Petrofac

GPA: Energy Optimization in the Gas Processing Industry
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Exchanger Selection & Design in an LPG Recovery Unit

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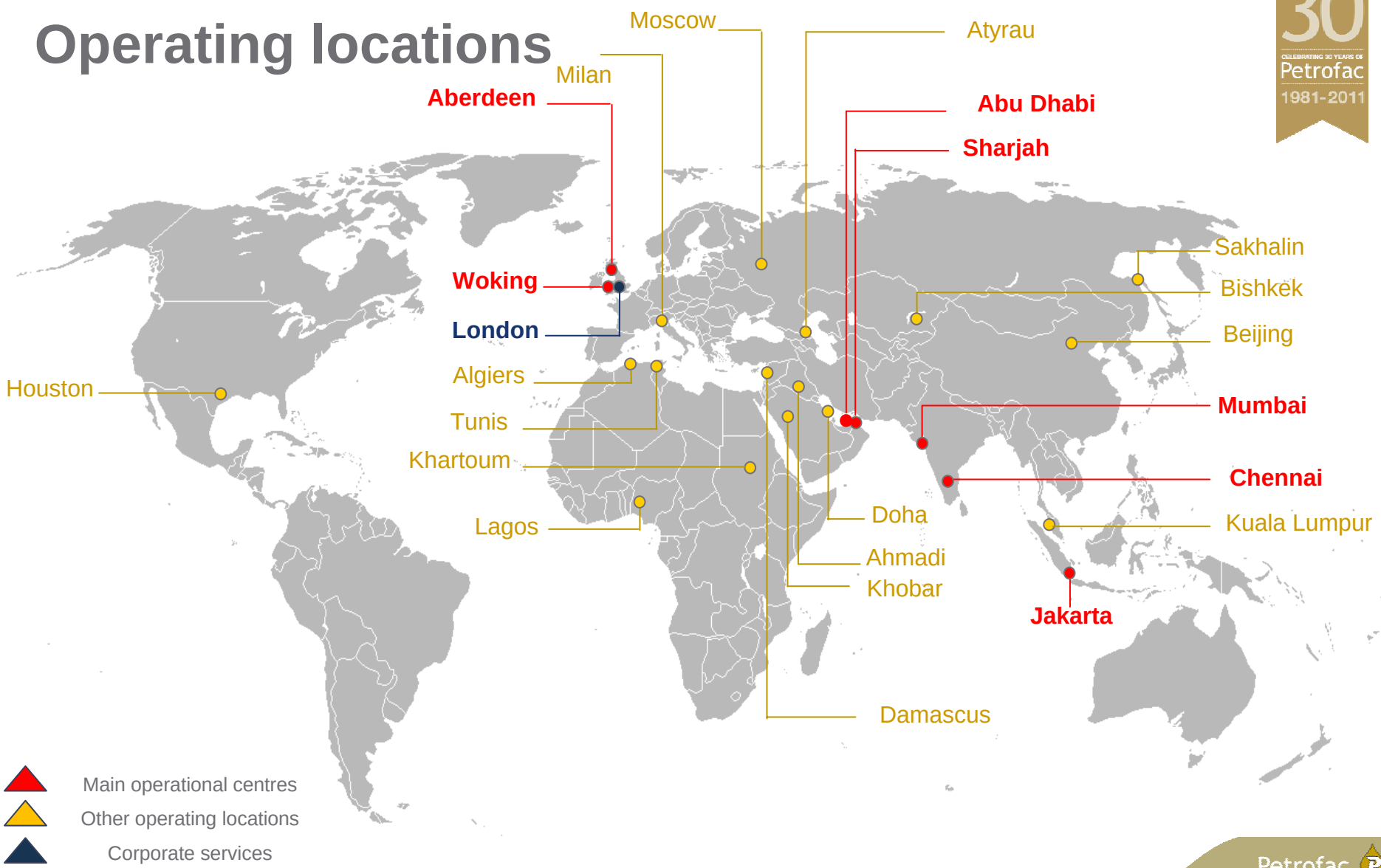
30
CELEBRATING 30 YEARS OF
Petrofac
1981-2011

Petrofac – at a glance

- **Portfolio**
  - We design and build oil & gas infrastructure; operate, maintain, and manage facilities and deliver competence-led training; and where we can leverage our service capability, develop and co-invest in upstream and infrastructure projects
- **Key markets**
  - Middle East and Africa, CIS and Asia Pacific and UK Continental Shelf
- **Financial**
  - a constituent of the FTSE100 Index
  - approximate market capitalisation of approximately US$8 billion
  - 2010 revenue US$4.4 billion
  - largest of the oil services sector listed in the UK by market capitalisation
- **Personnel**
  - over 14,000 personnel representing approximately 60 nationalities
- **Performance**
  - Worldwide Engineering News - Record (ENR) Survey 2009 rated Petrofac again in the top 10 international contractors in the oil & gas industry
  - Oil & Gas Middle East ranked Petrofac as No. 1 EPC contractor for the second successive year

