Gas Quality and Interchangeability 101

February 18, 2004

Agenda

- Gas Quality
  - Properties of Natural Gas
  - Gas Delivery Network – Production to Market
- Interchangeability
  - Properties of Liquefied Natural Gas (LNG)
  - Interchangeability with Domestic Natural Gas

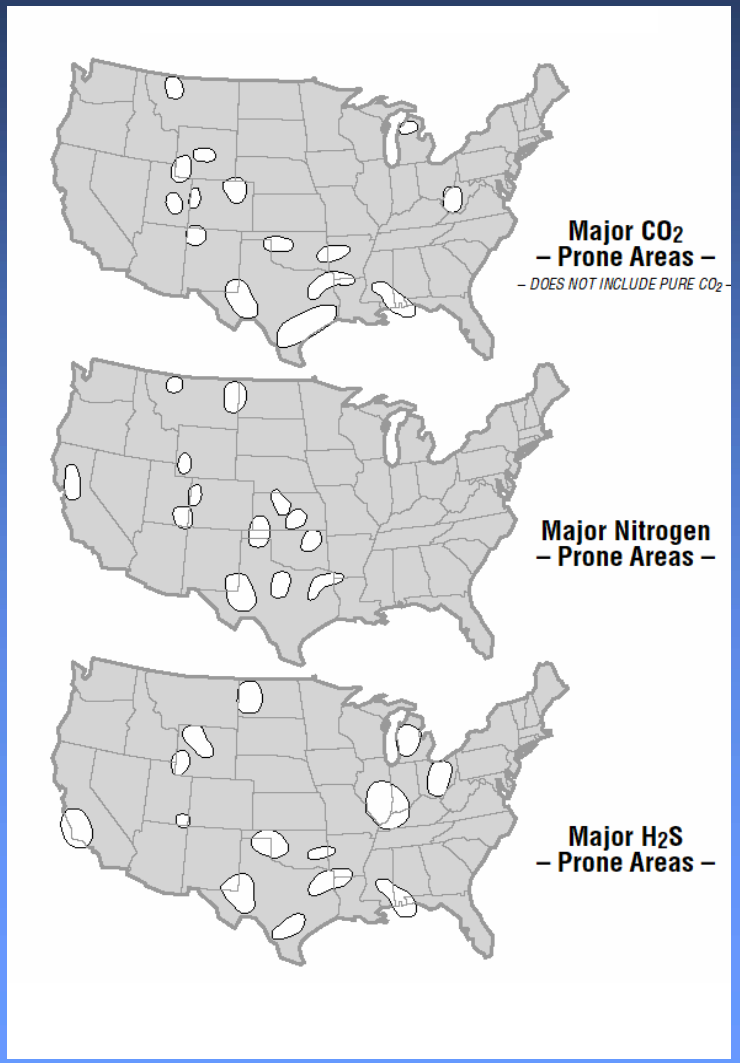
Properties of Natural Gas

Natural Gas Composition
Unprocessed

	Component	Typical (Mole Percent)	Range (Mole Percent)
Hydrocarbons	Methane (C1)	92.77	83.74 – 98.22
	Ethane (C2)	3.36	0.52 – 7.64
	Propane (C3)	1.51	0.18 – 4.74
	Iso-Butane (i-C4)	0.41	0.05 – 1.10
	Normal Butane (n-C4)	0.47	0.06 – 1.63
	Iso-Pentane (i-C5)	0.19	0.03 – 0.50
	Normal Pentane (n-C5)	0.13	0.00 – 0.42
	Hexane (C6)	0.27	0.09 – 0.78
Inerts	Nitrogen (N_2)	0.30	0.12 – 0.91
	Helium (He)	Trace	0.00 - 0.02
Impurities	Carbon Dioxide (CO_2)	0.59	0.13 - 1.86
	Hydrogen Sulfide (H_2S)	Trace	0.00 - 0.10
	Oxygen (O_2)	Trace	0.00– 3.00
	Water (H_2O)	Trace	0.00 - 0.01

Production Areas Prone to Gas Impurities

- Gas quality varies by production field
- Forty-one percent of gas reserves are anticipated to have excessive impurities
- Impurities are removed from the gas to meet various quality specifications to ensure it is merchantable
- Producers evaluate investment cost to produce vs. market value before deeming field commercial



