RISC

Celebrating 25 years

Gas (& Oil) Developments Introduction

May 2019

Who we are

- Resource Investment Strategy Consultants
- RISC is a truly independent advisory firm.
- We provide impartial advice to a broad range of clients in the oil and gas industry, enabling them to make their business decisions with confidence.
- We work in partnership with our clients to support their interests in the oil and gas industry, offering a broad and innovative perspective on oil and gas projects around the world.
  - We have many years of practical experience and provide a bespoke service.
  - We provide insightful views on technical, commercial and strategic issues
  - We help our clients understand the uncertainties and risks associated with th oil and gas industry.

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- The statements and opinions attributable to the author and/or RISC in this presentation are given in good faith and in the belief that such statements are neither false nor misleading.
- In preparing this presentation the author has considered and relied solely upon information in the public domain. This information has been considered in the light of RISC's knowledge and experience of the oil and gas industry
- In some instances, our perspectives may differ from some of our highly valued clients.
- In some cases the views and opinions of the author may differ from those held by others within RISC.
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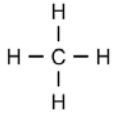
- RISC A&D hold AFSL #457327
- Martin Wilkes M.Eng. C.Eng. C.Env. M.I.ChemE.

Contents / Objectives

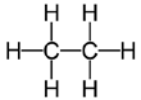
- What is Natural gas?
- Why do we process gas?
- What are the main issues involved?
- How are processing systems put together?

What is Natural Gas

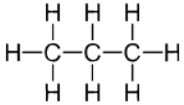
- Methane
  - CH4
  - C1



- Ethane
  - C2H6
  - C2

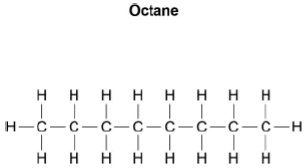


- Propane
  - C3H8
  - C3

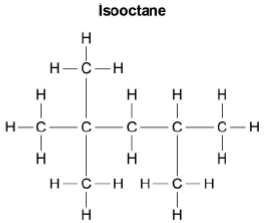


…

- Octane
  - C8H18
  - C8



Boiling point: 125 °C

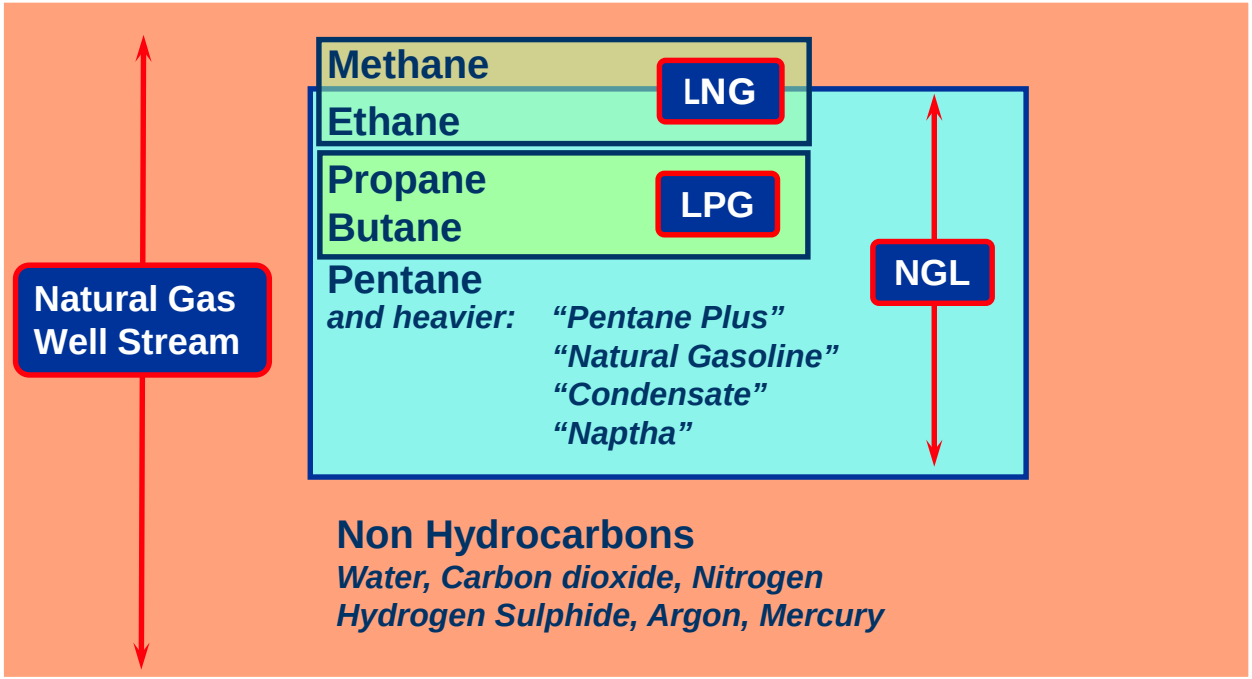


Boiling point: 99 °C

- …C30+

- Non Hydrocarbons:
  - Water, Carbon Dioxide, Nitrogen, Hydrogen Sulphide, Mercury, Argon…

Natural Gas terminology



Natural Gas Components & Characteristics

	Liquid at	MW
C1 - Methane	-161 °C	16
C2 - Ethane	- 88 °C	30
C3 - Propane	- 42 °C	44
C4 - Butane (iso)	- 12 °C	58
C4 - Butane (nor)	- 0.5 °C	
C5 - Pentane (iso)	28 °C	72
C5 - Pentane (nor)	36 °C	
C6 - Hextane	70 °C	86
C7 - Heptane	100 °C	100

Main Differences - Oil & Gas Devt.

- Markets
- Economics of processing and transportation
- Efficiency of energy generation (combustion)
- Environmental impact

Why do we Process Gas?

- Safety
  - Protect our customers, ourselves and the general public.
  - To protect our Assets, our customers assets.
    - To manage toxicity and corrosion concerns
    - To make it dry
- Specifications
  - To meet customers' specifications
  - To add value
- Transport
  - To allow for delivery conditions
  - To account for availability requirements

What don’t we want?

- Water (Corrosion / Hydrates)
- Heavy Hydrocarbons (2 Phase Flow)
- CO2 (Corrosion)
- H2S (Corrosion / Toxic)

Typical Product Specifications

Oil

Vapour Pressure	TVP < 83 kPa@T RVP < 10-12 psi
Base Sediment & Water	BS&W < 0.5%
Salt Content	NaCl < 70 g/m^3
Temperature	> PourPoint
Hydrogen Sulfide	H_2S < 70 g/ m^3

Water

Dispersed Oil Content	< 40 g/m^3
Suspended Solids Content	< 50 g/m^3
Composition & Compatibility	

Gas

Hydrocarbon Dew Point	-3^{o}C @ < 7000 kPa
Water Dew Point	-8^{o}C @ < 7000 kPa
Heating Value	37-43 MJ/Sm^3
Max amounts	Inerts, CO_2 , H_2S
Delivery Pressure & Temperature	

Water Content of Gas

- Why is water in gas?
  - Hydrocarbons are normally found in conjunction with water
  - Hydrocarbons and water have been in geological contact for millions of years

- Water content depends on:
  - Composition
  - Pressure
  - Temperature

- Why is water an issue?
  - Free water leads to
    - Corrosion in the presence of other components (CO, CO_2, H_2S etc)
    - Hydrates
  - Water is non-combustible

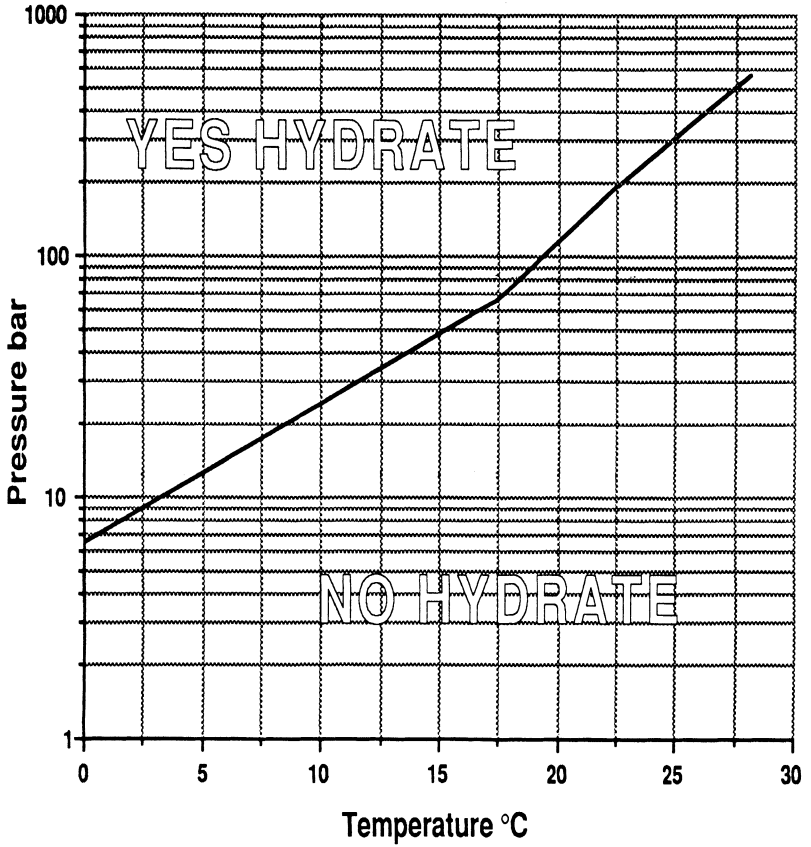
What are Hydrates

- Hydrates are:
  - Deposits resembling ice, compacted snow, or wax
  - Formed by combination of water and light HCs, CO2 and H2S
  - Grow like crystals that build up and plug lines, valves, orifices, etc