Operating locations



Main operational centres

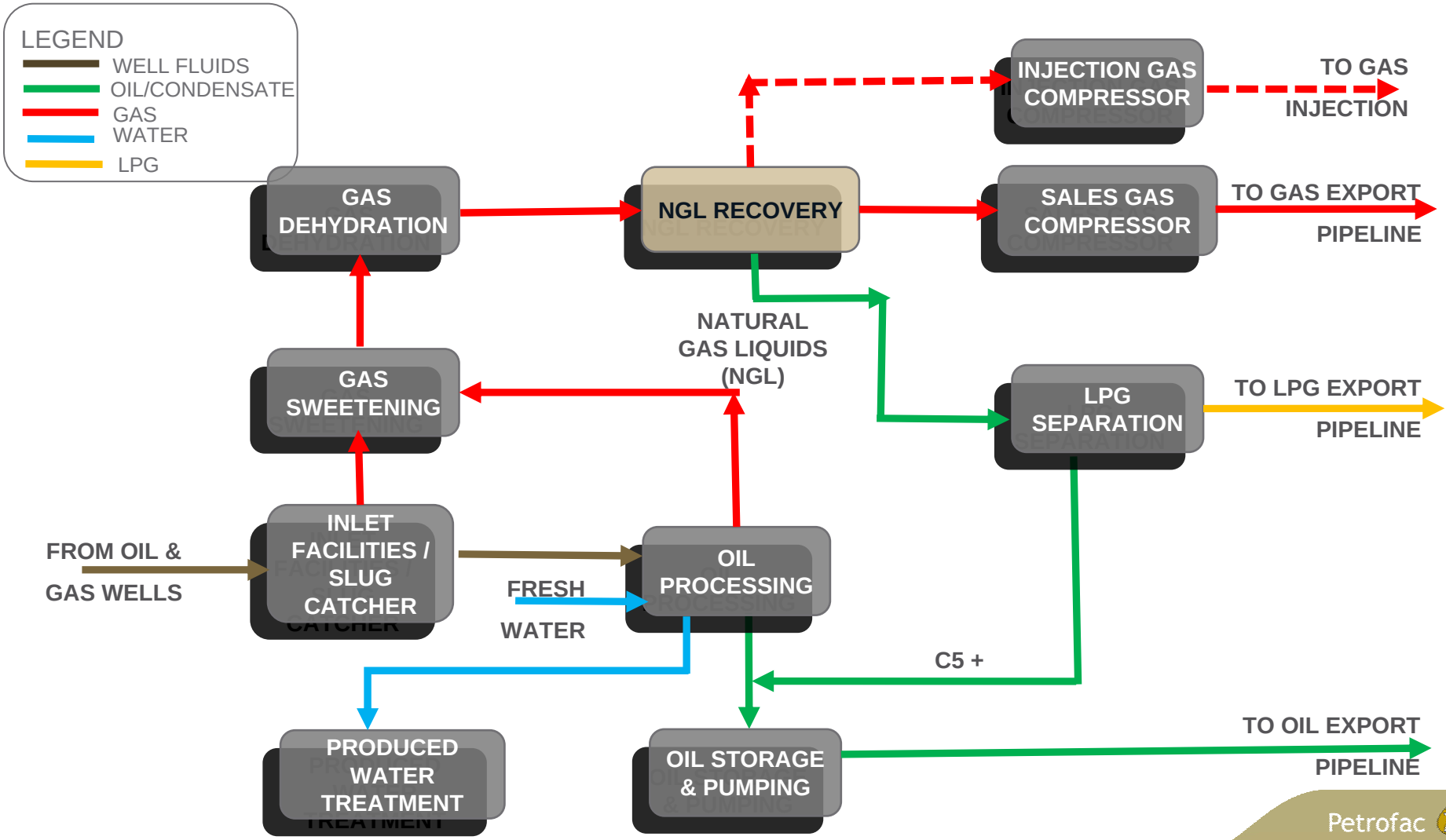
Other operating locations

Corporate services

Outline

- Background
  - o Where does LPG recovery fit into the overall oil & gas process
  - o Introduce typical turbo-expander based recovery processes
- Case Study
  - o Impact of approach temperatures on recovery and exchanger design
  - o Advantages of plate fin exchangers
  - o Simulation tools used for evaluation of alternatives : Aspen HYSYS® using HTFS modules (Aspen Shell& Tube and Aspen Plate Fin Exchanger program)

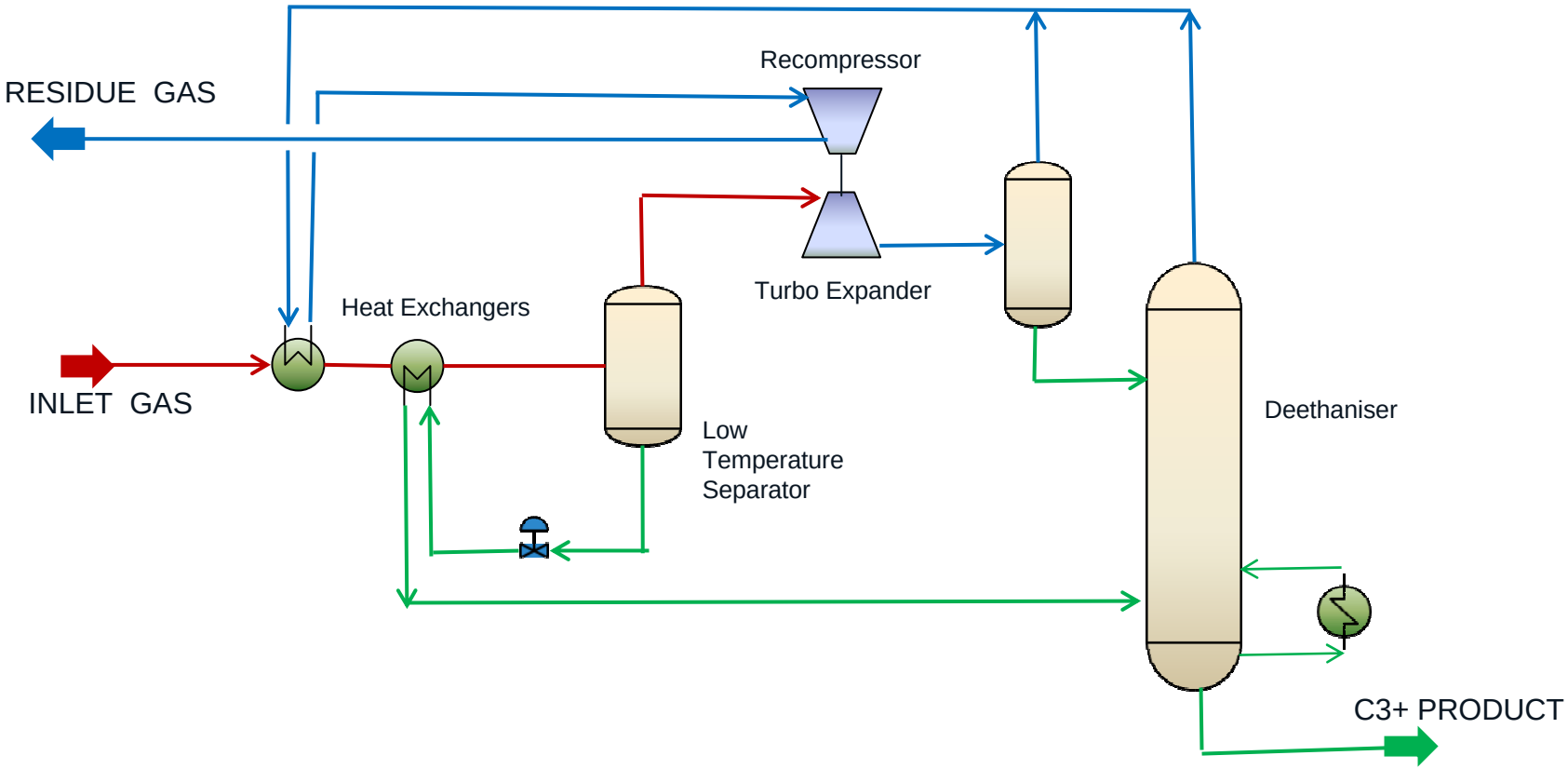
Overall Block Diagram: Oil & Gas Processing



