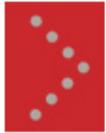




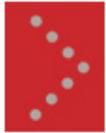
Infrastructure and value chain

Gas vs Liquid



❖ Agenda

- Value Chain - Gas vs Liquid
- Liquid recovery processes
- Musreau Deep Cut
- Saturn and Resthaven Projects



Field Liquid Extraction



- ❖ Gas vs Liquids - Frac spread
 - ❖ The difference in value between components such as ethane, propane and butane as a liquid and in the gaseous form. This drives the economics of extraction strategy.
 - ❖ Propane, butane and condensate pricing is linked to the price of oil, whereas natural gas pricing is largely independent of oil tracks to natural gas pricing.
 - ❖ Ethane tends to be priced on a cost of service basis.



Field Liquid Extraction



Value Chain





Field Liquid Extraction



- ❖ Key considerations
 - ❖ Marketing – Commodity Value Potential
 - ❖ Product Quality
 - ❖ Capital Costs
 - ❖ Operating Costs
 - ❖ Product egress
 - ❖ Location
 - ❖ Utilities



Field Liquid Extraction



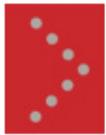
	Capital Cost to extract	Operating costs to extract	Commodity Value
Ethane (C2)			
Propane (C3)			
Butane (C4)			
Condensate (C5+)			



Field Liquid Extraction



Field liquid extraction processes



Gas Compositions



Gas Compositions from various WCSB areas

	Medicine Hat Shallow Gas	Kaybob South	Fox Creek	Ft. St. John	Musreau
	Cretaceous	Devonian	Cretaceous	Triassic	Cretaceous
N2	2.2	0.9	0.8	0.3	0.3
H2S	---	17.9	---	4.4	---
CO2	---	3.5	0.6	2.4	1.2
C1	96.5	56.5	87.7	85.3	85.1
C2	1.2	7.7	5.6	4.5	7.7
C3	0.1	3.4	3.0	1.5	2.7
iC4	---	0.9	0.4	0.3	0.5
nC4	---	1.7	0.8	0.5	0.7
C5+	---	7.5	1.1	0.8	1.8



Recovery effort



❖ Condensing temperatures

Chemical	Boiling Point	Energy Required
Methane	-259 °F.	
Ethane	-128 °F.	
Carbon Dioxide	-109 °F.	
Propane	- 44 °F.	
Isobutane	10.9 °F.	
Normal Butane	31.1 °F.	
Isopentane	82.2 °F.	
Normal Pentane	96.9 °F.	



NGL Recovery



Recoveries	Condensate	Butane	Propane	Ethane
Shallow Cut (C5+)	90+%	Less than 2%	~0%	~0%
Shallow Cut (C3+)	92+%	50-65%	25-35%	Less than 2%
Turbo-expansion Deep (C2+)	99.9+%	99+%	98+%	Up to 80%



NGL Recovery (C5+/C3+)

