohamed S. Al-Shehhi. Journal of Natural Gas Science and Engineering 25 (2015) 66e76*

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Sulphur – H_2S Cont…

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- Variable with different pipelines
- Removal required
  - Eliminate black dust
  - Reduce emissions control
    - < SO_x pollution and < deterioration of abatement systems
  - Feedstock purity – into catalytic processes
  - Elemental S formation leading to equipment fouling

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Mercury - Hg

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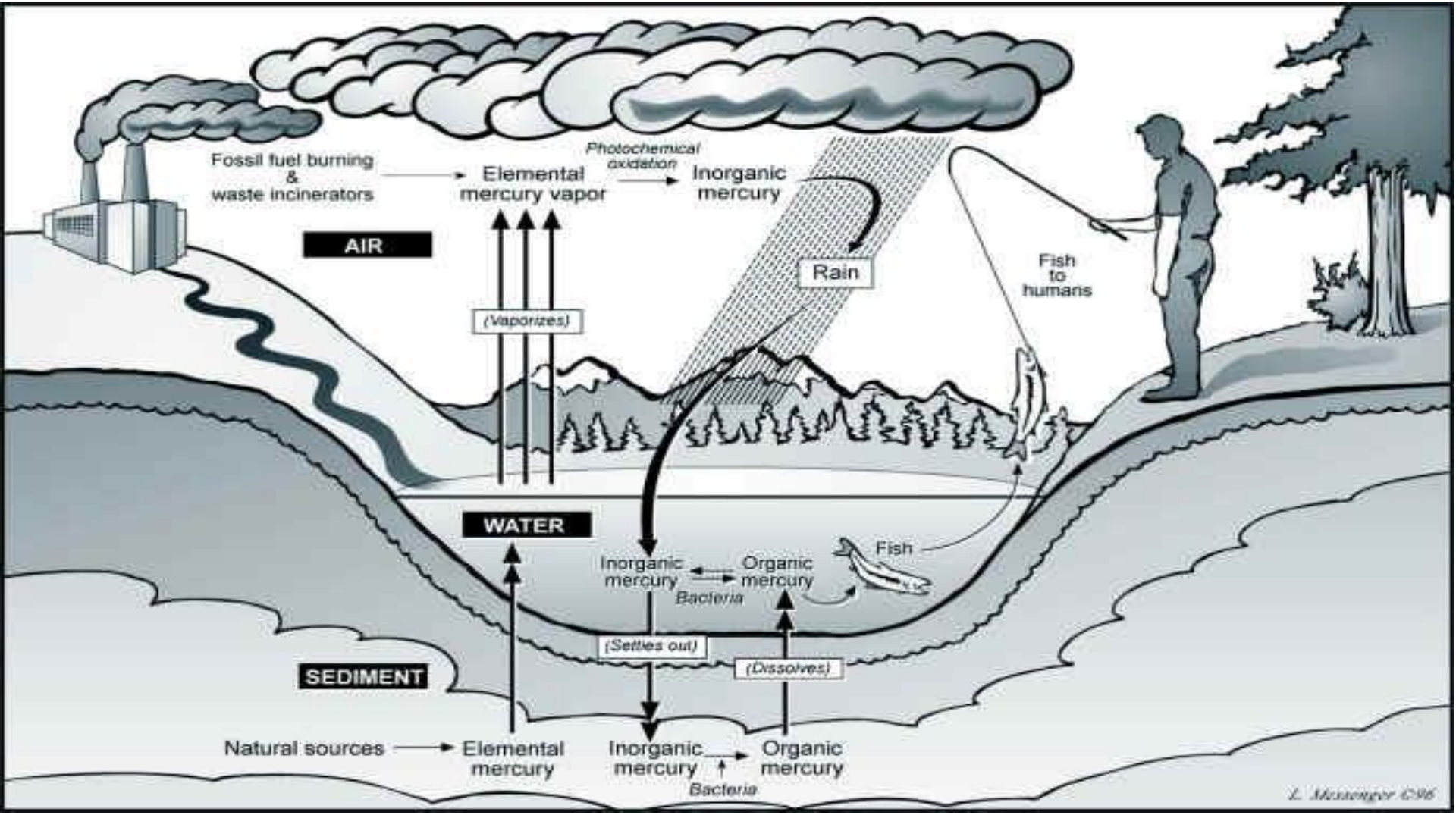
- Present in geological formations