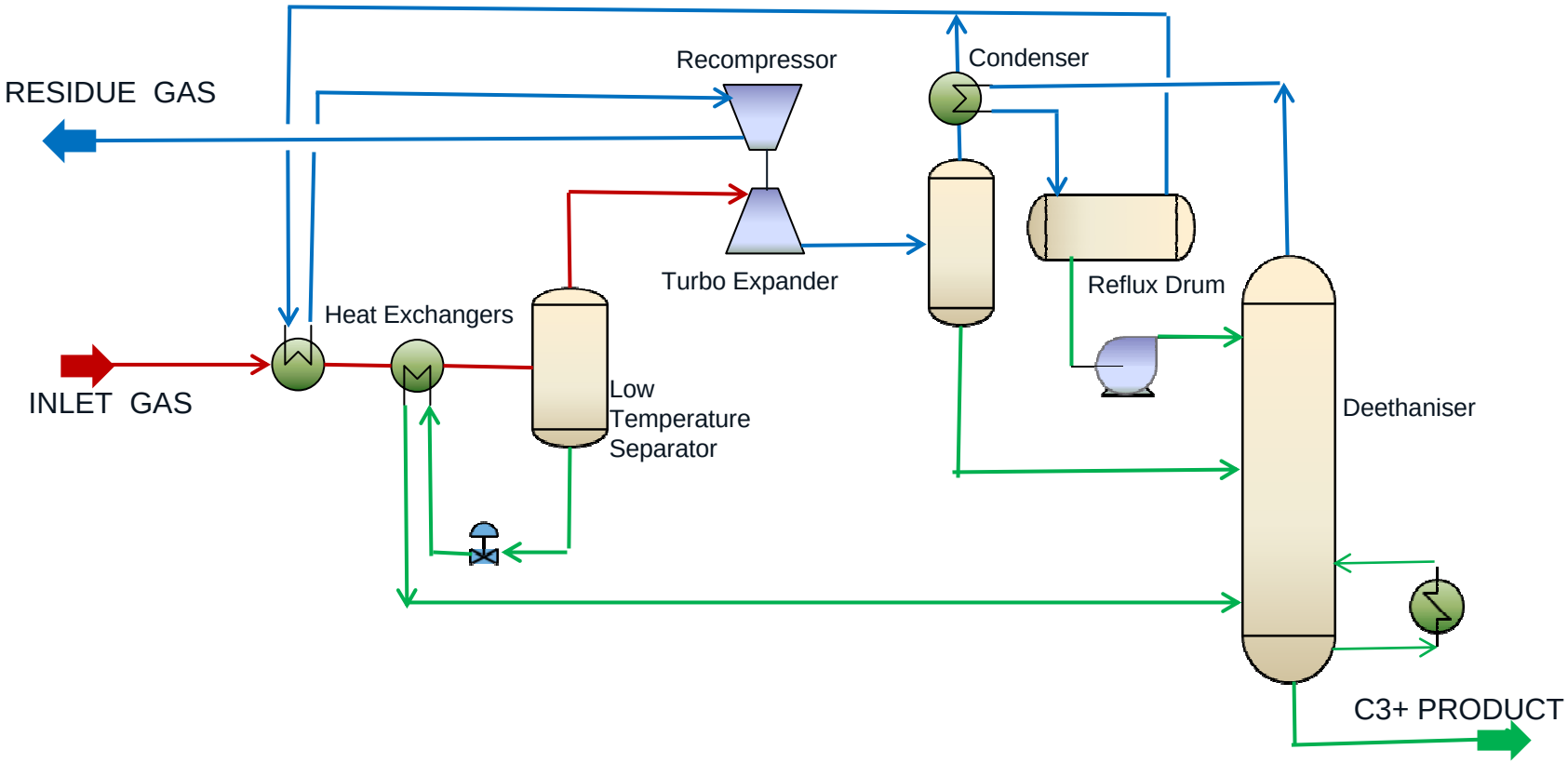
Processes

- Lean Oil Absorption
- External Refrigeration
- Expansion Refrigeration Joule Thompson Cooling
  - J-T Valve
  - Turbo Expander

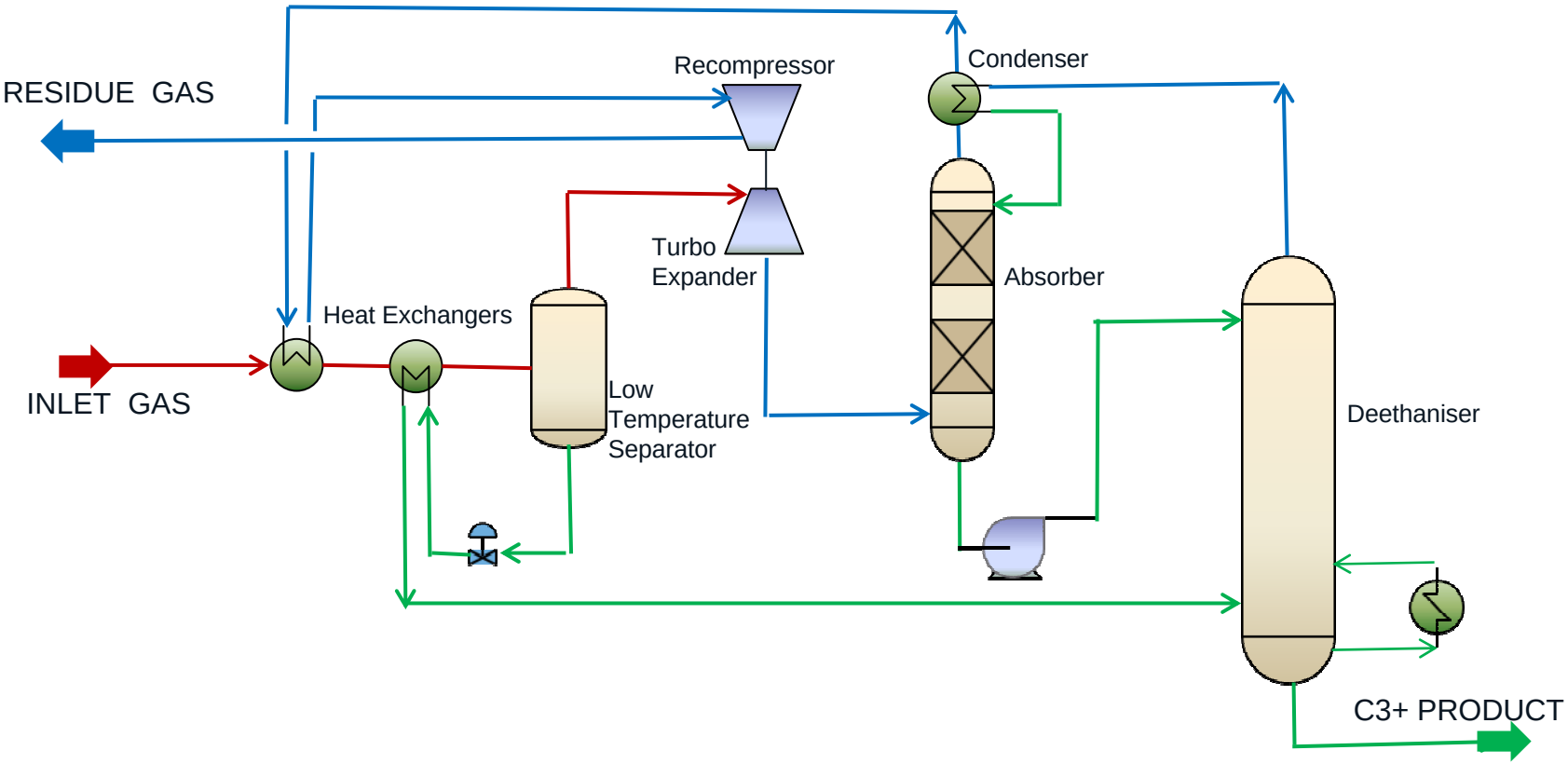
Conventional Expander process



Refluxed Deethaniser Process



Overhead Recycle (OHR) Process



Case Study : LPG Recovery

Feed gas

Inlet Pressure 74 barg

Design Case	Normal
Flow rate, MMSCFD	500
Composition	**% mol**
Nitrogen	1
CO_2	1.5
Methane	75
Ethane	16
Propane	4
i-Butane	0.5
n-Butane	1.5
i-Pentane	0.5
n-Pentane	0