Requirements for Hydrates

- For hydrates to form the following are pre-requisites:
  - Free water
  - High Pressure
  - Low Temperature

- Different Strategies:
  - Stay out of the hydrate region (keep warm)
  - Ensure no free water (dry)
  - Hydrate inhibition
    - MEG / Methanol



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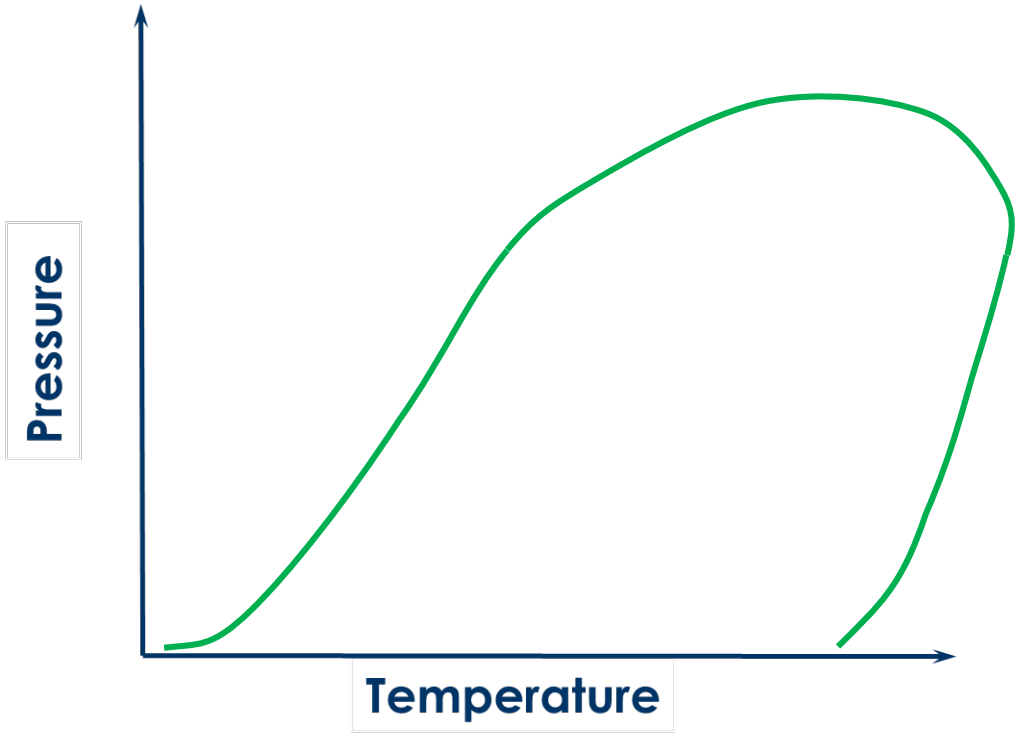
Multi-component Hydrocarbon Phase behaviour - The Phase Envelope



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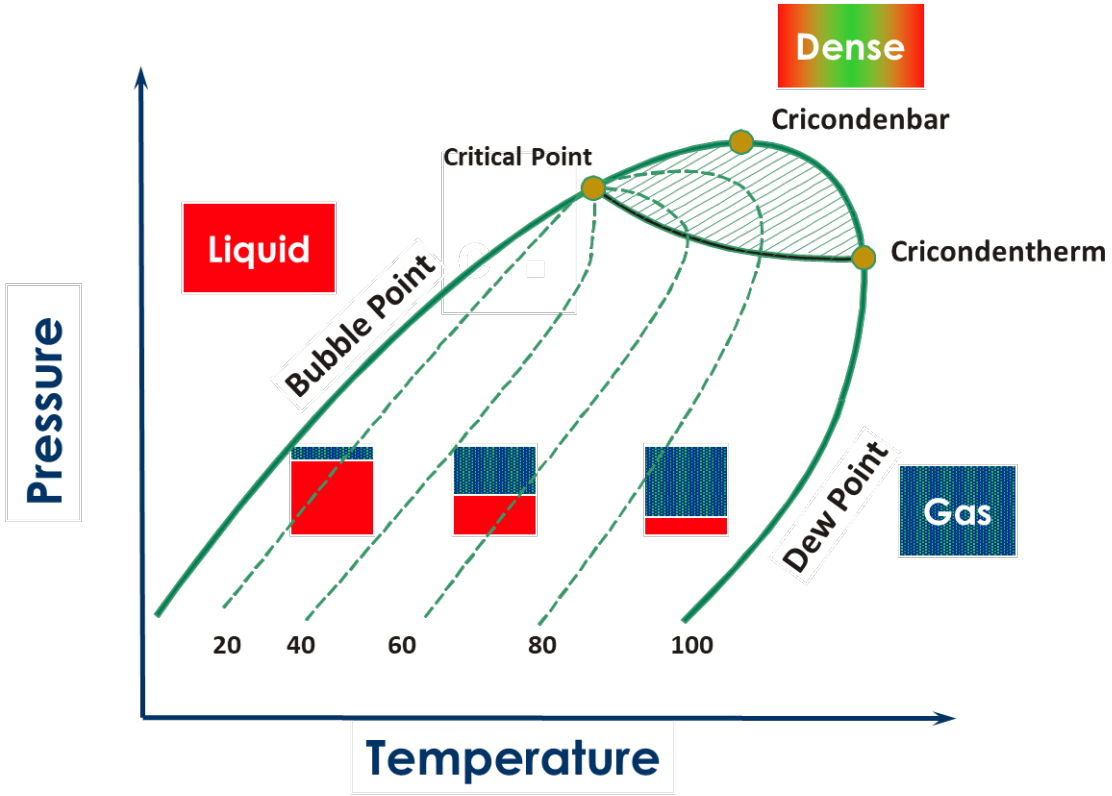
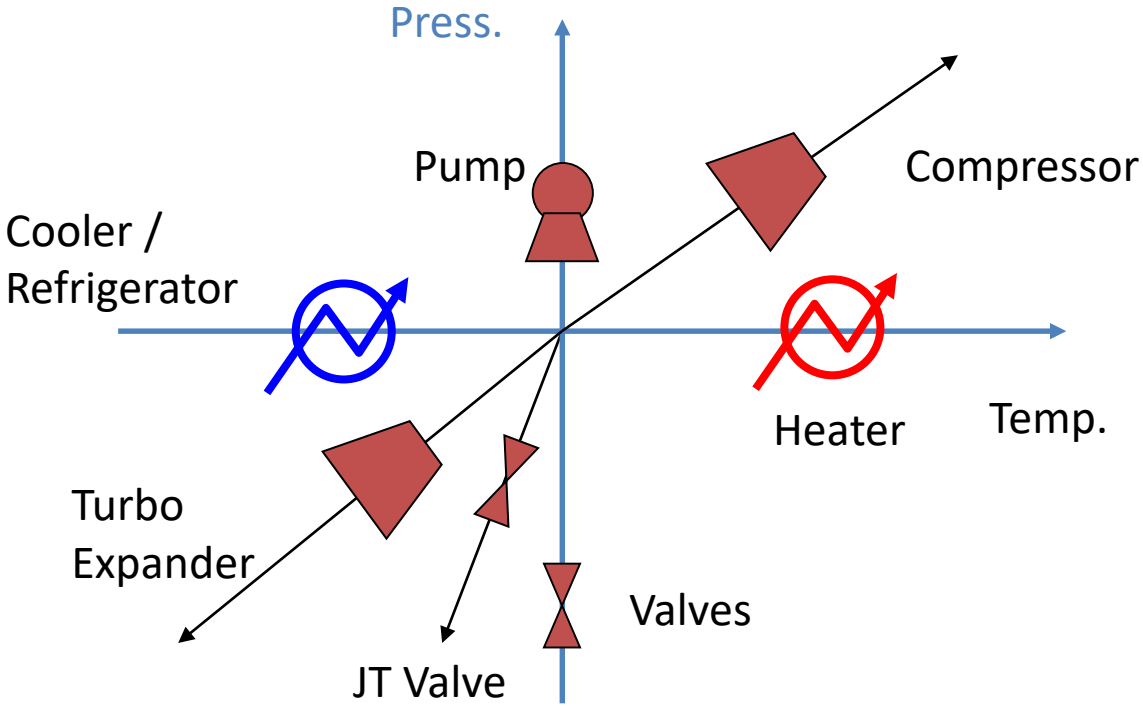
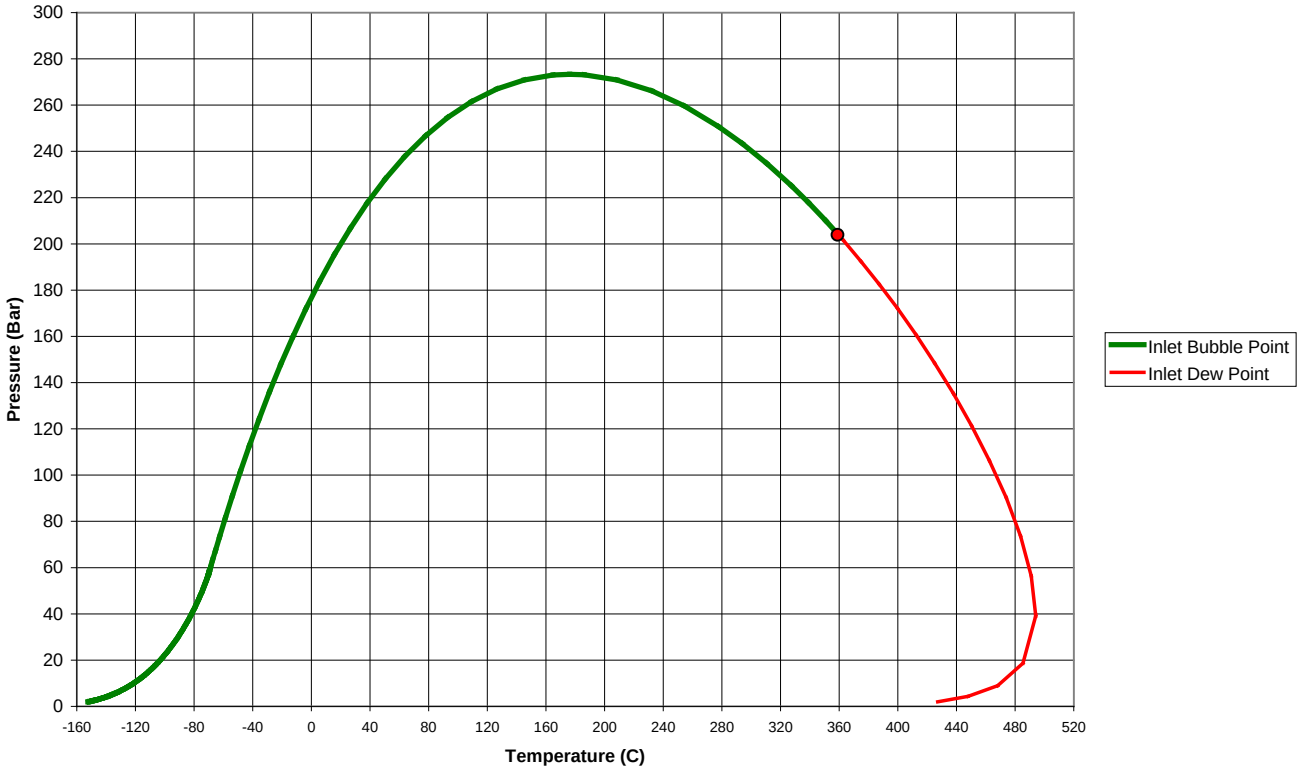