Mercury - Hg

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- Present within produced natural resources
  - Oil and Gas
- No legislation
- Specifications implemented due to other factors
  - 10ng/Nm3 typical specification – Set by historic level of detection
  - Hazardous to health and the environment
  - Release to atmosphere on combustion
  - Catalysts poison
  - Attack on some metal alloys leading to failure

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Siloxanes

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- Mainly stemming from landfill gas
  - Organosilicon compounds formed in biological activity
- Problems with gas engines
  - Melts and deposits in a glass like layer
  - Rotating equipment damaged
  - Exhaust management systems damaged

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Radioactive Materials

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- Another contamination issue with gas pipelines is presence of radioactive materials, i.e. Radon
- Bulk Radon is removed during processing of natural gas
- Presence of such materials creates a potential hazard to personnel, public and environment
- Introduces requirement for NORM, Naturally Occurring Radioactive Material, measurements
  - Guidelines for NORM monitoring
  - Identification & assessment of risks
  - Control measures
  - Disposal procedures

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Variable gas quality impacting engine performance

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- Chemical composition influences the combustion behaviour and knocking characteristics of a fuel
  - Knock characteristics are specific to gas composition
  - Methane Number is calculated to indicate resistance of the fuel to end gas knock and ignition capability
- Gas engines are designed to accept, within design limits, a wide range of gas quality, but fluctuating fuel quality affects performance:
  - Engine knock
  - Reduced Efficiency
  - Increased emissions
  - Damage to engine

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Variable gas quality impacting exhaust temperatures for gas turbine engines

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- Variable gas composition affect the exhaust temperature of gas turbine engines in ACC Power plants
- Increased heat release from the combustion of heavier hydrocarbons
- Temperatures in excess of 1600oC can be attained
- Turbine blade integrity is impacted at these temperatures
  - Blade damage

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Variable gas quality impacting Burners

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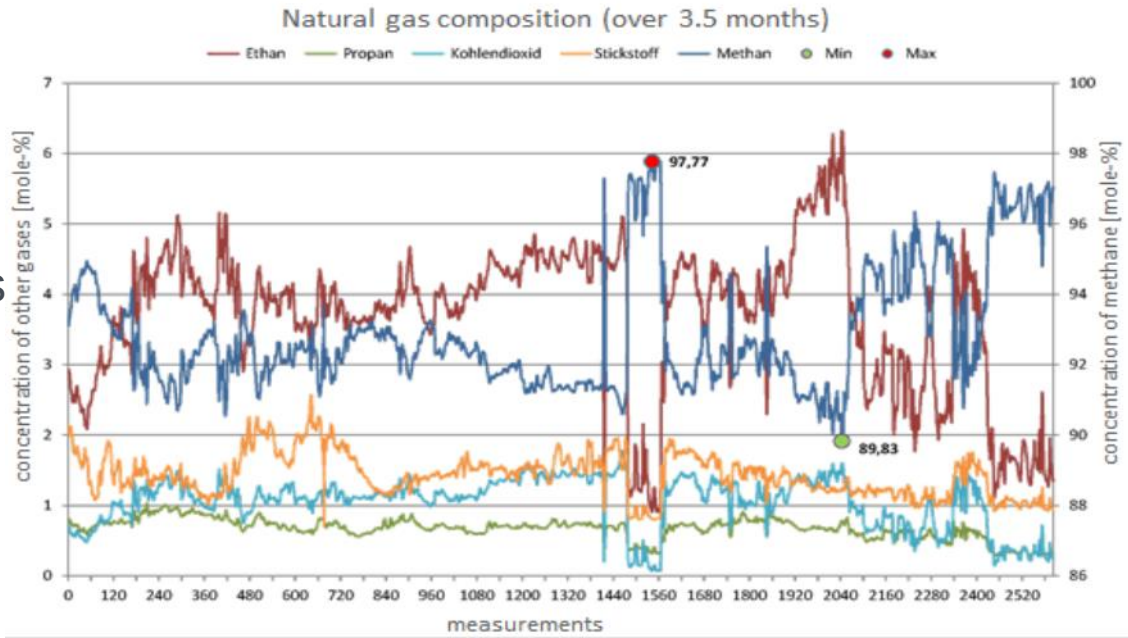
- Variability in feed gas composition affects:
  - Flame shape
  - Flame height
  - Luminosity
- Variability is posing great challenges for the glass and ceramic industry
  - Furnace control
    - Time/Temperature
    - Shaping step
      - Out of Spec glass