Gas to Reinjection

340 barg pressure

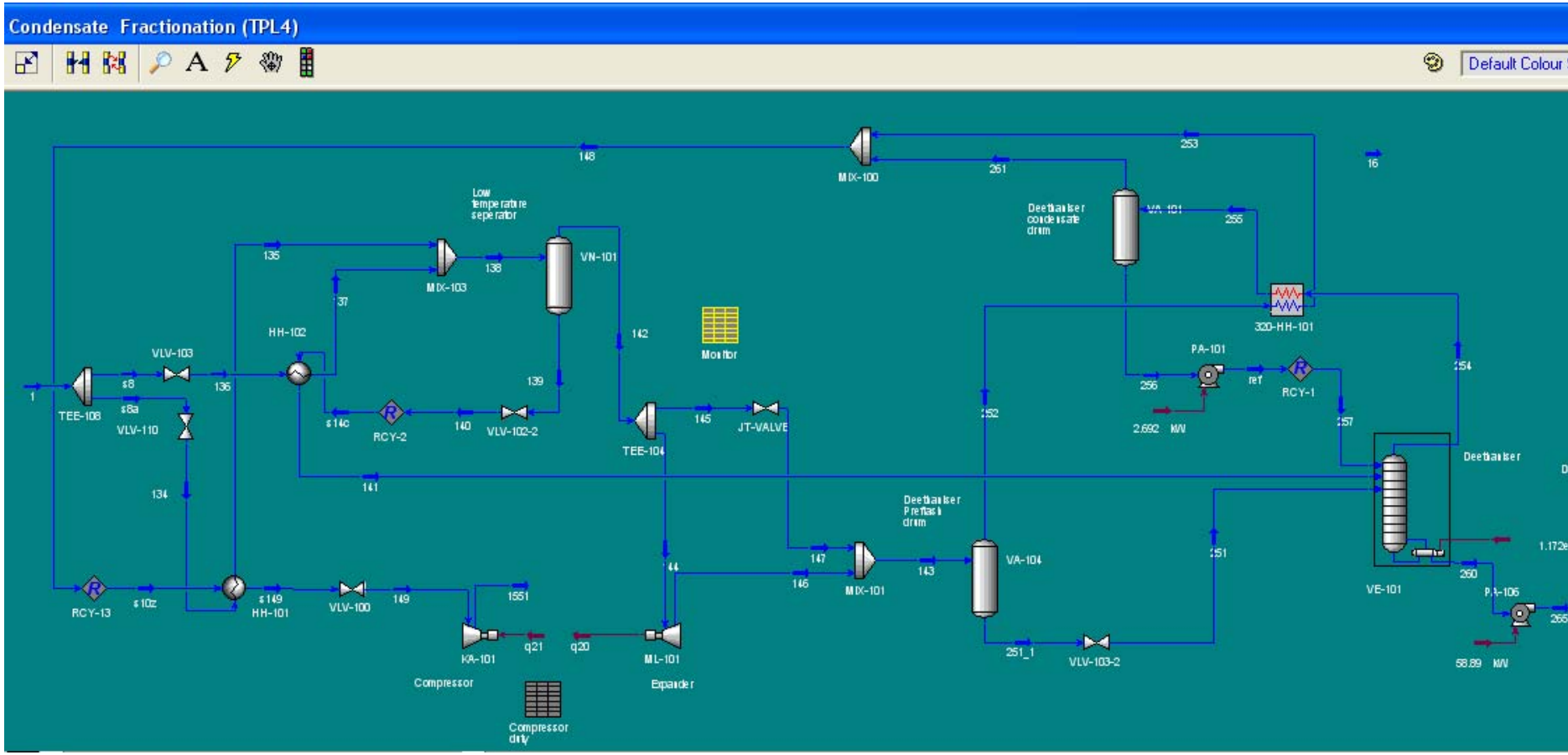
LPG min 90% recovery

C2 and lighter <2.6% mol

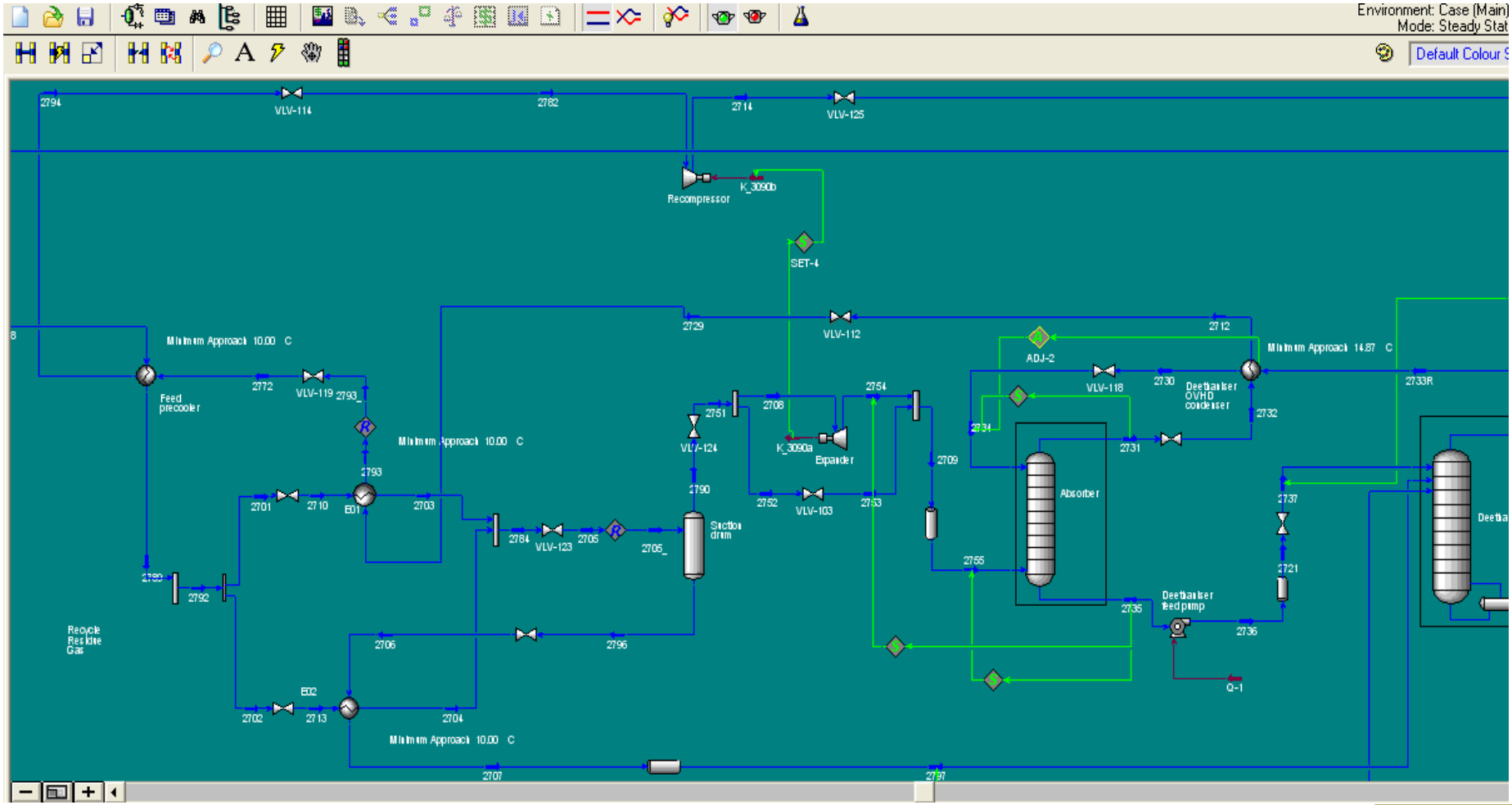
Iso & N Pentane <0.4% mol

LPG recovery critical to plant economics since gas is used for reinjection, revenue is only from LPG recovered.