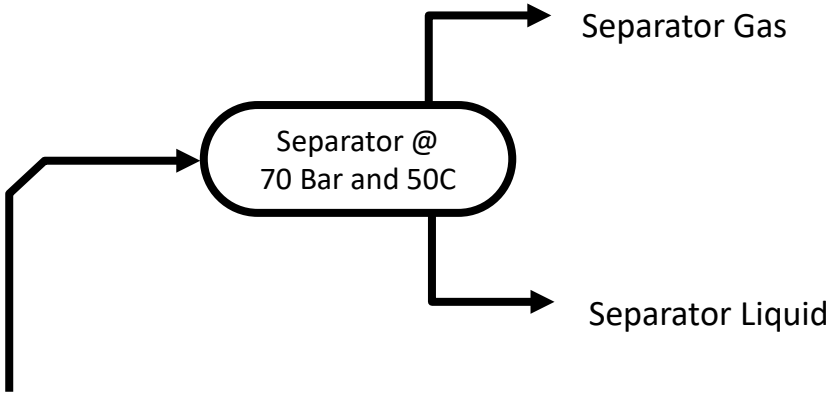
Moving around the P-T Diagram



How do we use and change Phase Envelopes?



Separation: changing the envelope



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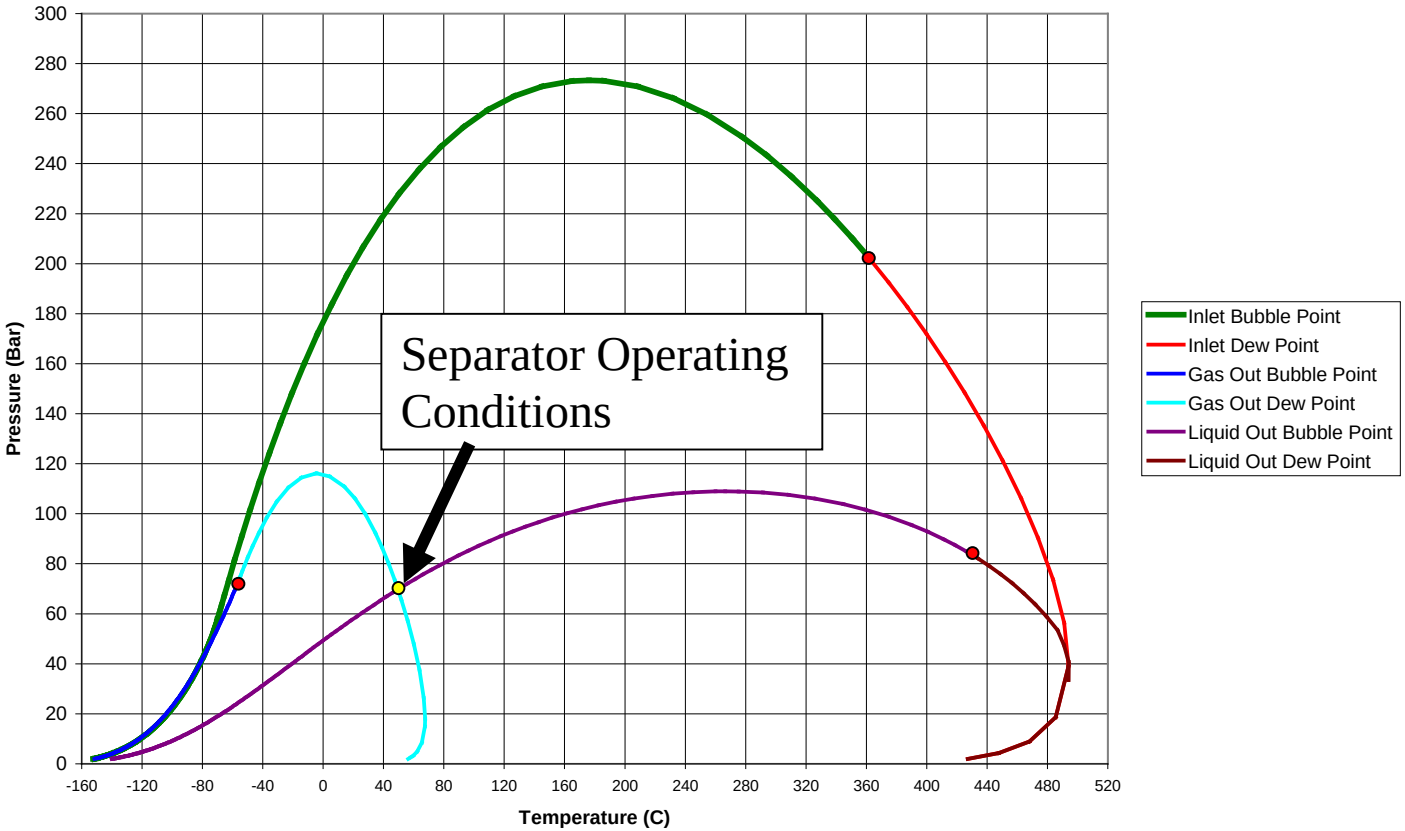
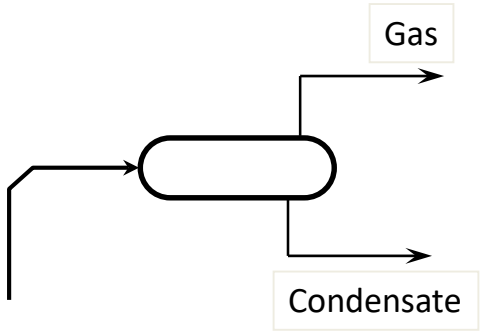
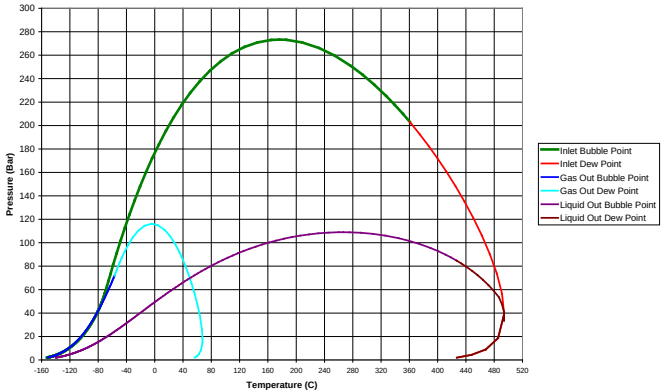