Impurities Potentially Damaging to Natural Gas Facilities

Panhandle Energy

- Gas is treated to reduce these impurities to acceptable levels
- Water (H_2O)
  - Enters as vapor or liquid
  - Water vapor can condense to liquid water
  - Can result in freezing of lines and equipment
  - Collects in low spots in pipeline
  - Virtually no internal corrosion occurs without liquid water
- Carbon Dioxide (CO_2), Hydrogen Sulfide (H_2S), Oxygen (O_2)
  - Reacts with liquid water and with each other potentially causing corrosion
  - Byproducts of internal corrosion can lead to wear and damage of compressors and measurement equipment

Hydrocarbon Property Measures

- Higher Heating Value (HHV) - measure of the energy generated by combustion (including the heat that turns the water created into steam)

  Note: HHV is the standard measure used for commercial transactions

- Wobbe Index – a measure of the interchangeability at the burner

Heating Value of Components

Hydrocarbon Component	Higher Heating Value @ (60 °F, 1 atm) (BTU/scf)
Methane (C_1)	1010.0
Ethane (C_2)	1769.6
Propane (C_3)	2516.1
Iso-Butane (i-C_4)	3251.9
Normal Butane (n-C_4)	3262.3
Iso-Pentane (i-C_5)	4000.9
Normal Pentane (n-C_5)	4008.9
Hexane (C_6)	4755.9
Heptane (C_7)	5502.5
Octane (C_8)	6248.9
Decane (C_9)	7742.9

Composition of gas comprised of hydrocarbon components determines the heating value of the gas

Hydrocarbons C_{10} and above are liquids at typical pipeline operating conditions

Hydrocarbon Dewpoint (HDP)

Dewpoint

Temperature below which some components in a gas begin to condense and drop out as liquids