Option 1:
Refluxed Deethaniser



Option 2: OHR process



Case Study : Process Selection

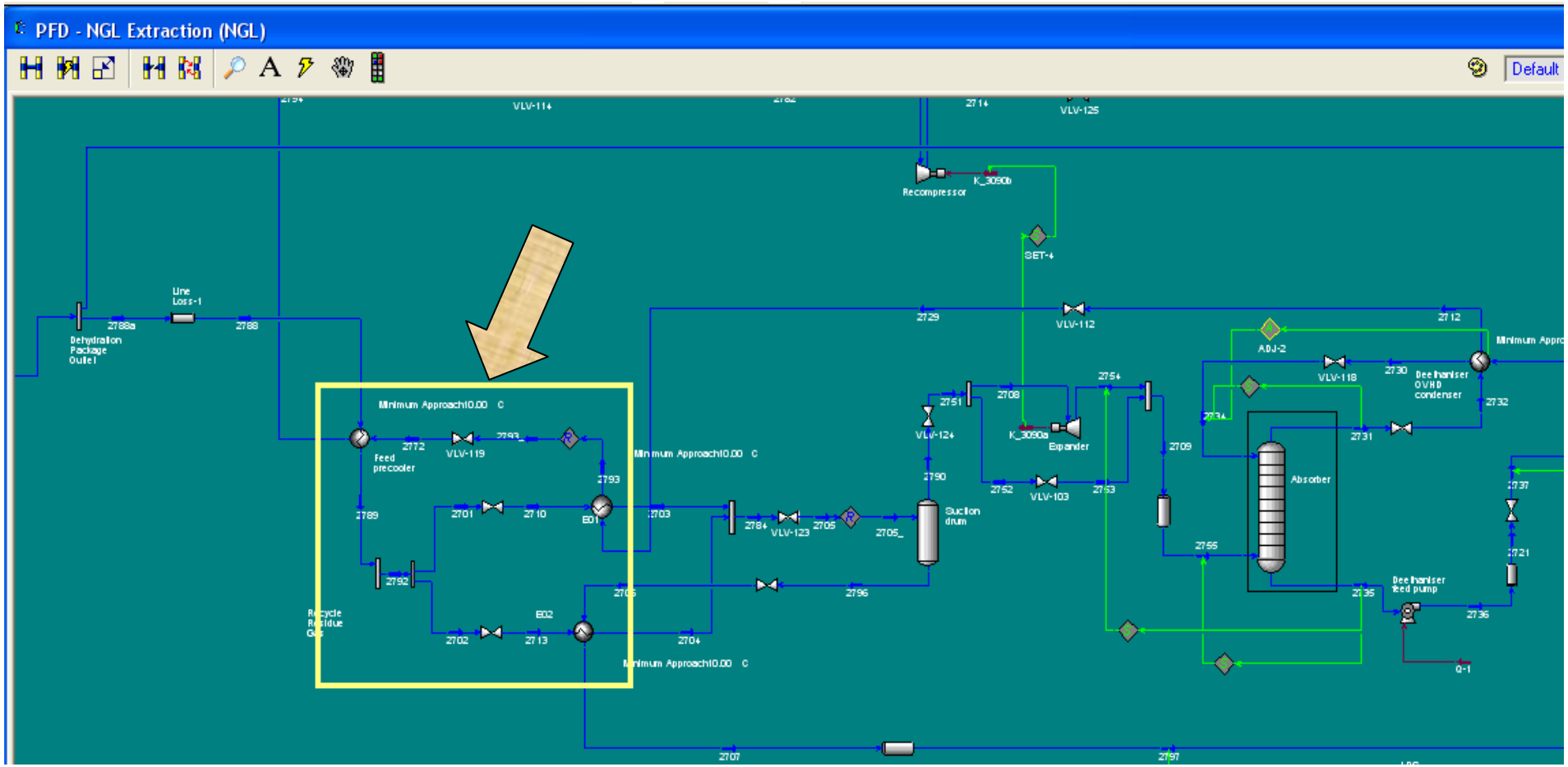
- Process schemes considered

1. Expander scheme with a refluxed de-ethaniser
2. Overhead recycle (OHR) process

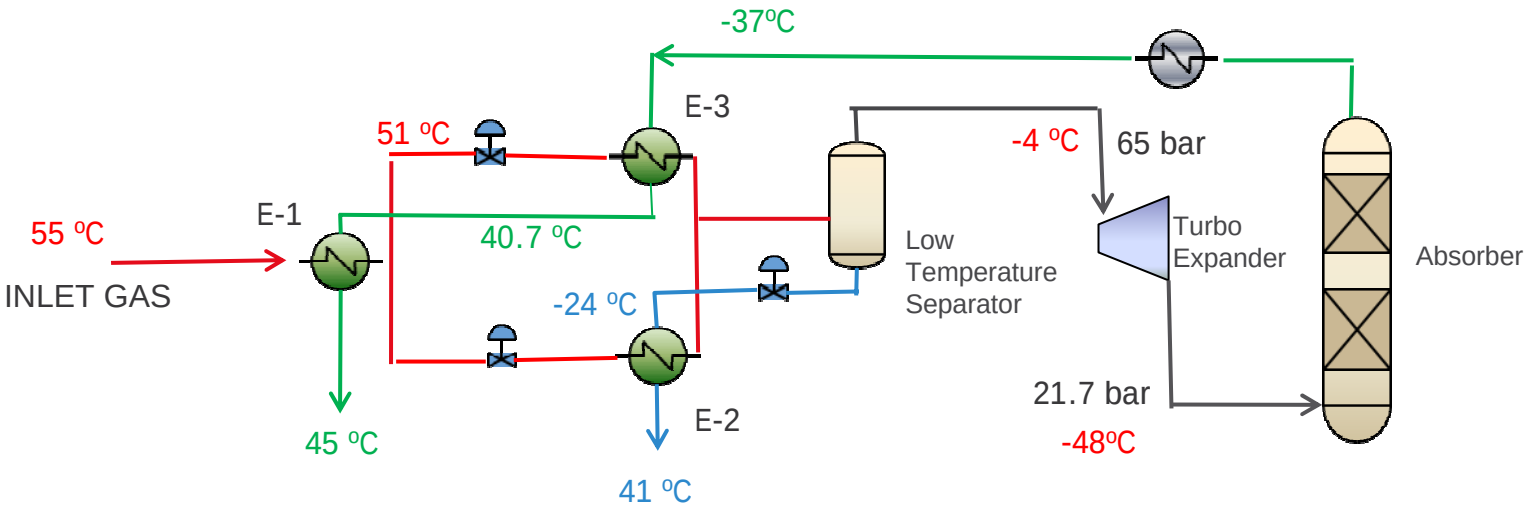
- The OHR process gave higher LPG recoveries of more than 10% for similar operating conditions

- In the subsequent discussion impact of temperature approach and exchanger selection on LPG recovery for OHR process is examined