Building the Gas Processing System

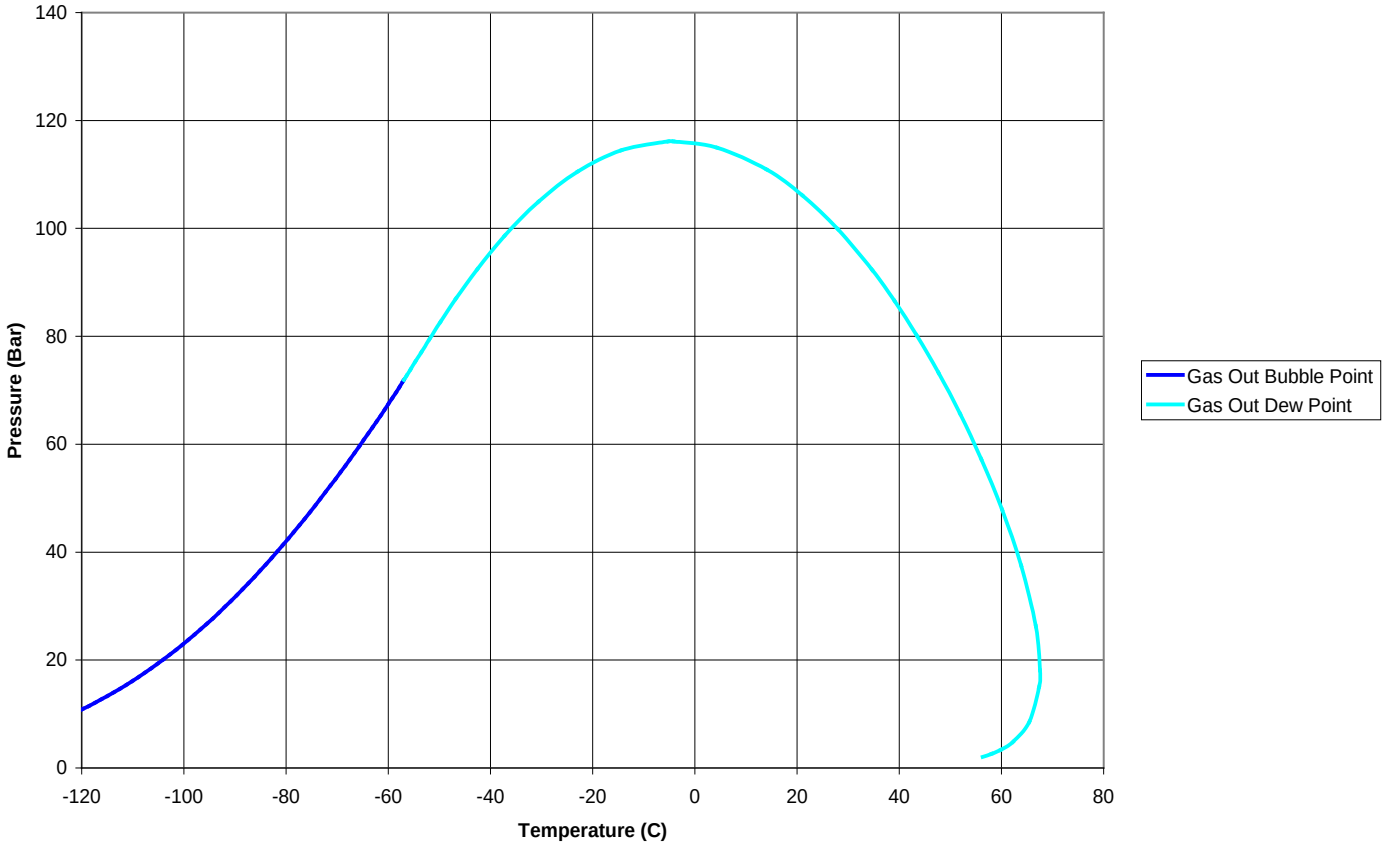
- Gas Spec.
  - Hydrocarbon dewpoint < 0C at all P < 100 bar
  - Delivery pressure 100 bar