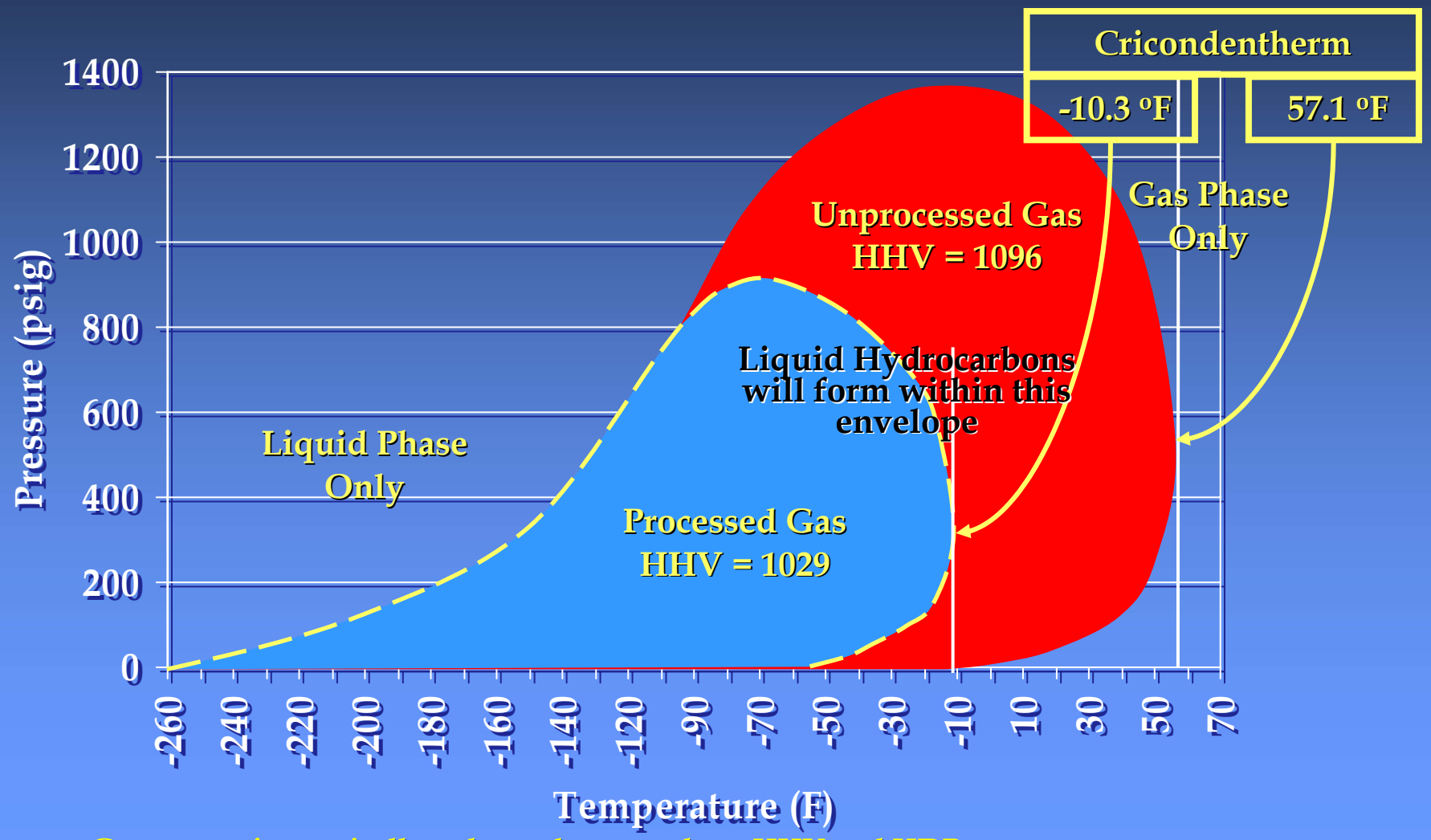
Atmosphere

When the air temperature falls below the air dewpoint it begins to rain

Pipeline

When the gas temperature falls below the hydrocarbon dewpoint it begins to "rain" hydrocarbons in the pipeline. Highly dependant on C6+ concentration