Option 2: OHR process

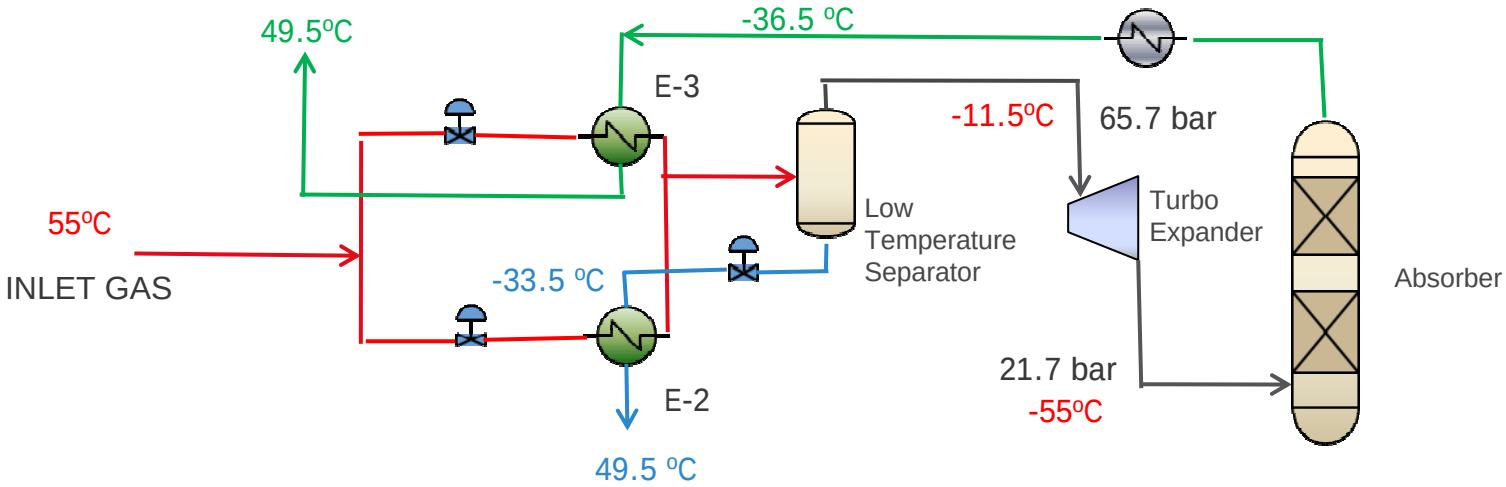


Cooling scheme : Shell & Tube 10 Deg C approach



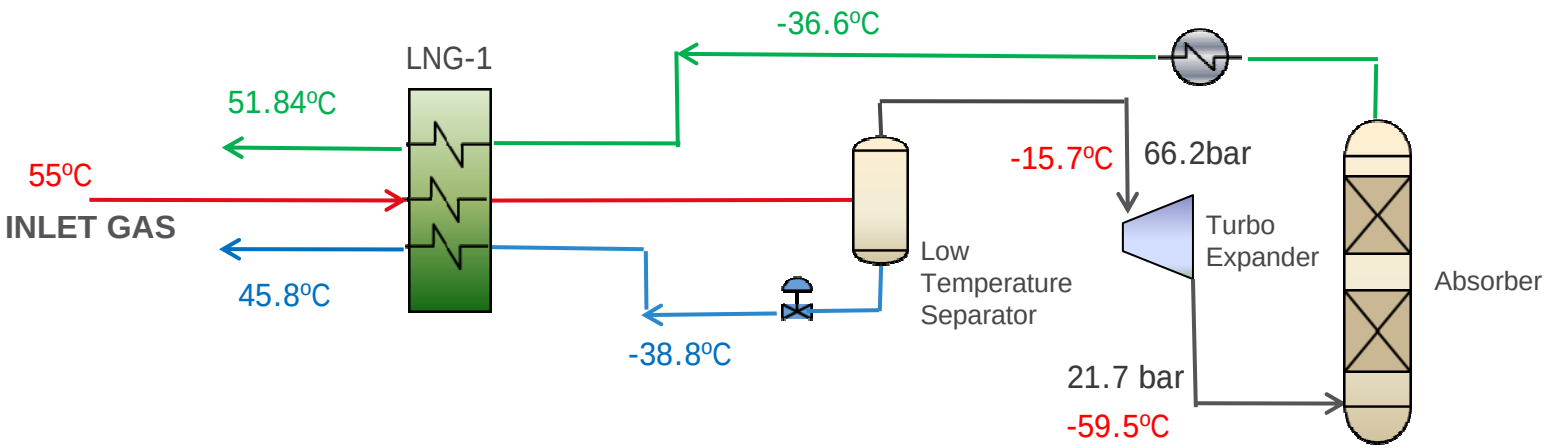
Cooling scheme : Shell & Tube 5 Deg C approach

- Exchanger E-1 deleted since duty becomes very low due to better approach in E-3
- Increase in Turbo-expander inlet pressure corresponding to E-1 pressure drop

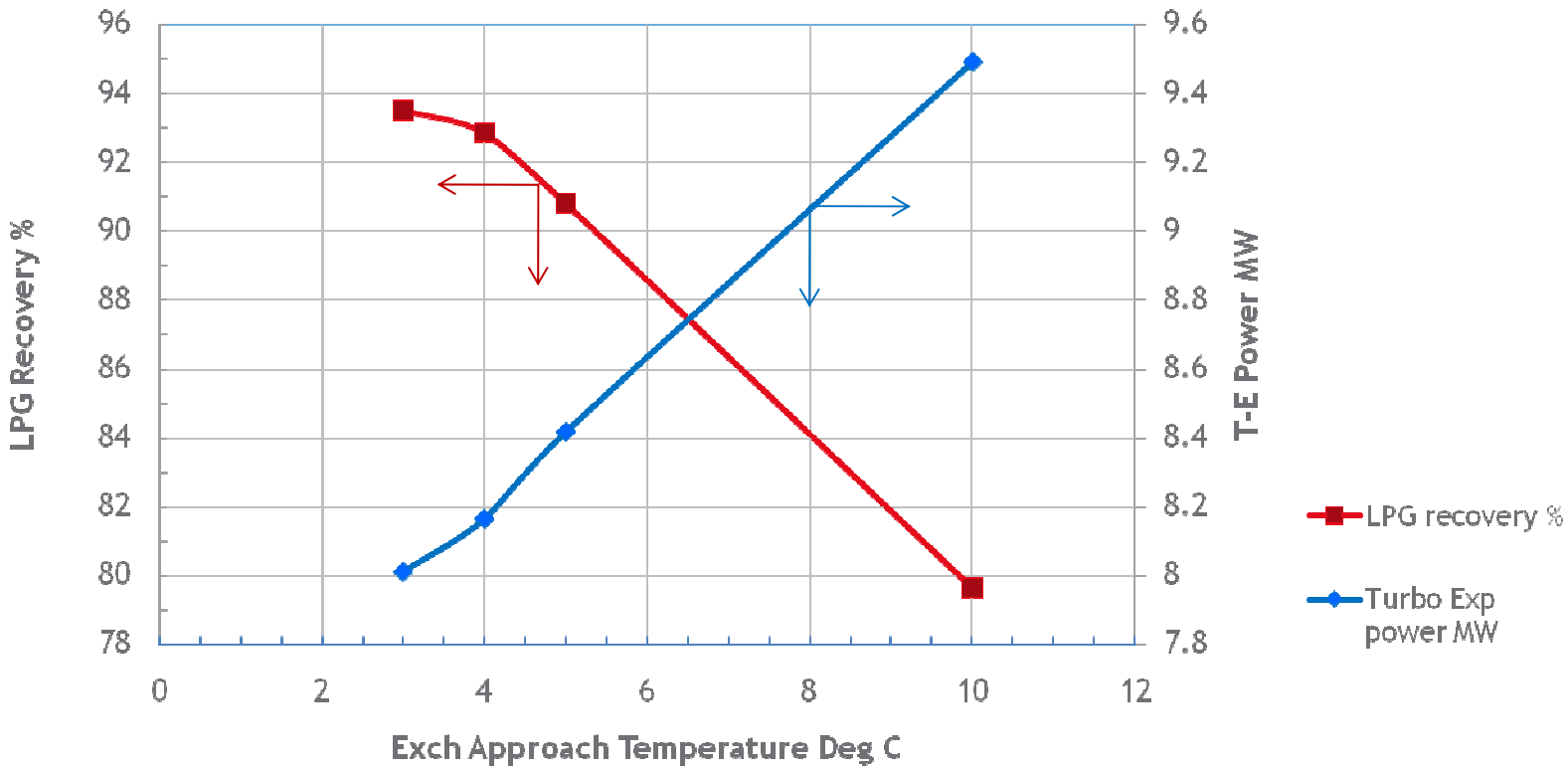


Cooling scheme: Plate-fin exchanger

- Exchangers E-2 & E-3 replaced by single LNG exchanger
- Control valves in feed line deleted since no splitting of feed required
- Higher Turbo expander inlet pressure due to control valve deletion



Effect of Exchanger Approach Temperature on LPG Recovery



Exchanger Sizing : Shell & Tube

Case	10 deg C app			5 deg C app	
Exchanger	E1	E2	E3	E2	E3
Heat exchanged, kW	1308	2157	21278	7865	23432
Configuration	1P, 1S	1P, 1S	2P, 1S	1P, 2S	2P, 2S
Surface area, m2	203	144.5	5042	3314	10730
Geometry	BEM	BFU	BFU-NTIW	BFU	BFU-NTIW
Total cost, $ (HTFS)	2.58 million			5.3 million	

Closer approach temperatures result in

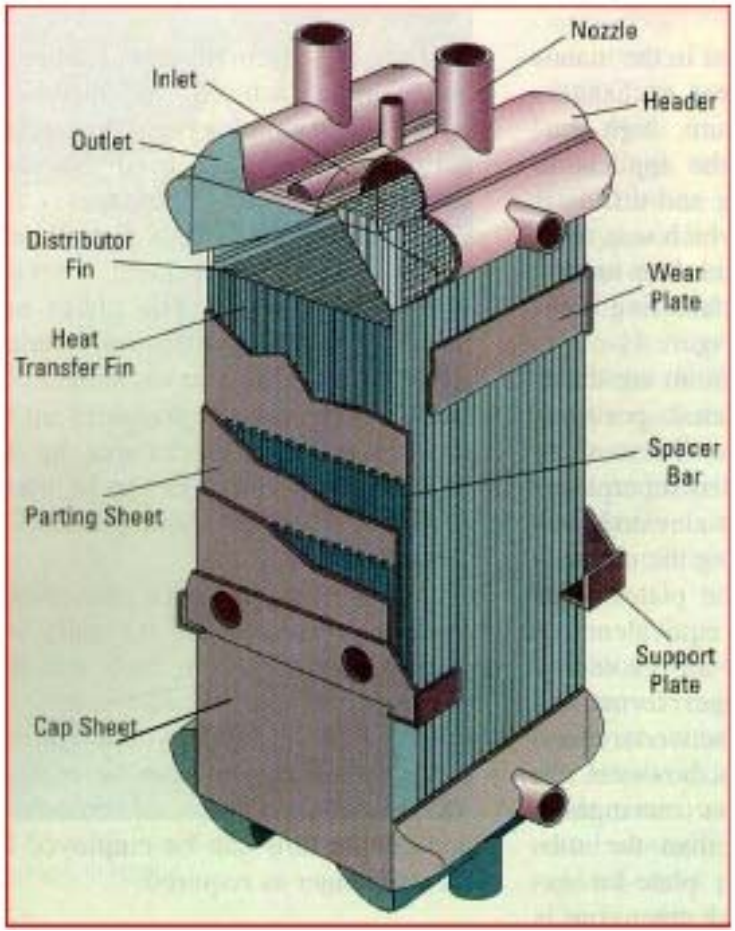
- More complex exchanger designs
- Greater degree of uncertainty in the design