  - Gas field with primary separator at 70 bar and 50C

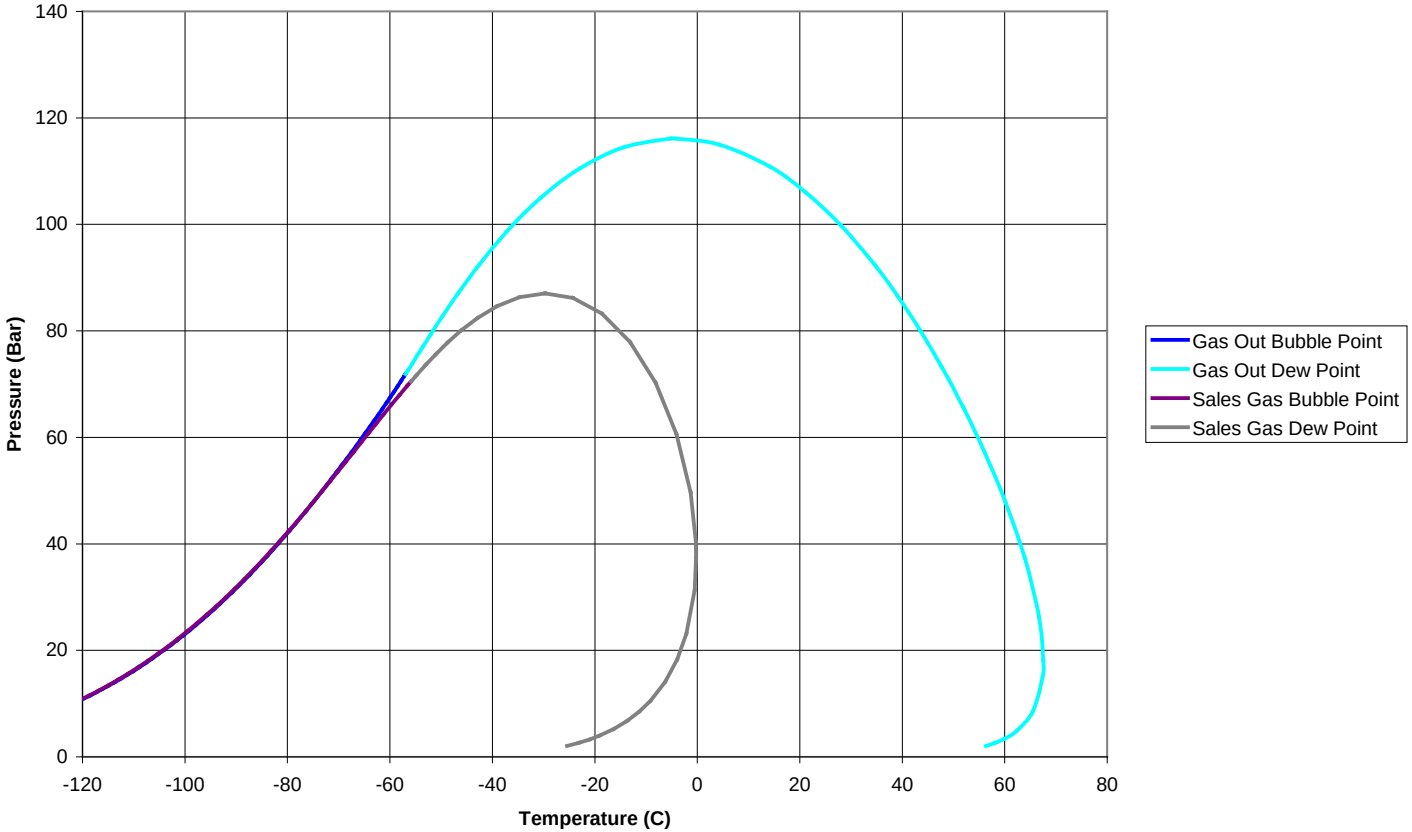




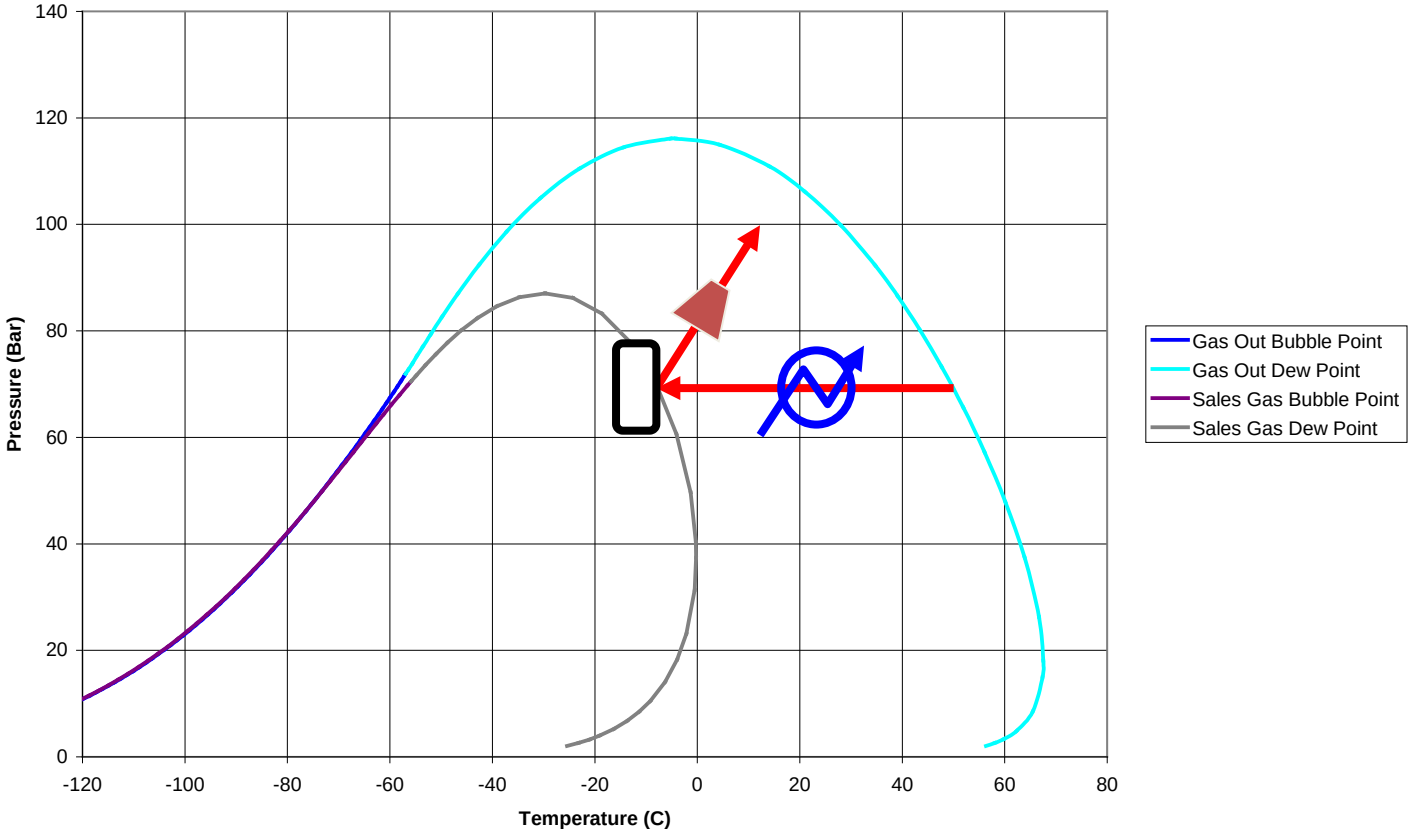
Separator Gas Phase Envelope



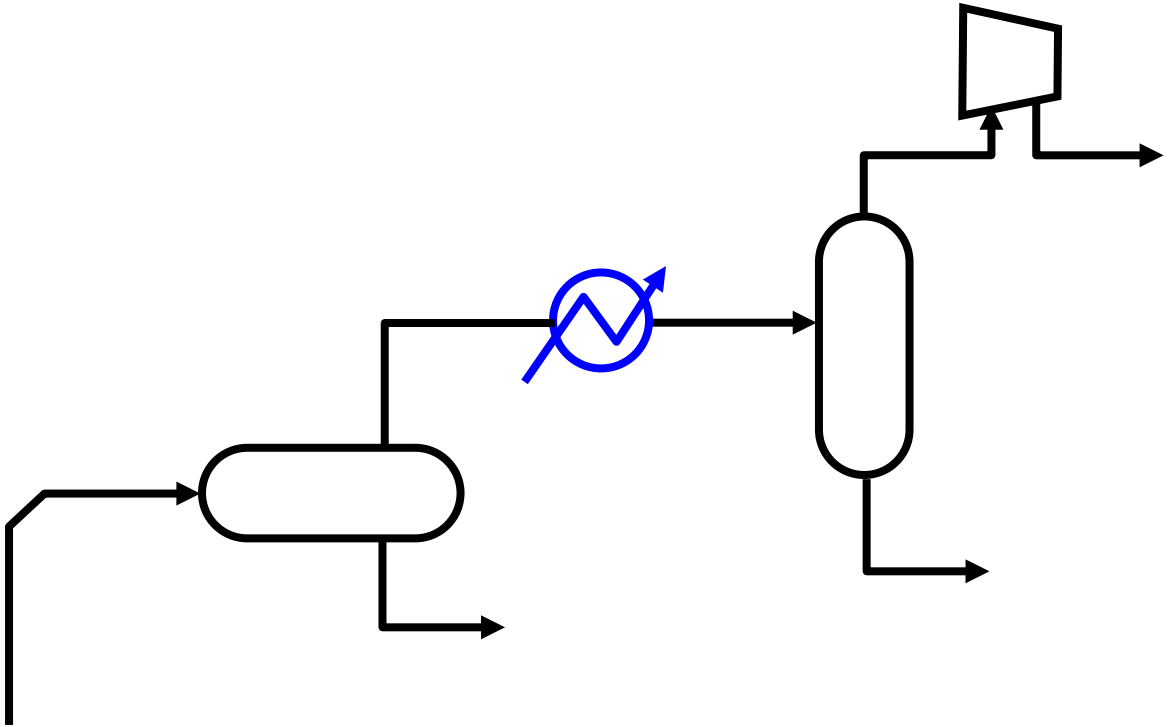
Meeting specification



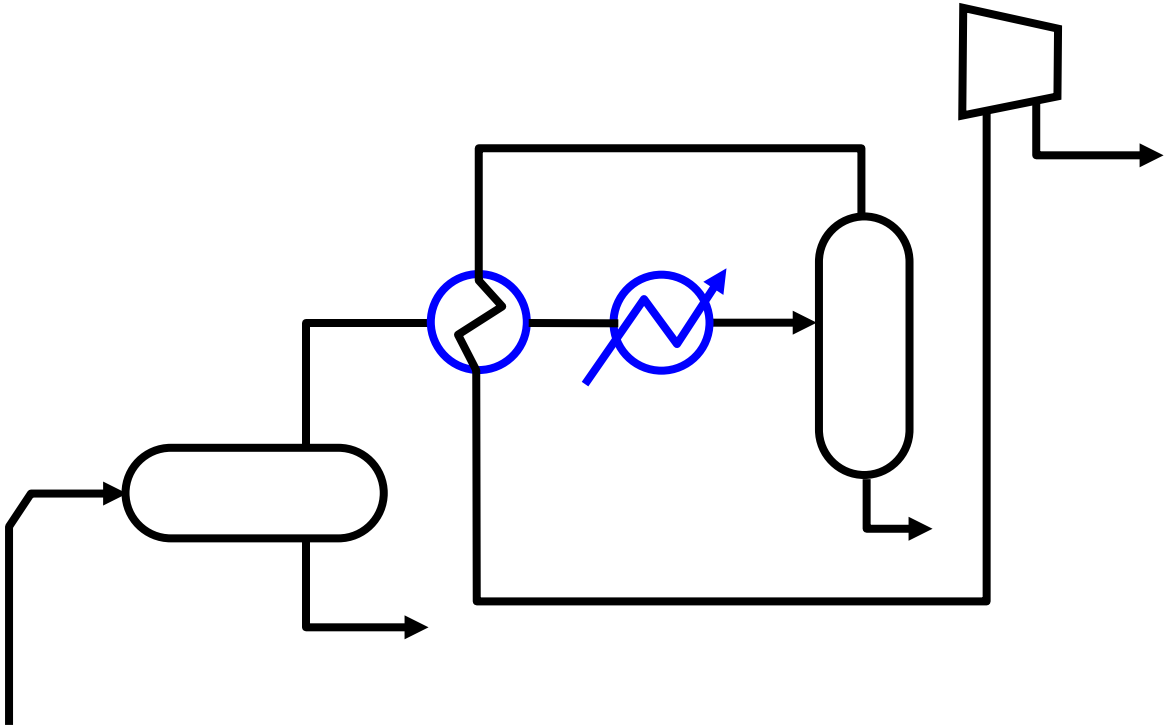
Meeting specification through cooling



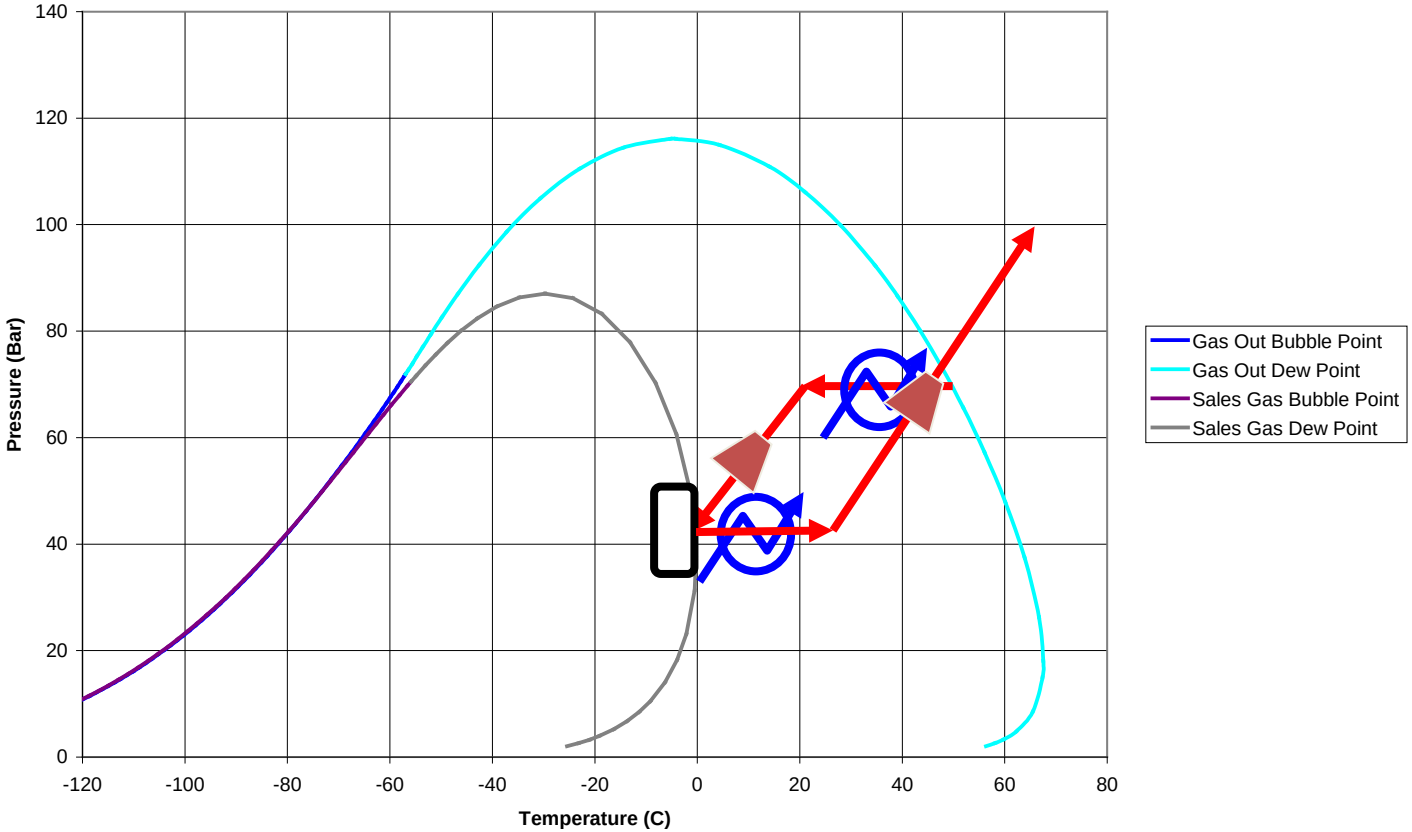
Simple cooling/refrigeration PFS 1



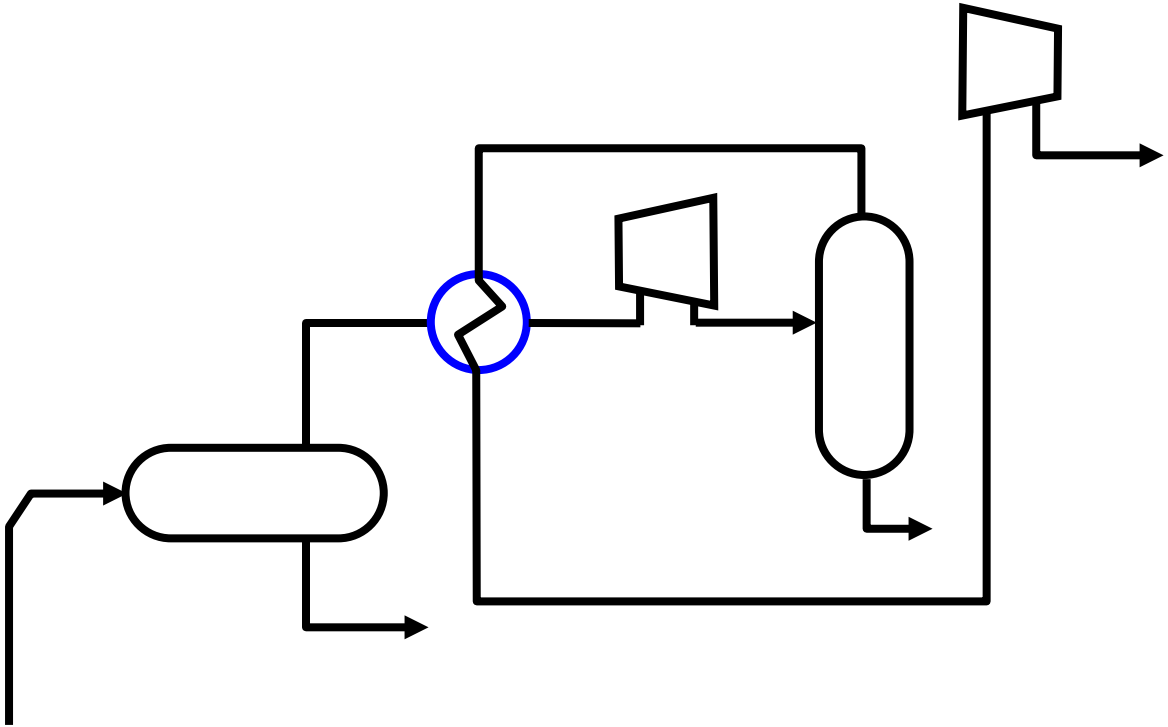
Refrigeration and cross exchange PFS 2