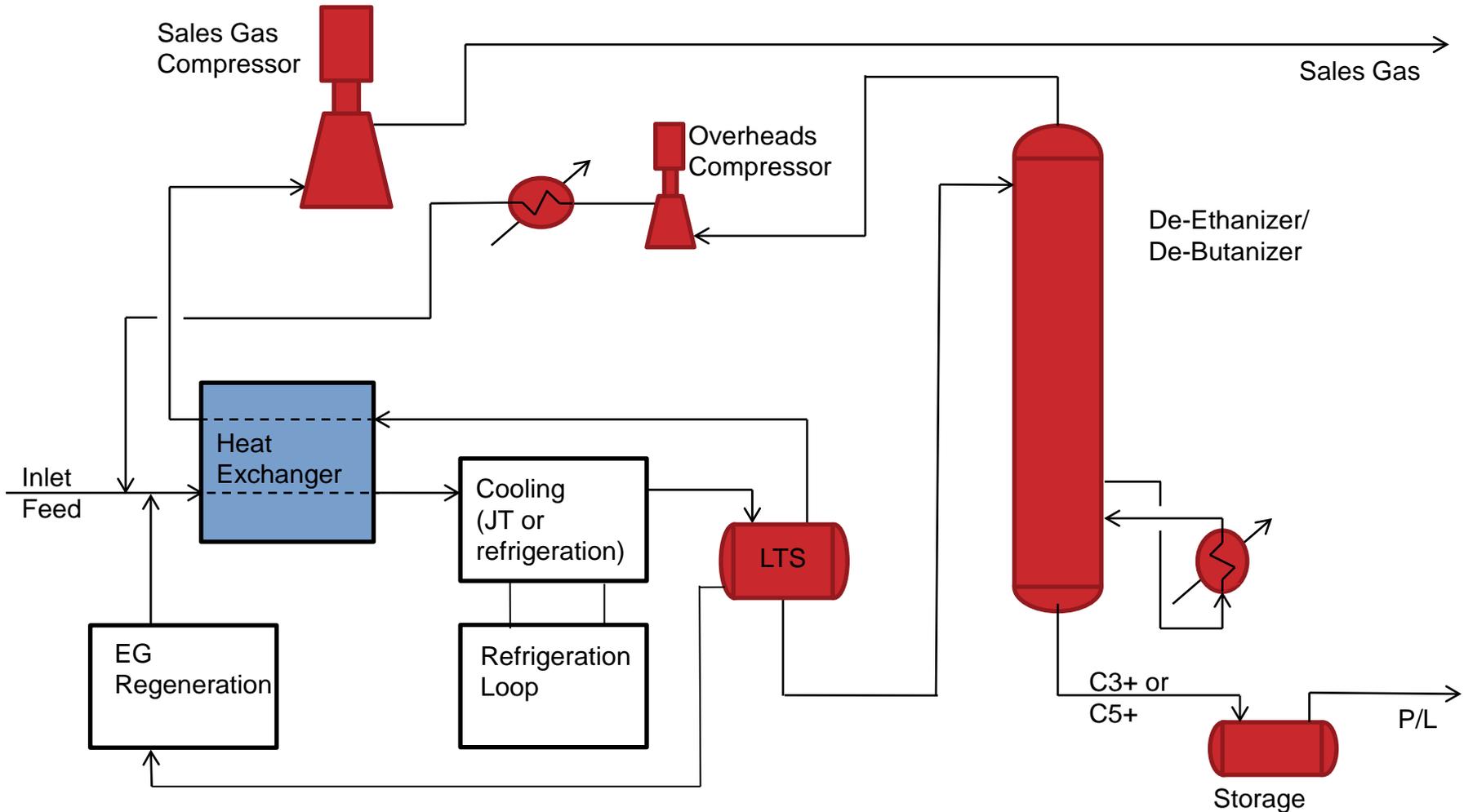


› Primary recovery (shallow cut)

- › Used to meet sales gas pipeline hydrocarbon dew point spec. (-10 °C at 5,500 kPa)
- › Typical liquid recoveries, 25-35% propane, 40-60% butane, 90+% condensate
- › Process involves expansion or refrigeration down to -25°C (in some cases to -40°C)
- › Relatively common equipment and processes
- › Process engaged and equipment requirements driven by:
 - › Product Quality
 - › Impurities
 - › Sour or sweet
 - › Process (JT or refrigeration)
 - › Egress



Shallow Cut schematic





NGL Recovery (C2+)

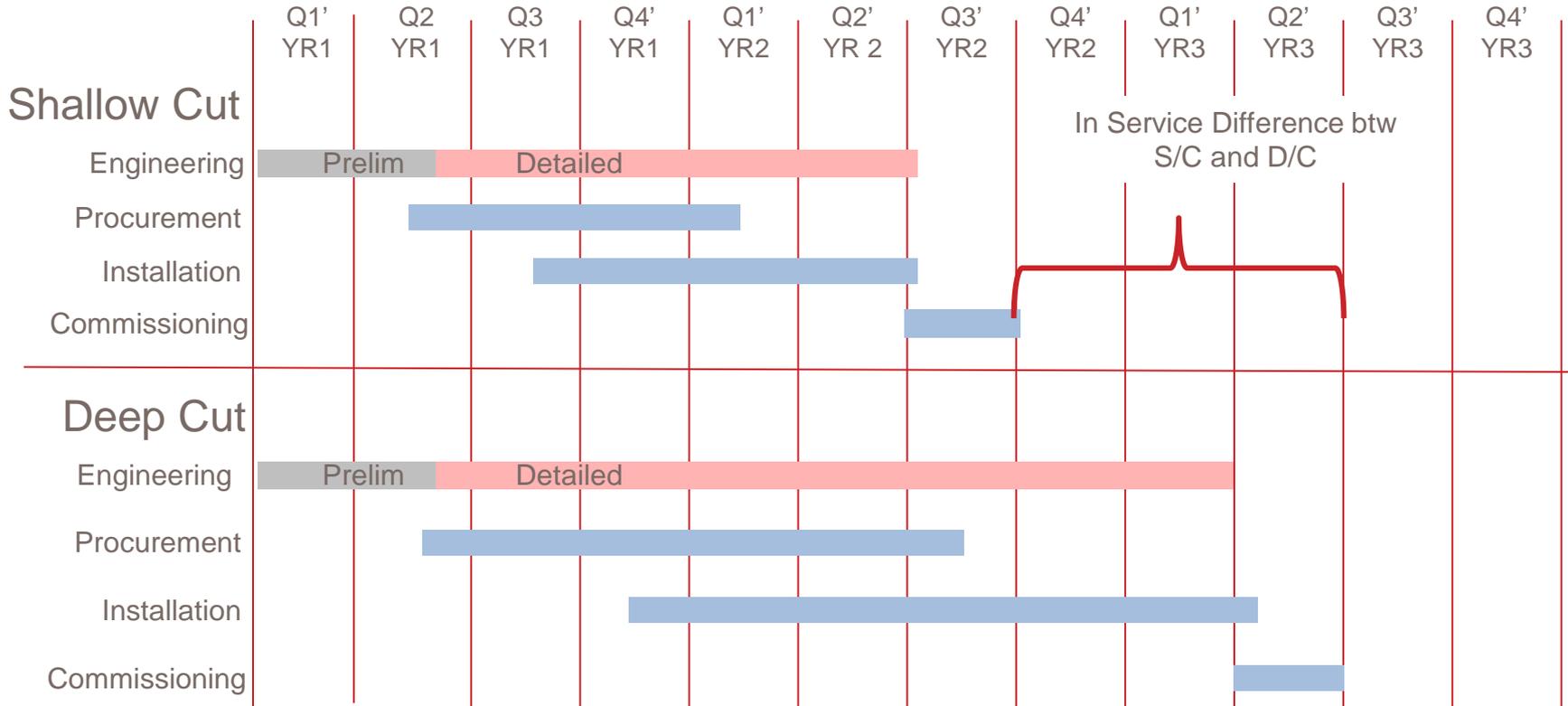


‣ Deep Cutting - raw inlet or field straddle

- Results in significantly higher propane and butane recovery and includes ethane recovery
- Requires enhanced dehydration equipment (molecular sieve)
- Process involves cooling gas down to -80°C
- Requires significant compression
- Process engaged and equipment requirements driven by:
 - Product quality (raw gas or sales gas)
 - CO_2 content (and any other impurities)
 - Egress Specifications and infrastructure