Features of Plate-fin exchangers

LNG Exchangers/ Brazed Aluminum exchangers/ Plate-fin exchangers

- Simple construction, compact and lightweight design
- Can handle more than 2 streams
- Useful for low temperature applications
- Can handle phase change
- Can handle close temperature approach that becomes very difficult with shell & tube exchangers
- Not prone to vibration problems as in Shell & tube exchangers in Gas-Gas service

Plate-fin Exchanger : Construction



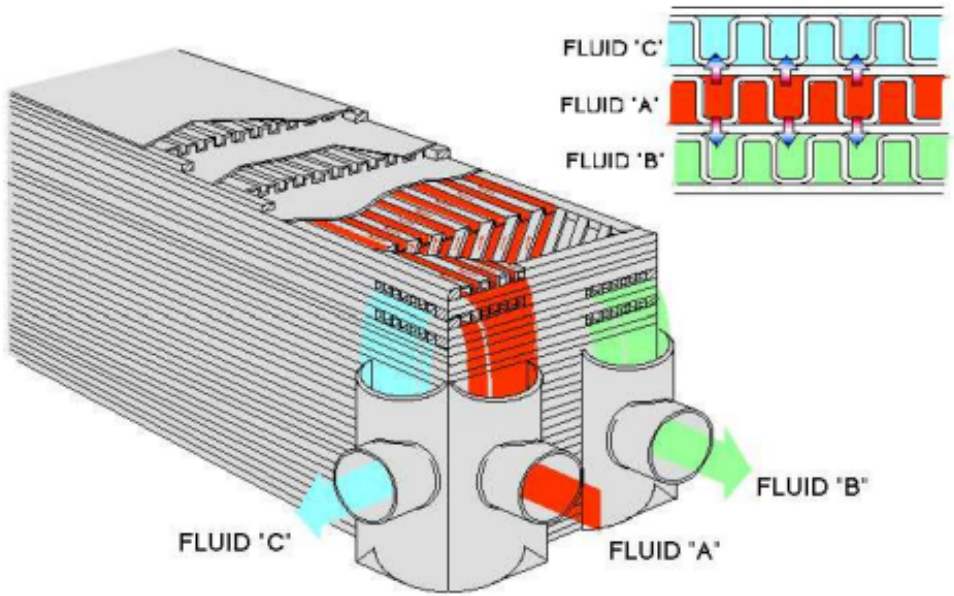
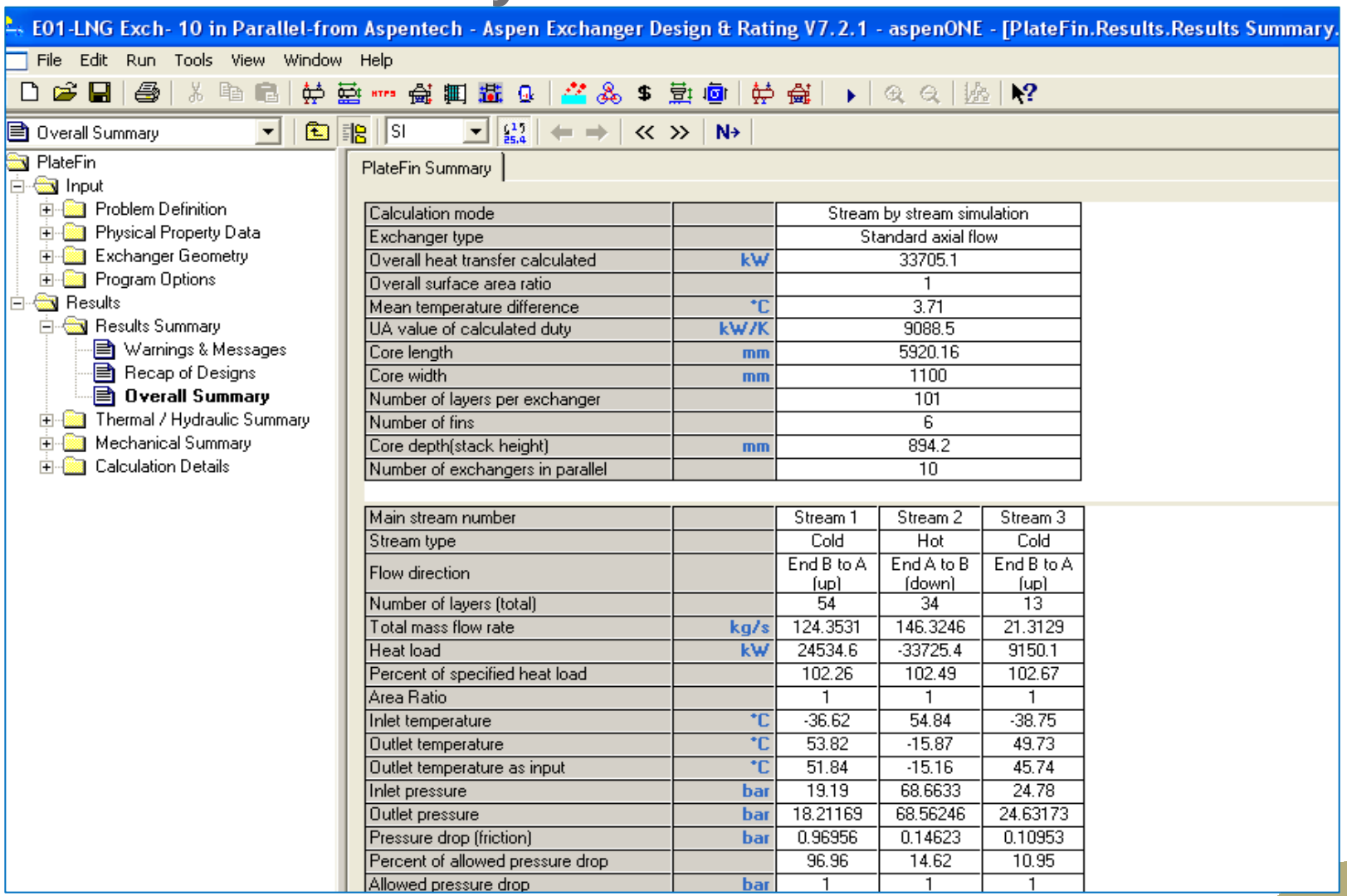


Plate-fin Summary



Calculation mode		Stream by stream simulation
Exchanger type		Standard axial flow
Overall heat transfer calculated	kW	33705.1
Overall surface area ratio		1
Mean temperature difference	°C	3.71
UA value of calculated duty	kW/K	9088.5
Core length	mm	5920.16
Core width	mm	1100
Number of layers per exchanger		101
Number of fins		6
Core depth(stack height)	mm	894.2
Number of exchangers in parallel		10

Main stream number		Stream 1	Stream 2	Stream 3
Stream type		Cold	Hot	Cold
Flow direction		End B to A (up)	End A to B (down)	End B to A (up)
Number of layers (total)		54	34	13
Total mass flow rate	kg/s	124.3531	146.3246	21.3129
Heat load	kW	24534.6	-33725.4	9150.1
Percent of specified heat load		102.26	102.49	102.67
Area Ratio		1	1	1
Inlet temperature	°C	-36.62	54.84	-38.75
Outlet temperature	°C	53.82	-15.87	49.73
Outlet temperature as input	°C	51.84	-15.16	45.74
Inlet pressure	bar	19.19	68.6633	24.78
Outlet pressure	bar	18.21169	68.56246	24.63173
Pressure drop (friction)	bar	0.96956	0.14623	0.10953
Percent of allowed pressure drop		96.96	14.62	10.95
Allowed pressure drop	bar	1	1	1