Alternative – Turbo Expander



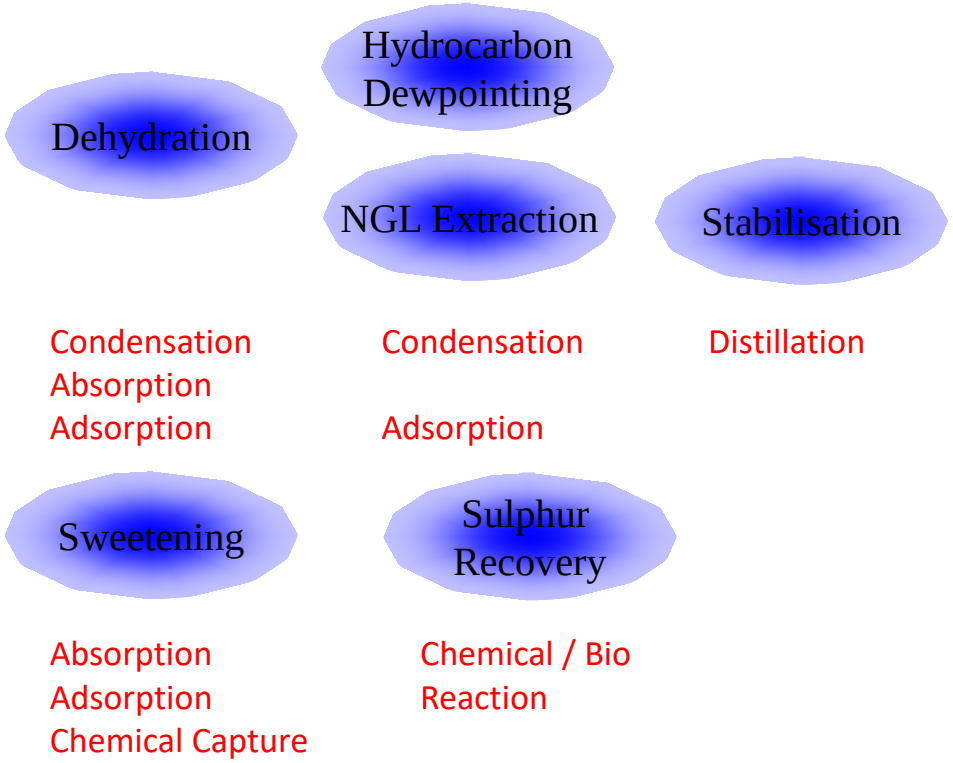
Turbo Expander PFS 3



What don’t we want?

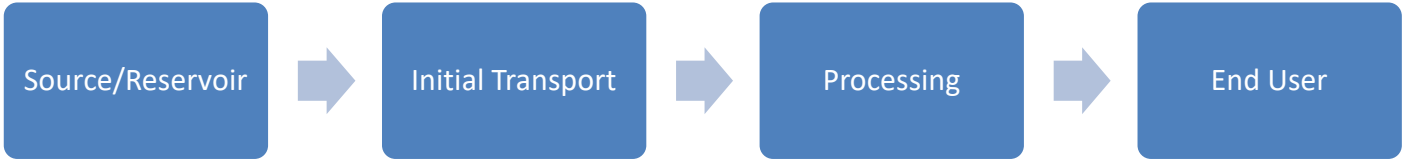
- Water (Corrosion / Hydrates)
- Heavy Hydrocarbons (2 Phase Flow)
- CO2 (Corrosion)
- H2S (Corrosion / Toxic)

Gas Processing Scheme



Generic Process Scheme Development

Simple (Onshore gas plant delivering to local system)

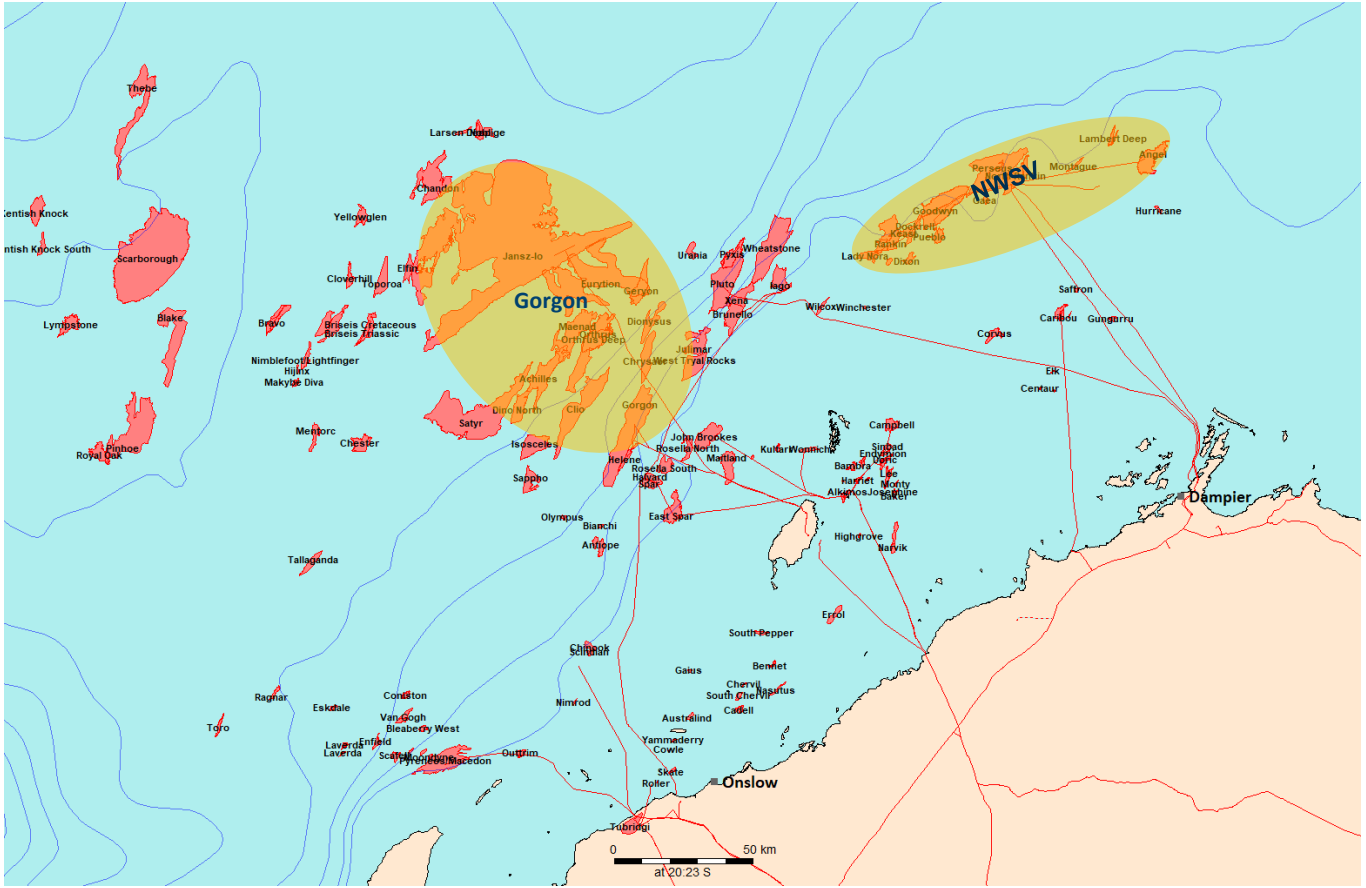


Complex (LNG Delivery system)