Timeline





Field Liquid Extraction



Musreau Gas Plant

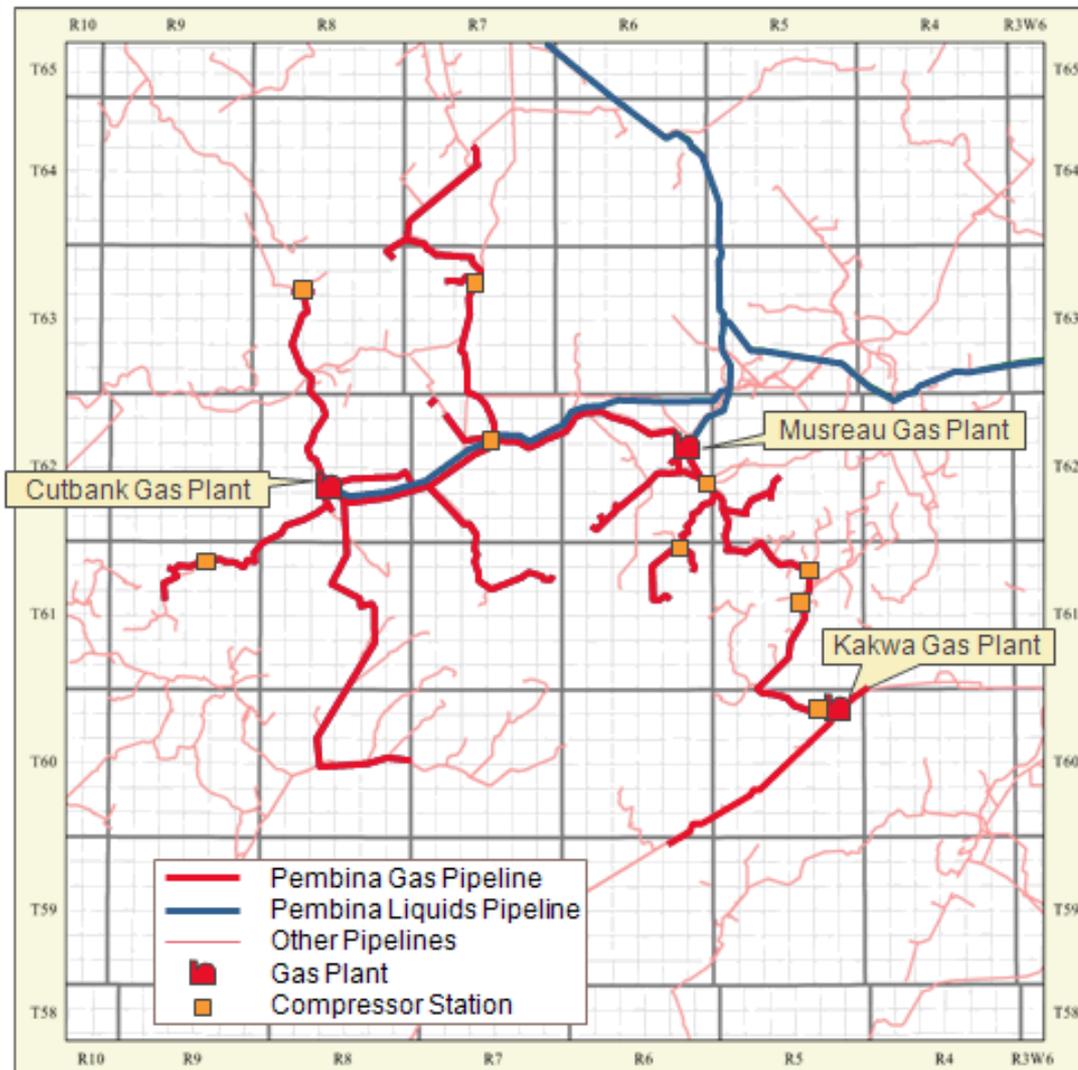


Cutbank-Musreau Complex



- ❖ Pembina Gas Services LP, a subsidiary of Pembina Pipeline Corporation purchased the integrated Cutbank-Musreau sweet gas gathering and processing complex from Talisman Energy in 2009.
- ❖ Located approximately 100 km. south of Grande Prairie.
- ❖ Located in the Deep Basin – extensive asset mix
- ❖ Active E&P companies
- ❖ Significant undeveloped lands
- ❖ Existing liquid rich reserves
- ❖ Extensive existing gas gathering and processing infrastructure
- ❖ Extensive downstream infrastructure (sales gas and liquids)

Cutbank–Musreau Complex



- ❖ The Complex consists of:
 - ❖ Over 300 km. of gathering lines
 - ❖ 9 compressor stations
 - ❖ 3 gas plants – Cutbank (110 mmscf/d to C5+); Musreau (200 mmscf/d to C5+ and C3+); Kakwa (60 mmscf/d to C5+)
 - ❖ High net processing capacity
 - ❖ Pipeline connections between the 3 plants provides a high degree of operational flexibility.



Musreau Deep Cut?



Opportunity:

- Frac spread was very positive
- Producer value
 - Higher netbacks
 - Higher reserve bookings
- Pembina Gas Services already providing shallow cut processing services every day so an extension of existing services
- Sales gas quality outlet volumes from shallow cut - little to no additional gas conditioning for ethane extraction was required
- Product egress for both gas and liquids were a relatively short distance from Musreau Gas Plant
- Opportunity to access a used deep cut extraction facility capable of processing 140 mmscf/d of gas
- Overall area was good candidate for ethane extraction – field straddle
- Must be cost effective



Musreau Deep Cut



Used equipment

- Facility - Bonnie Glen Cycle Plant
- Standard GSP process
- Equipment available included:

Inlet filters and mole sieve dehydrators

Heat exchangers for cooling and energy recovery

Turbo expander/compressor unit

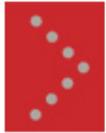
Cryogenic demethanizer tower, reboiler and pumps

Low temperature separator

Ethane plus liquids surge vessel and transfer pumps

10,000 HP primary residue electric drive compressor

Cryogenic flare stack and knockout drum



Musreau Deep Cut



Key Considerations:

- Electric drive compressor – only 6 km of new power line required
- Service and maintenance history of equipment – service was ethane extraction – clean service - little for impurities and maintenance history very good and thorough
- Engineering time to re-design – process orientation for Musreau similar to Bonnie Glen – equipment sizing reasonable
- Can capacity be increased – can modifications to be kept focused and straightforward.
- Can timeline be shortened – need to understand time value of equipment.
- commercial arrangements – flow through or all-in



Musreau Deep Cut



-Final design utilized the following equipment

- Mole sieve dehydrators
- Heat exchanger (BAHE) for cooling and energy recovery
- Turbo expander/compressor
- Cryogenic demethanizer tower and transfer pumps
- Ethane plus liquids surge vessel
- 10,000 HP primary residue electric drive compressor w/ MCC
- Regen gas compressor

-New major equipment

- One BAHE
- Cold Separator



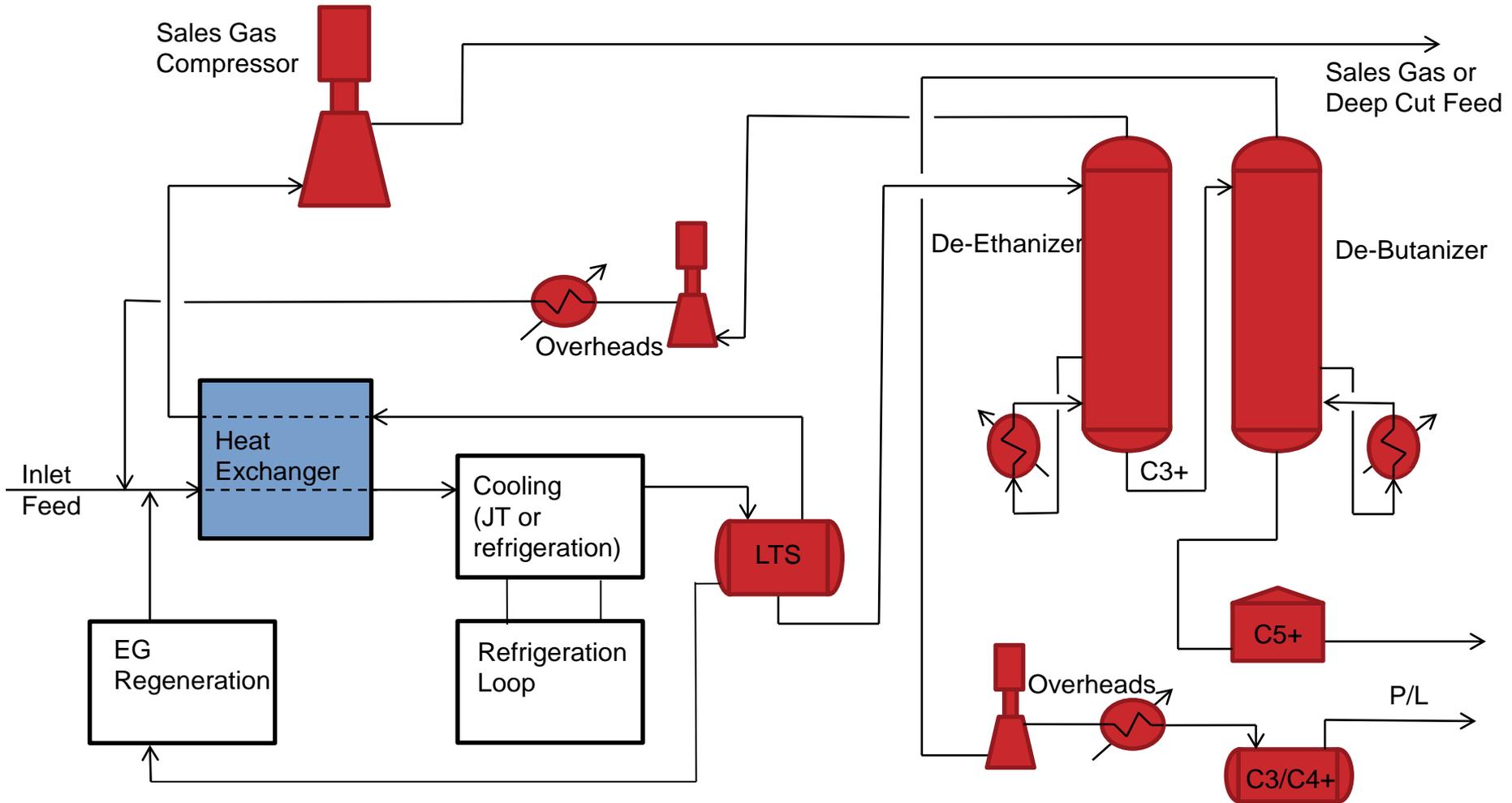
Musreau Deep Cut



- Process – Standard GSP
- Inlet - 200 mmscf/d - sales quality gas
- Liquid volumes (vary on composition)
 - Ethane 80% 1400 m3/d
 - Propane 98.5+% 430 m3/d
 - Butane 99.9+% 90 m3/d
 - Condensate 99.9+% 30 m3/d
 - Total 2050 m3/d
- Outlet - 175 mmscf/d residue gas
- Compressor – electric drive centrifical
- Pipeline connection – 10 km 6” pipeline + U/G tube storage at Peace Mainline