Impact of Gas Processing



Gas processing typically reduces the natural gas HHV and HDP

Gas Delivery Network

Production to Market

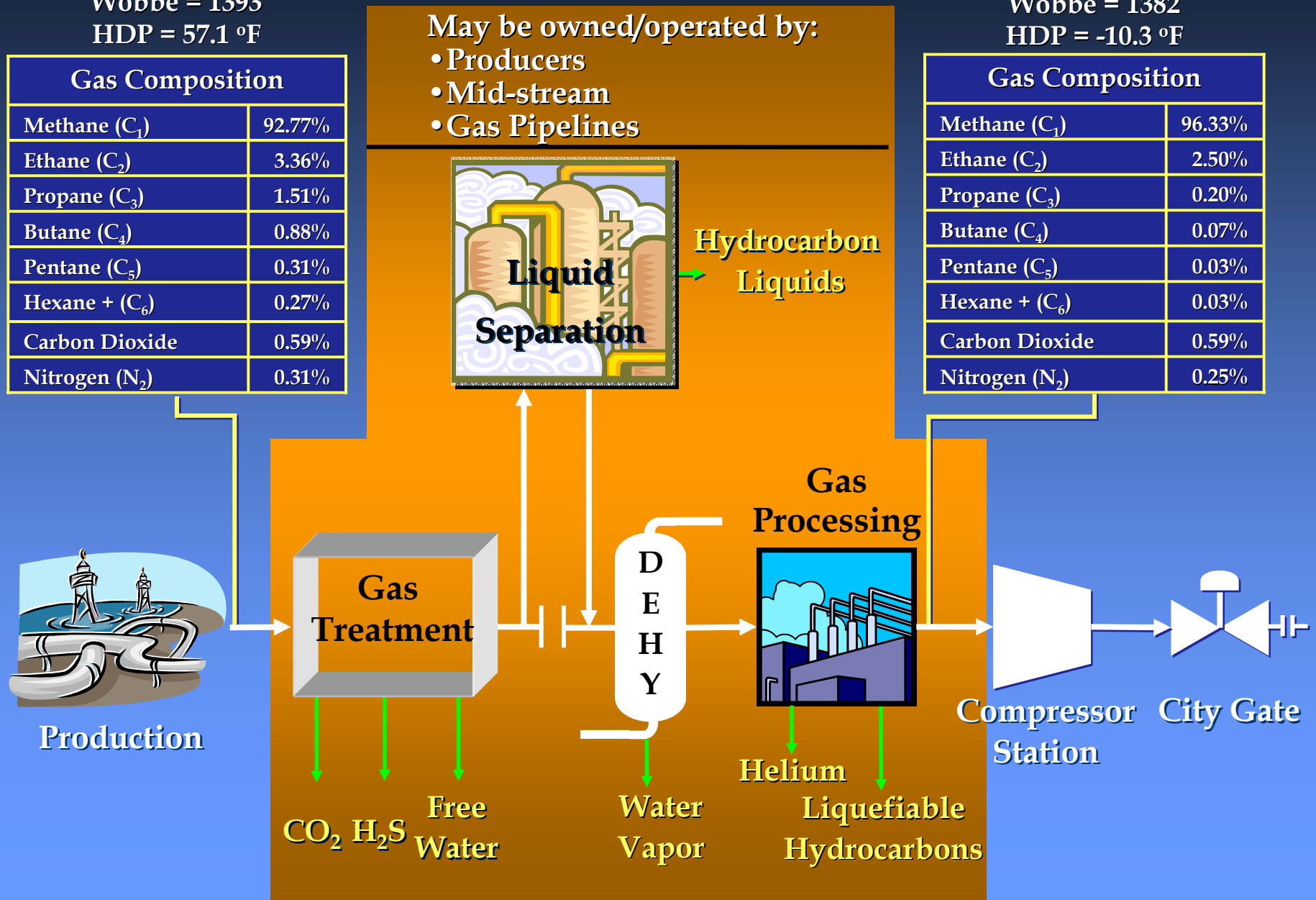
Gas Delivery Network Example

HHV = 1096
Wobbe = 1393
HDP = 57.1 °F

Gas Composition	
Methane (C_1)	92.77%
Ethane (C_2)	3.36%
Propane (C_3)	1.51%
Butane (C_4)	0.88%
Pentane (C_5)	0.31%
Hexane + (C_6)	0.27%
Carbon Dioxide	0.59%
Nitrogen (N_2)	0.31%