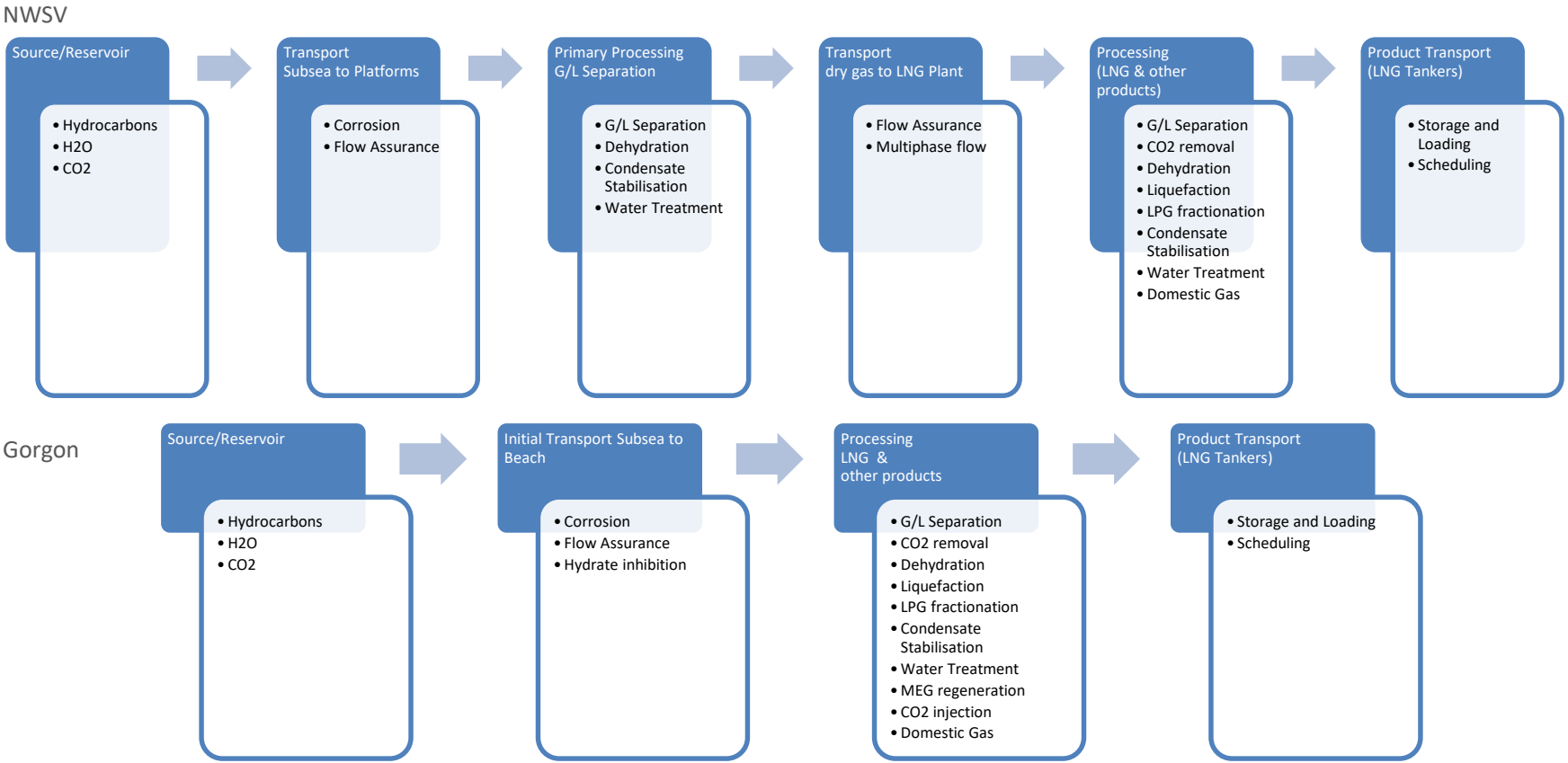
Which gas is it?

Symbol	Component	Mol % 1	Mol % 2	Mol % 3
CO2	Carbon Dioxide	3.35	0.38	12.00
N2	Nitrogen	0.32	5.34	1.50
C1	Methane	74.45	93.85	77.91
C2	Ethane	10.77	0.41	3.00
C3	Propane	4.19	0.01	2.50
iC4	i-Butane	0.61	0.00	0.50
nC4	n-Butane	1.24	0.00	1.05
C5	neo-Pentane	0.01	0.01	0.02
iC5	i-Pentane	0.42	0.00	0.40
nC5	n-Pentane	0.47	0.00	0.60
C6	Hexanes	0.56	0.00	0.30
C7	Me-Cyclo-pentane	0.13		
	Benzene	0.04		
	Cyclo-hexane	0.27		
	Heptanes	0.37	0.00	0.10
C8	Me-Cyclo-hexane	0.37		
	Toluene	0.16		
	Octanes	0.40	0.00	0.05
C9	Ethyl-benzene	0.02		
	Meta/Para-xylene	0.14		
	Ortho-xylene	0.03		
	Nonanes	0.29	0.00	0.02
C10	Tri-Me-benzene	0.04		
	Decanes	0.26	0.00	0.00
C11+	Undecanes +	1.10	0.00	0.05
H_2O	Water mg/Sm^3	50	1000	500