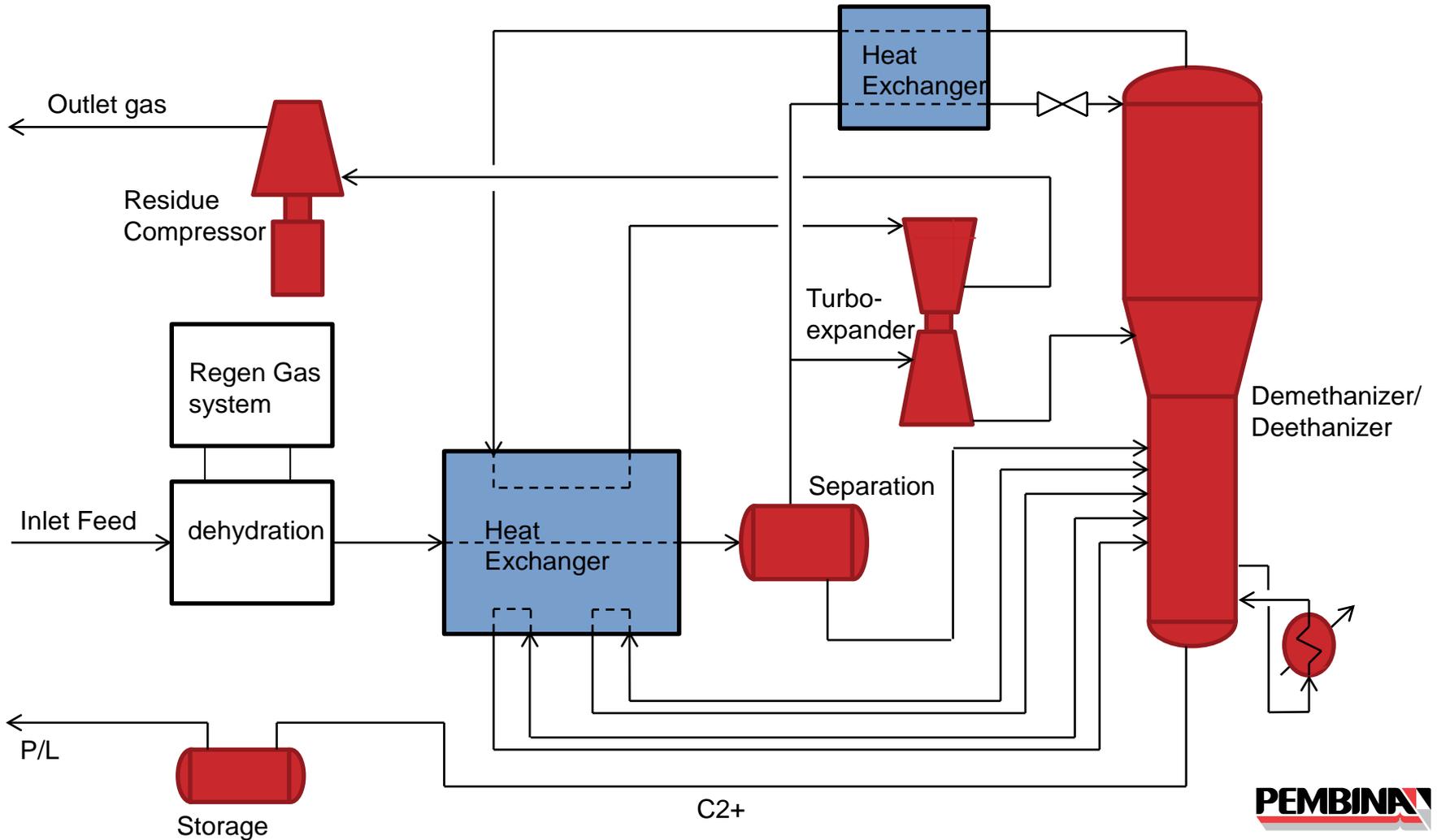


Musreau Gas Plant – S/C





Musreau Gas Plant – D/C





Musreau Gas Plant





Musreau Deep Cut





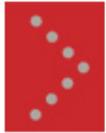
Musreau Gas Plant





Musreau Gas Plant





Learnings



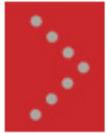
- ❖ Commercial - the decision to purchase the used equipment was made prior to the conclusion of commercial arrangements
 - ❖ Delay – project put on hold for 5 months – lengthened schedule
- ❖ Vendor capability (OEM and otherwise) – review carefully
 - ❖ OEM not always required– centrifical compressor aero section reworked by third party – significant savings
 - ❖ OEM reworked turbo expander – cost of refurbishment close to new unit cost
- ❖ Control systems
 - ❖ Consult OEM on control systems – electric motor and gearbox
- ❖ Field Execution
 - ❖ Due to project delays – civil work completed in mid winter – significantly higher civil cost
 - ❖ Labour supply tightened as project progressed - labour pool experience changed and costs increased
 - ❖ Installation on brownfield site introduces complication and cost
- ❖ Overall
 - ❖ Used equipment provided good value – recommend modularization to reduce field installation costs – consider greenfield



Field Liquid Extraction



Saturn Gas Plant



Saturn Gas Plant



Opportunity-

- Favourable frac spread
- Gas quality suitably rich
- Economies of scale
- Active development area
- Sufficient feed gas – significant existing infrastructure in area
- Raw gas gathering and processing already in place in the area – no gas conditioning required
- Focus was C2+ extraction only
- CO2 up to 2% - customer driven – CO2 freezing an issue – technology available
- Egress infrastructure readily accessible for residue gas
- Egress for C2+ liquid extensive



Saturn Gas Plant



Resultant Project Scope

- Deep Cut sales gas feed - field straddle
- Economies of scale - 200 mmscf/d capacity
- Inlet conditioning minimal – sales gas feed
- CO₂ up to 2% - outside stable operating conditions for GSP – proprietary process engaged
- Ethane content over 7% - significant ethane volume
- significant propane and butane in feed gas
- Egress for residue gas easily accessible on adjacent TCPL system
- Suitable year round access
- Utility power available
- Liquid egress infrastructure was considerable (70+ km 6" pipeline), and did meet economic requirement for project to progress