HHV = 1029
Wobbe = 1382
HDP = -10.3 °F

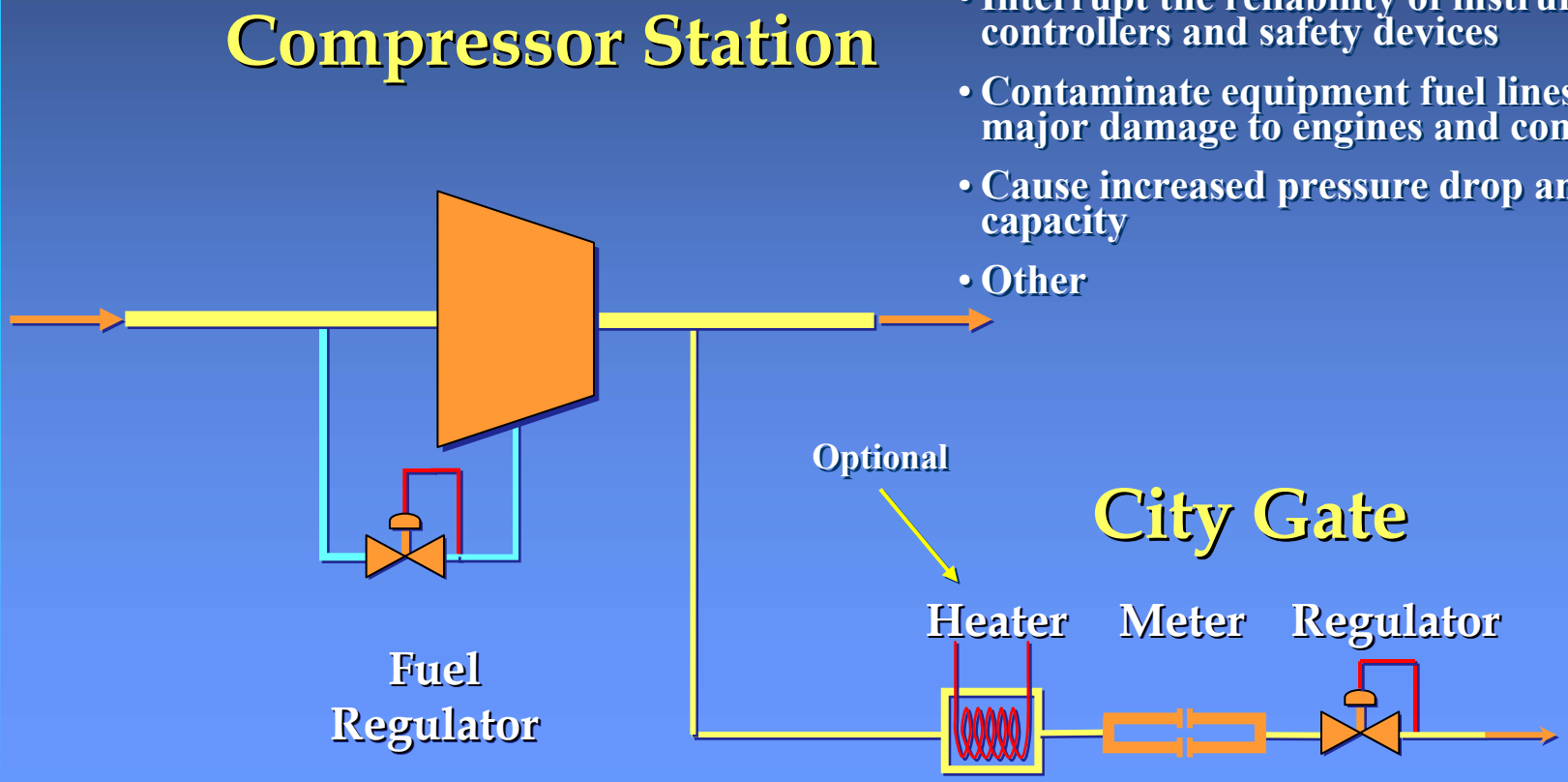
Gas Composition	
Methane (C_1)	96.33%
Ethane (C_2)	2.50%
Propane (C_3)	0.20%
Butane (C_4)	0.07%
Pentane (C_5)	0.03%
Hexane + (C_6)	0.03%
Carbon Dioxide	0.59%
Nitrogen (N_2)	0.25%



Gas Pipeline Network

Free liquid hydrocarbons may:

- Form due to pressure drop at regulators
- Freeze regulators and controllers
- Interrupt the reliability of instrumentation, controllers and safety devices
- Contaminate equipment fuel lines leading to major damage to engines and compressors
- Cause increased pressure drop and loss of capacity
- Other



Liquefied Natural Gas

Interchangeability with Domestic Natural Gas

Liquefied Natural Gas (LNG)

- Natural gas liquefied by cooling to minus 260°F
- Shipped and stored at near atmospheric pressure
- Volume reduction of approximately 600 to one