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The Solution

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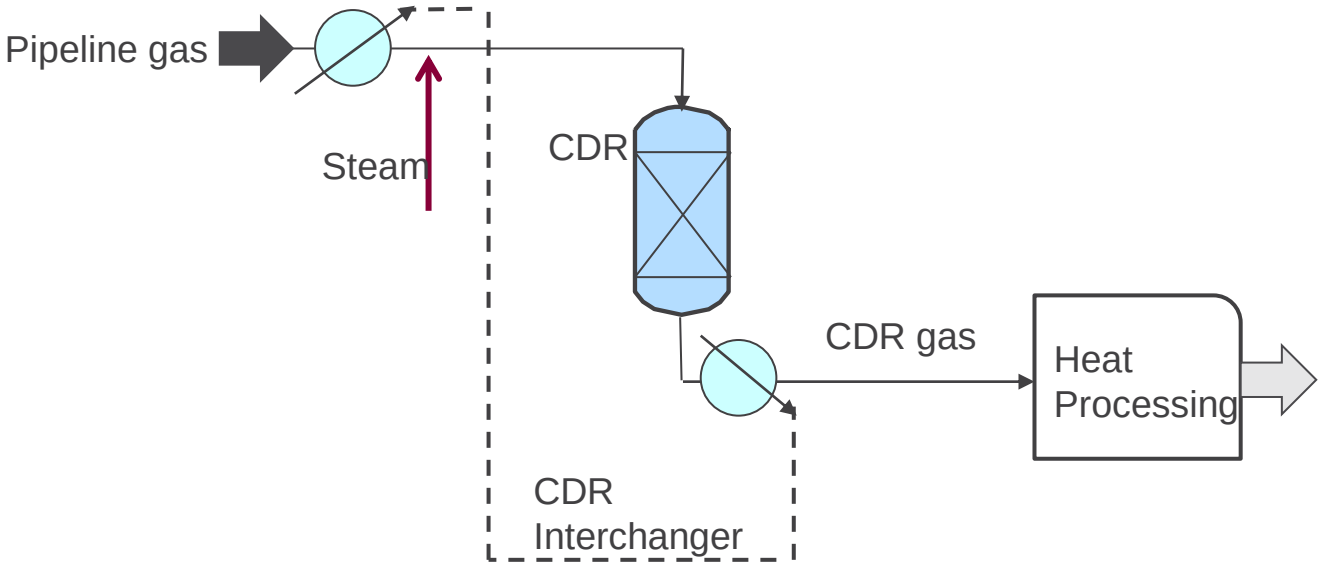
- Catalytic route to converting higher HCs to methane
- Precious metal catalyst system
- Hydrogen addition achieved through steam addition



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Solution

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- The move to LNG as the source of pipeline gas would allow higher standards of purity
- Change to a “chemical specification” for pipeline gas – is a near 100% methane target achievable?
- Use CDR to convert heavy hydrocarbons to methane
- Use fixed bed absorbents for total H_2S and Hg removal
- Switch to non-sulphur odorants.
- Questioning specifications placed on “green” initiative gases eg bio-gas and land-fill gas

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