Saturn Gas Plant



- Process – Ortloff RSV
- Inlet - 200 mmscf/d of sales quality gas
- Liquid volumes (vary on composition)
 - Ethane 85+% 1500 m3/d
 - Propane 99.5+% 430 m3/d
 - Butane 99.9+% 90 m3/d
 - Condensate 99.9+% 30 m3/d
 - Total 2050 m3/d
- Outlet - 175 mmscf/d residue gas
- Compressor – turbine
- Pipeline connection – 70+ km 6” pipeline + U/G tube storage at Peace Mainline



Saturn Gas Plant

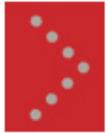




Field Liquid Extraction



Resthaven Gas Plant

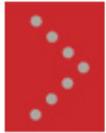


Resthaven Gas Plant



Opportunity-

- Frac spread significant
- Gas quality suitably rich
- Economies of scale were appropriate
- Raw gas gathering system in place in the area
- Focus was C2+ extraction from raw gas
- CO₂ up to 1.6% - CO₂ freezing not an issue as ethane recovery target is 80%
- Ethane content sufficiently high
- Egress infrastructure readily accessible
- Egress for C2+ liquid required significant pipeline infrastructure



Resthaven Gas Plant

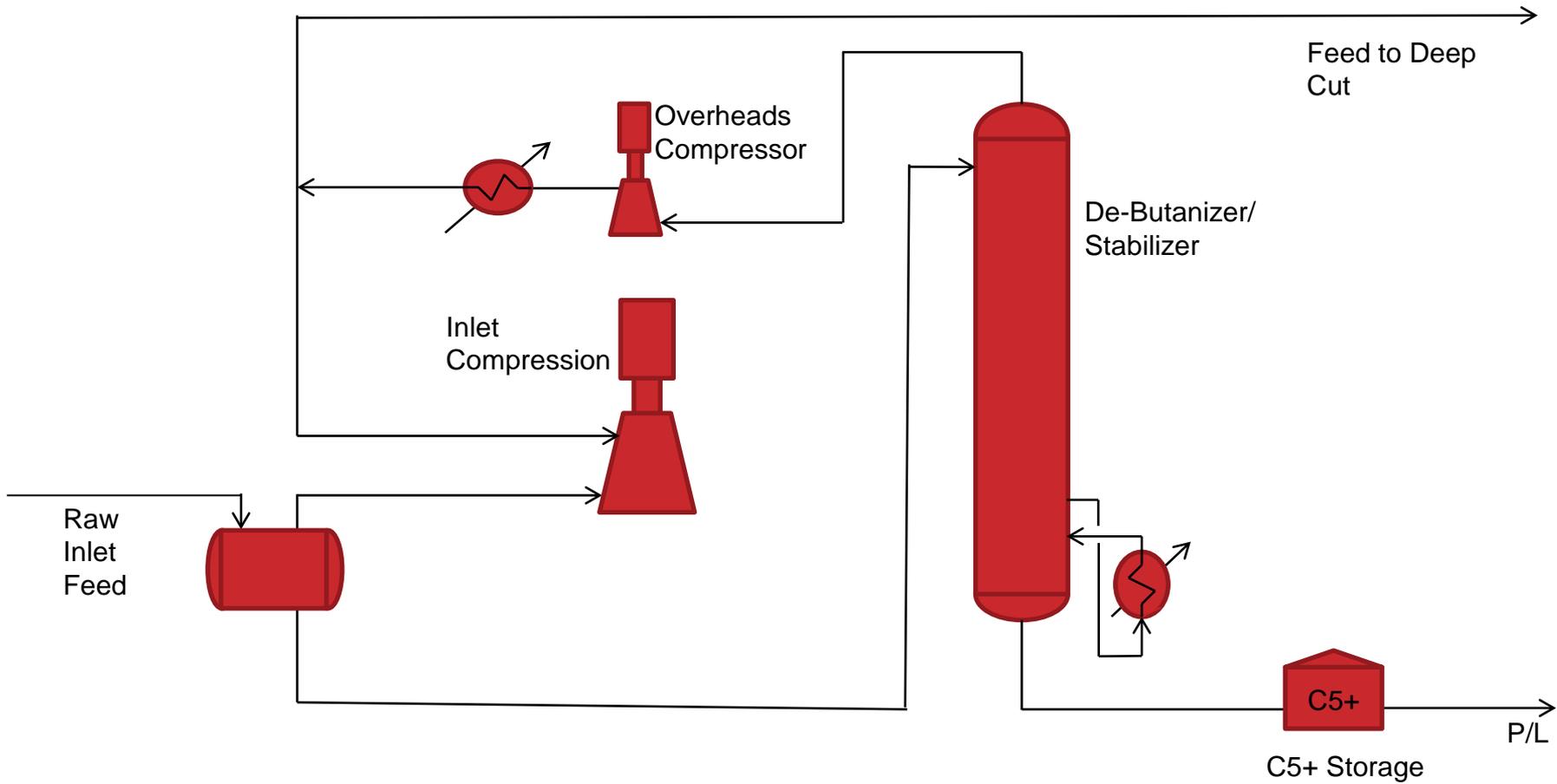


Resultant Project Scope

- Deep cut raw gas inlet ethane extraction facility – now separate shallow cut facilities required
- Economies of scale – 200-300 mmscf/d capacity
- Condensate stabilization system required due to raw gas inlet
- CO₂ up to 2% - outside stable operating conditions for GSP – proprietary process readily available
- Ethane content over 7% - significant ethane content
- significant propane and butane in gas to further support project economics
- Egress for residue gas accessible on adjacent TCPL system
- Suitable year round access
- On-site power generation is required
- Liquid egress infrastructure was considerable (60+ km 6" pipeline), and did meet economic requirements for project to progress