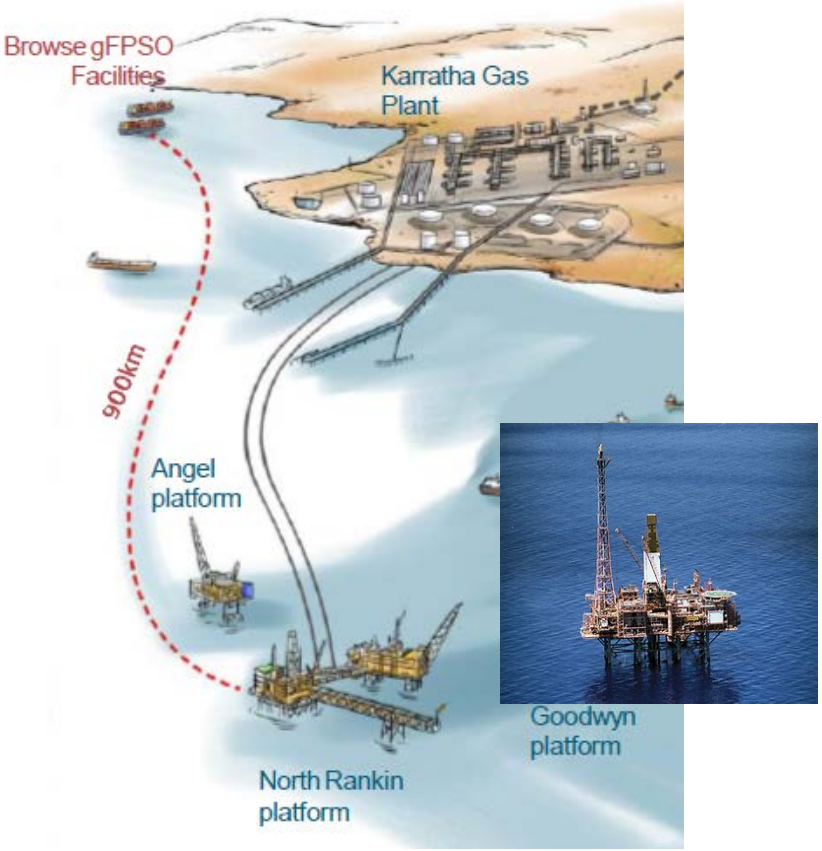
NWSV and Gorgon



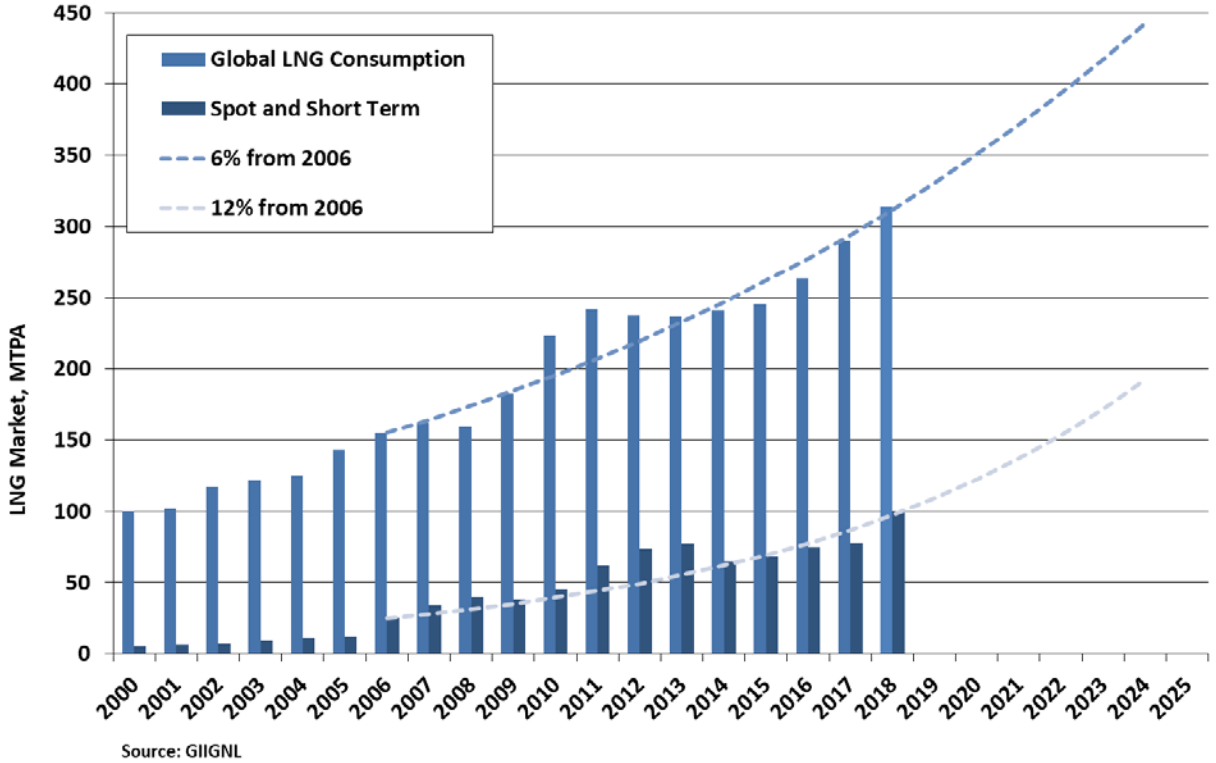
Comparison of NWSV and Gorgon Field Developments



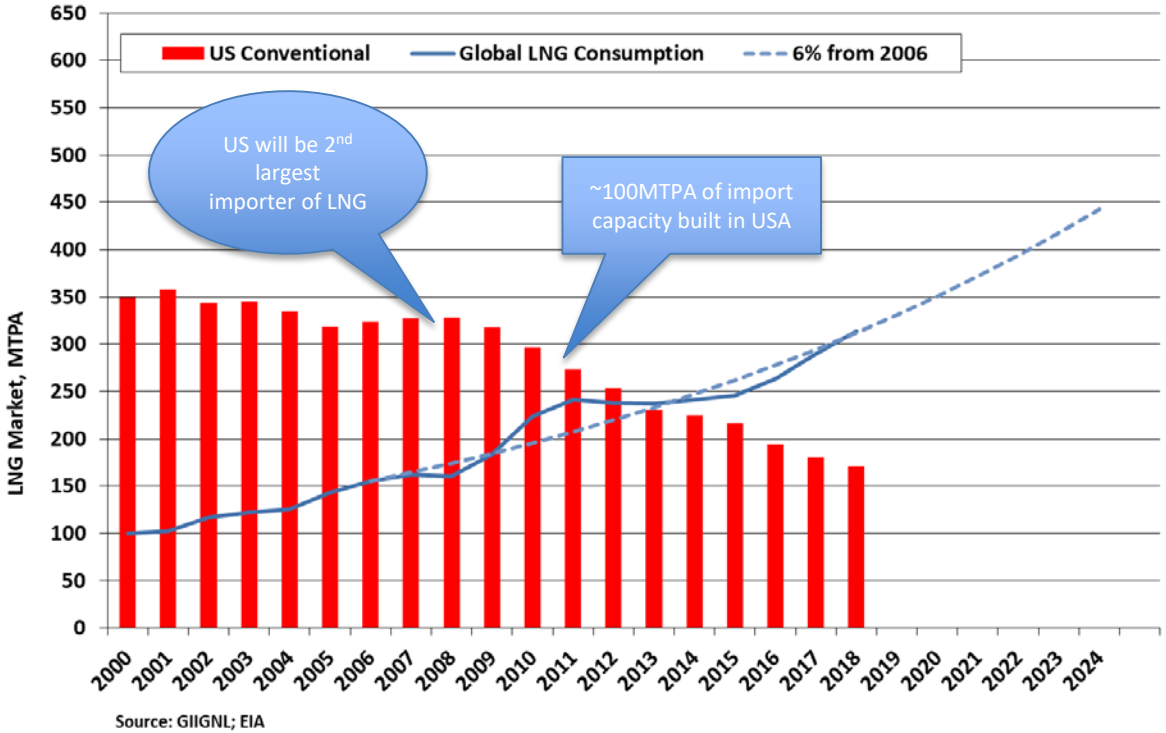
Comparison of NWSV and Gorgon



The Global LNG Market is growing and changing



In Context…


US Conventional
Global LNG Consumption
6% from 2006
US will be 2nd largest importer of LNG
~100MTPA of import capacity built in USA
LNG Market, MTPA
650
600
550
500
450
400
350
300
250
200
150
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2000
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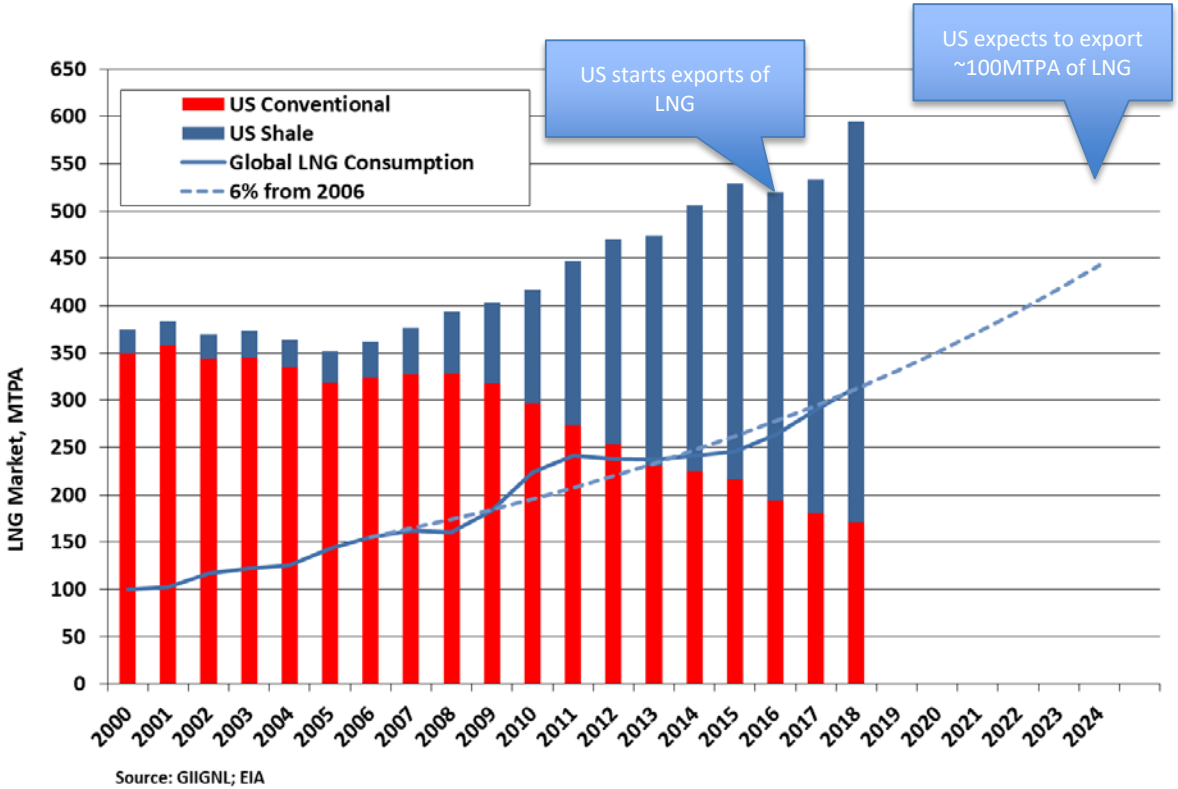
2024
Source: GIIGNL; EIA

In Context…


US starts exports of LNG
US expects to export ~100MTPA of LNG
US Conventional
US Shale
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LNG Market, MTPA
650
600
550
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Source: GIIGNL; EIA

www.riscadvisory.com

Perth

Level 2
1138 Hay Street
WEST PERTH WA 6005
P. +61 8 9420 6660
F. +61 8 9420 6690
E. admin@riscadvisory.com

Brisbane

Level 10
239 George Street
BRISBANE QLD 4000
P. +61 7 3025 3397
F. +61 7 3188 5777
E. admin@riscadvisory.com

London

4th floor Rex House
10 Regent Street
LONDON UK SW1Y 4PE
P. +44 203 356 2960
F. +44 203 356 2701
E. admin@riscadvisory.com

Dubai

Suite 503, Shangri La Offices
Sheikh Zayed Road
DUBAI UAE
P. +971 4 401 9875
F. +61 8 9420 6690
E. admin@riscadvisory.com

South East Asia

Jakarta
Indonesia
P. +61 8 9420 6660
F. +61 8 9420 6690
E. admin@riscadvisory.com

Renewables are not the panacea for power generation