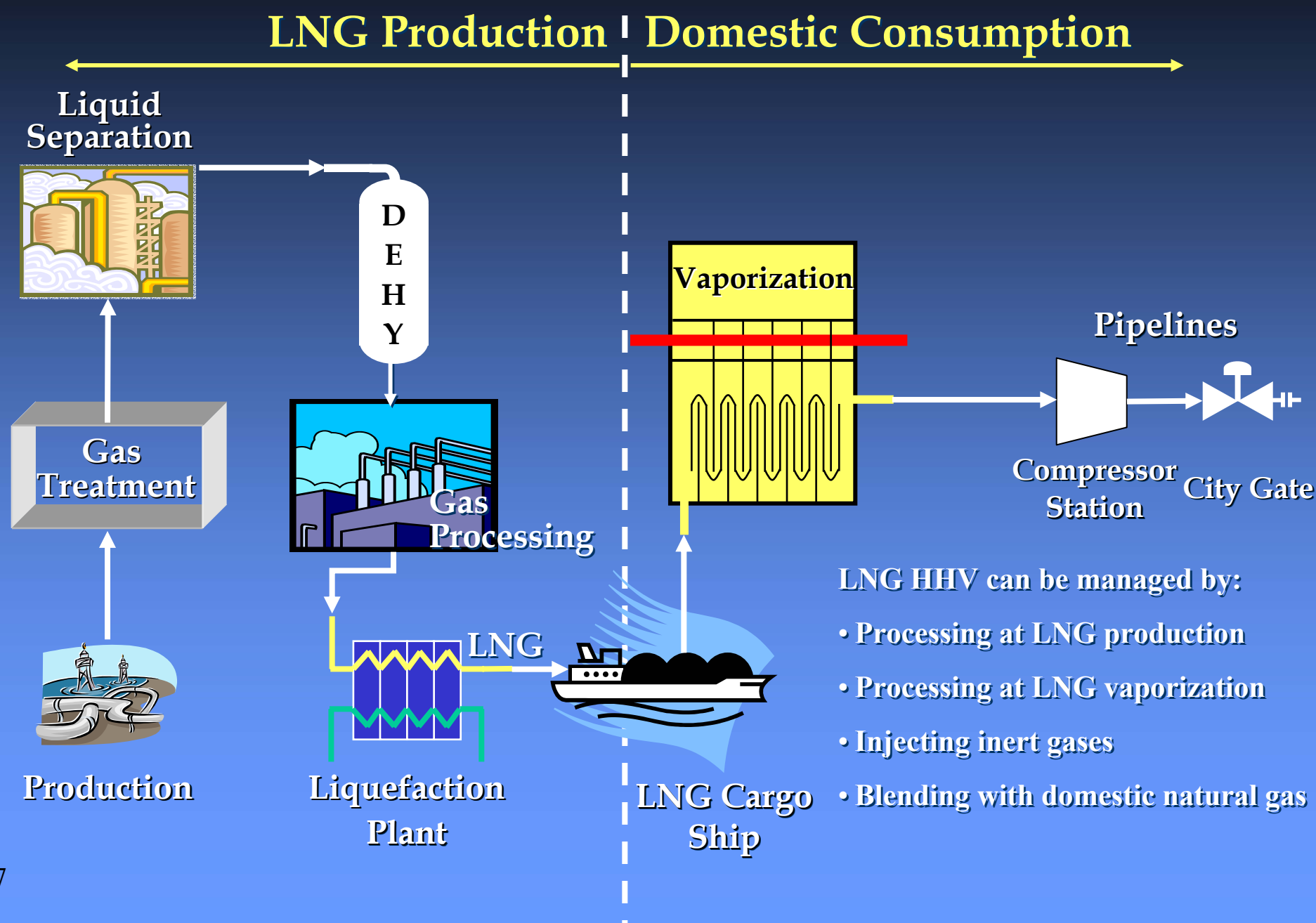
LNG Properties

	Historical LNG Cargoes[1]			Majority of Future Cargoes to Lake Charles Terminal[2]	
	Trinidad	Algeria	Oman	Minimum	Maximum
HHV (BTU/scf)	1048	1103	1168	1045	1064
Interchangeability Index (Wobbe)	1380	1406	1444	1379	1390
HDP (°F)	-94.6	-49.7	+3.68	-88.4	-87.2
Composition					
Methane (C_1)	96.13%	89.57%	86.52%	96.18%	93.48%
Ethane (C2)	3.40%	8.61%	8.31%	3.38%	6.47%
Propane (C3)	0.39%	1.18%	3.32%	0.29%	0.03%
Iso-Butane (i-C4)	0.04%	0.13%	0.85%	0.03%	–
n-Butane (n-C4)	0.03%	0.18%	0.85%	0.03%	–
Iso-Pentane (i-C5)	–	0.01%	0.06%	–	–
n-Pentane (n-C5)	–	–	–	–	–
Hexane (C6)	–	–	–	–	–
Nitrogen (N2)	0.01%	0.32%	0.09%	0.09%	0.02%

[1] Source: GTI - Gas Interchangeability Tests, April 2003

[2] Represents a large percentage of future LNG imports from BG LNG Services starting in 2005
LNG contains no impurities - H_2S, O_2, CO_2 or H_2O

LNG Production to Market



LNG HHV can be managed by:

- Processing at LNG production
- Processing at LNG vaporization
- Injecting inert gases
- Blending with domestic natural gas