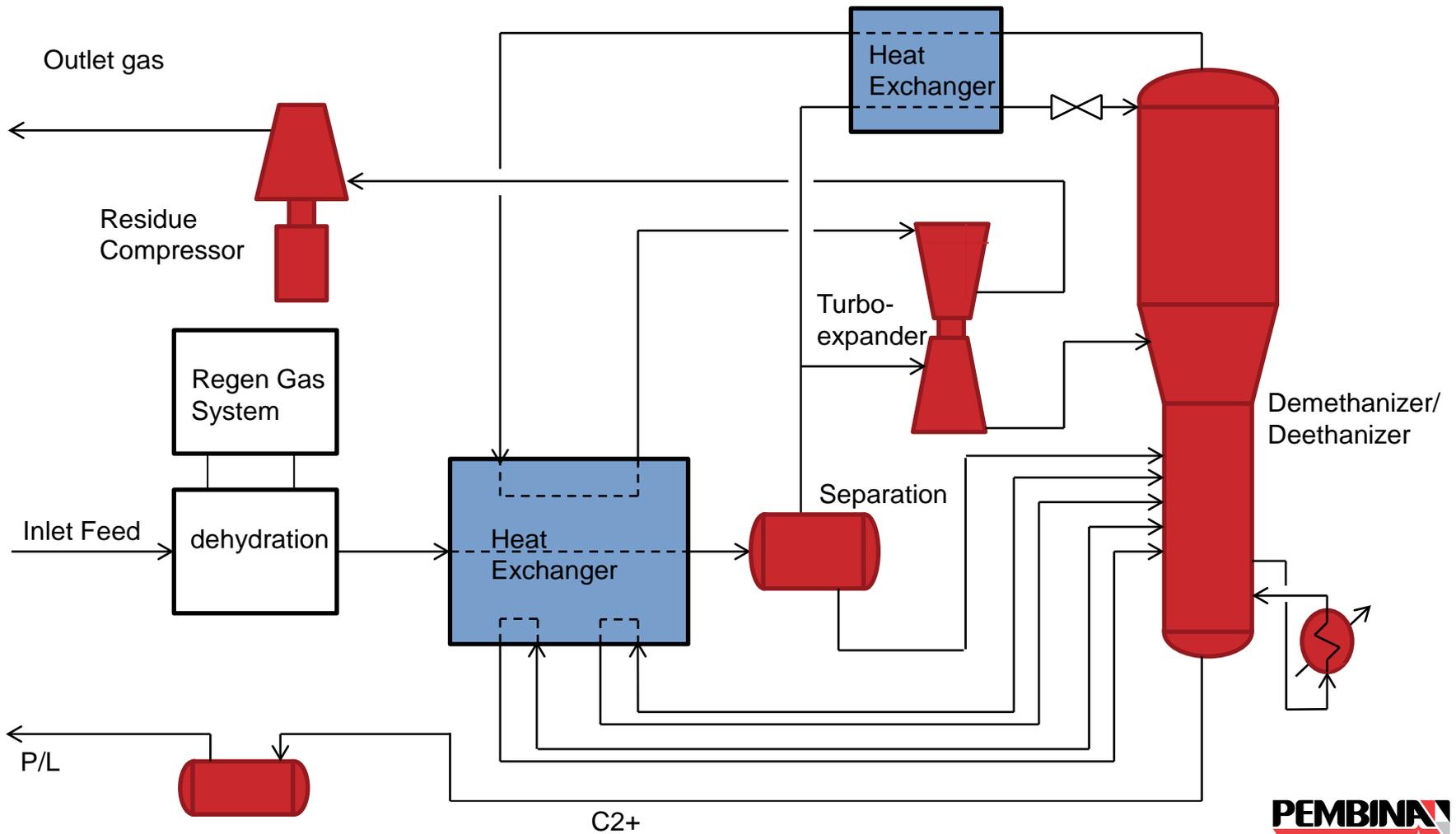


Resthaven Gas Plant





Resthaven Gas Plant - GSP





Resthaven Gas Plant





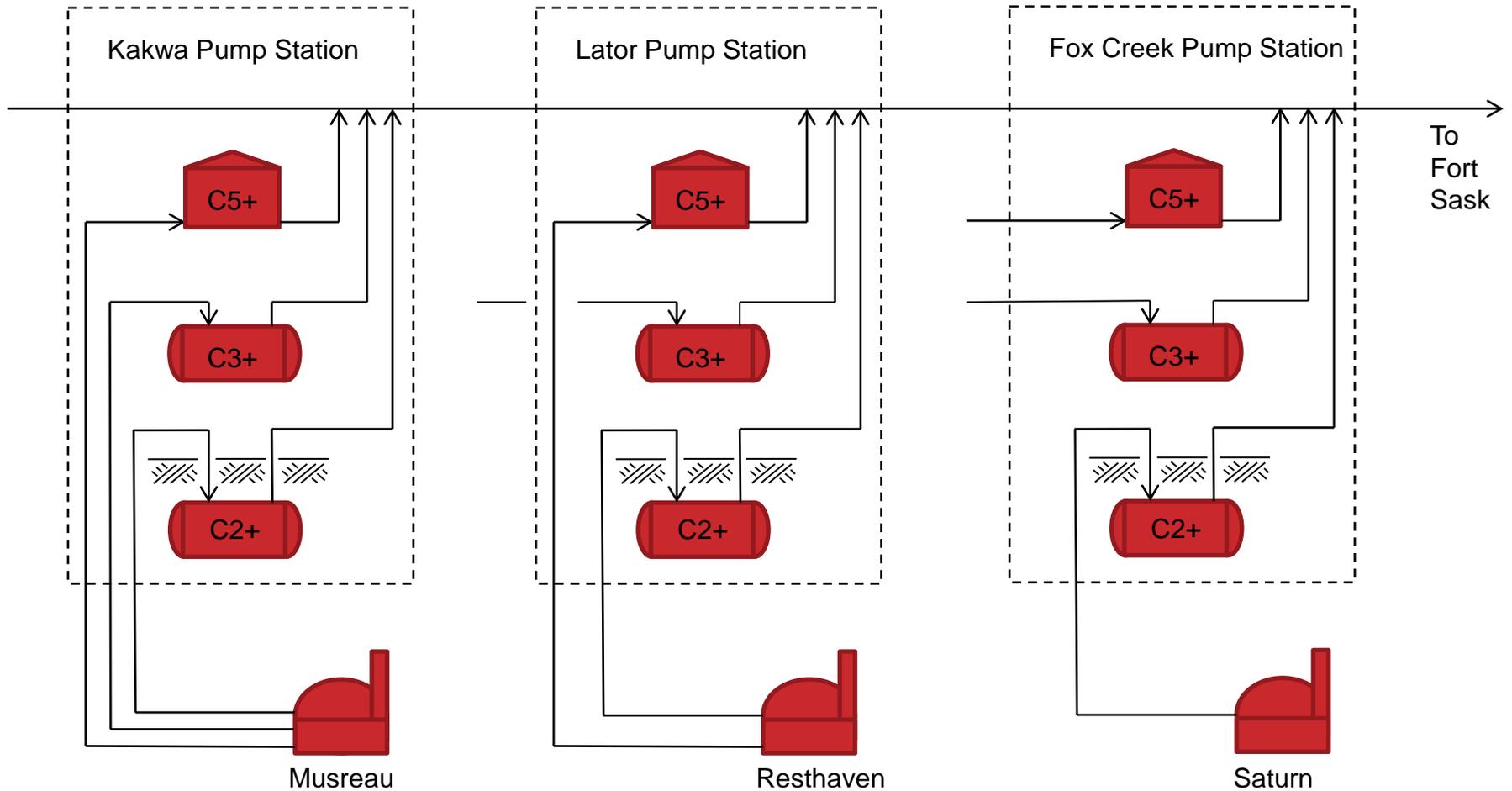
Resthaven Gas Plant



- Process – GSP
- Inlet - 300 mmscf/d of raw inlet gas
- Liquid volumes - Phase 1 (vary on composition)
 - Ethane 85% 1500 m3/d
 - Propane 99.5+% 430 m3/d
 - Butane 99.9+% 90 m3/d
 - Condensate 99.9+% 30 m3/d
 - Total 2050 m3/d
- Outlet
 - 175 mmscf/d residue gas (Phase I)
 - 250 mmscf/d residue gas (Phase II)
- Compression – gas drive recip compressors
- Pipeline connection – 60 km 6” pipeline + U/G tube storage at Peace Mainline



Transportation System





New Plays

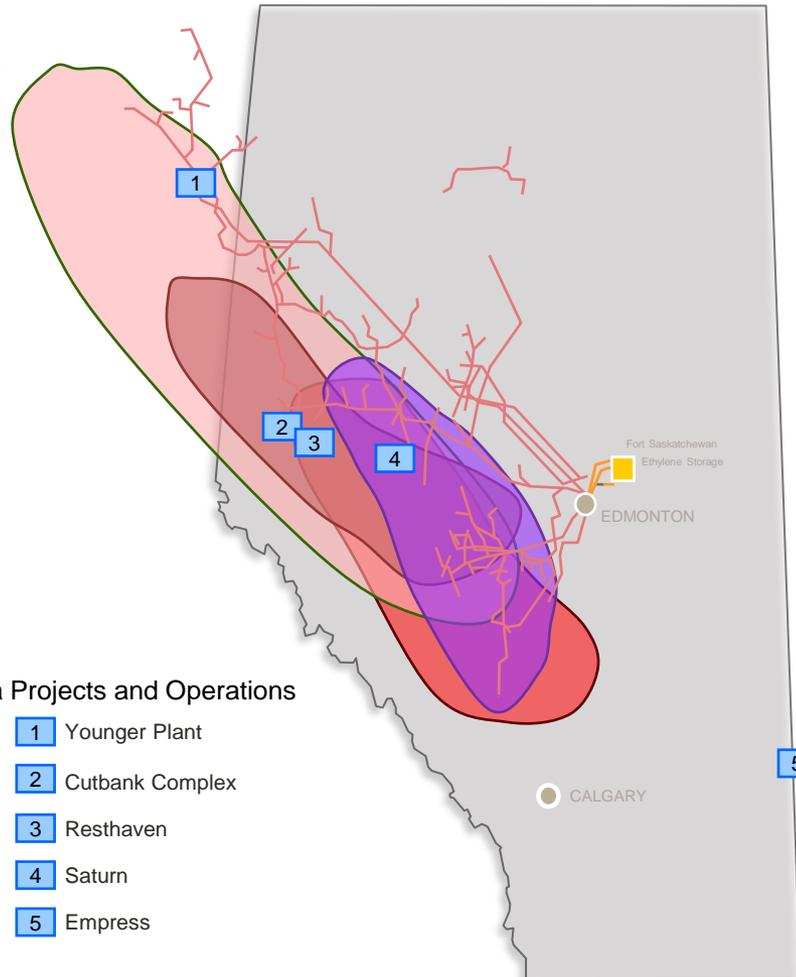


Major Geological Plays & assets

-  Montney
-  Cardium
-  Duvernay
-  Deep Basin

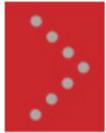
Pembina Projects and Operations

-  1 Younger Plant
-  2 Cutbank Complex
-  3 Resthaven
-  4 Saturn
-  5 Empress



Map for illustrative purposes only.





Field Liquid Extraction



- Favourable market conditions do exist
- Gas composition
- NGL recovery increases the value of reserves (i.e. increased netbacks and reserve bookings)
- Economies of scale – aggregating volumes
- Impurities can be managed (i.e. CO₂)
- Variety of recovery targets are achievable
- Pipeline egress can be developed
- Plants can be built to suit variety of needs – i.e. raw gas, sales gas handling (field straddle), phased approaches, integrated, stand alone, etc
- Opportunities vary but deep cut liquid extraction should always be considered in the development of a reserve asset or play



Field Liquid Extraction



QUESTIONS?