Plate-fin Exchanger Temperature Profile

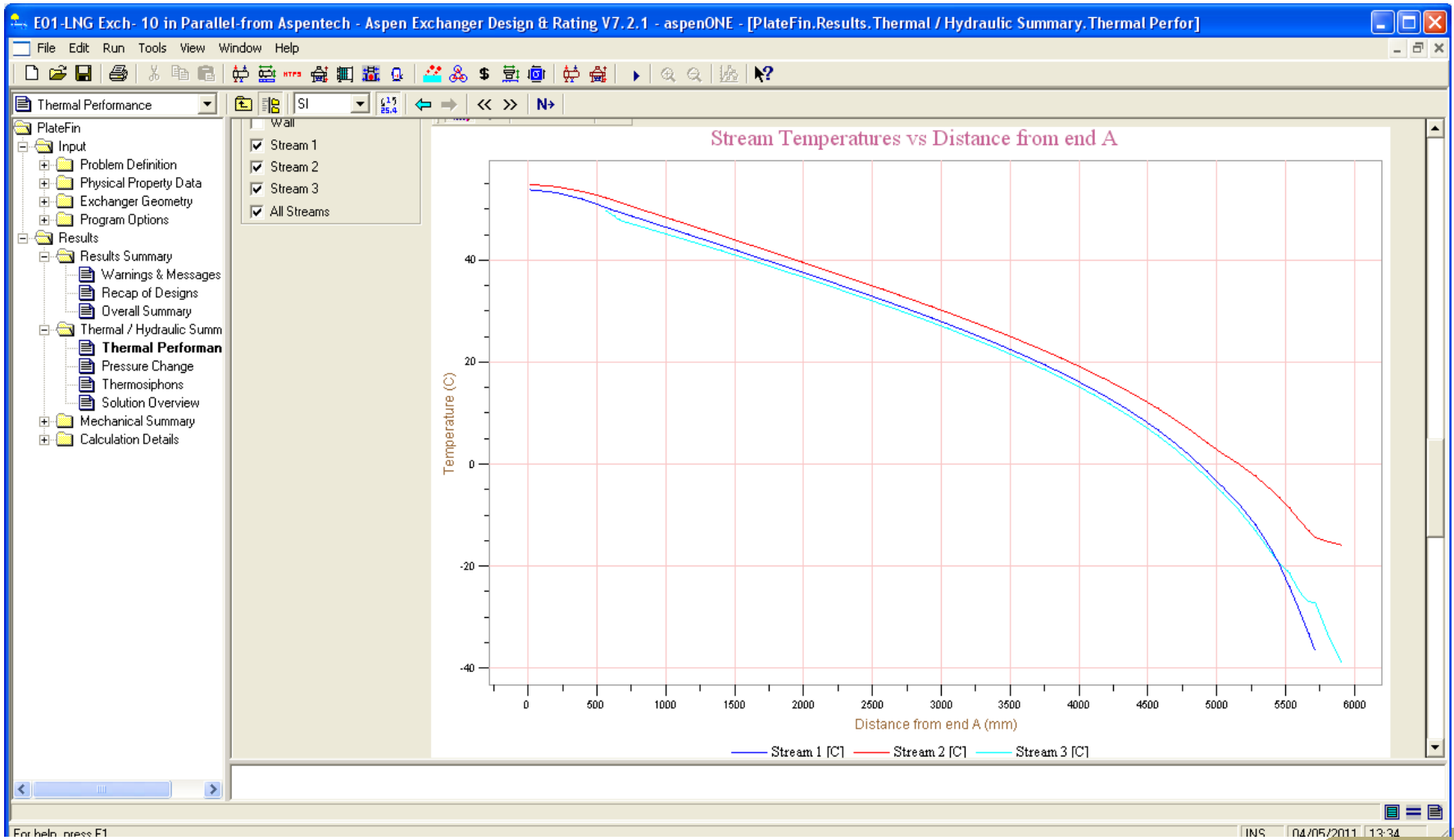
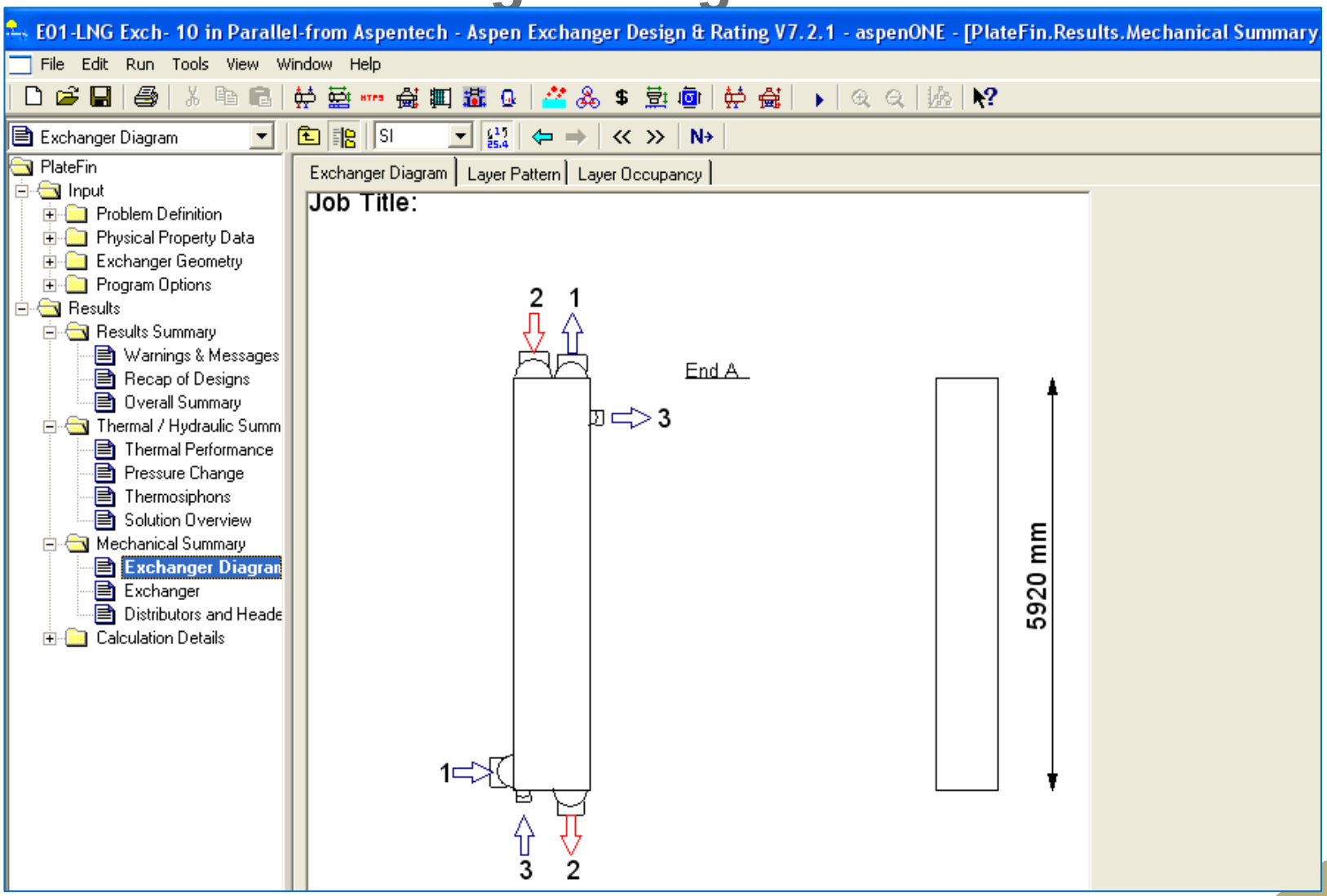
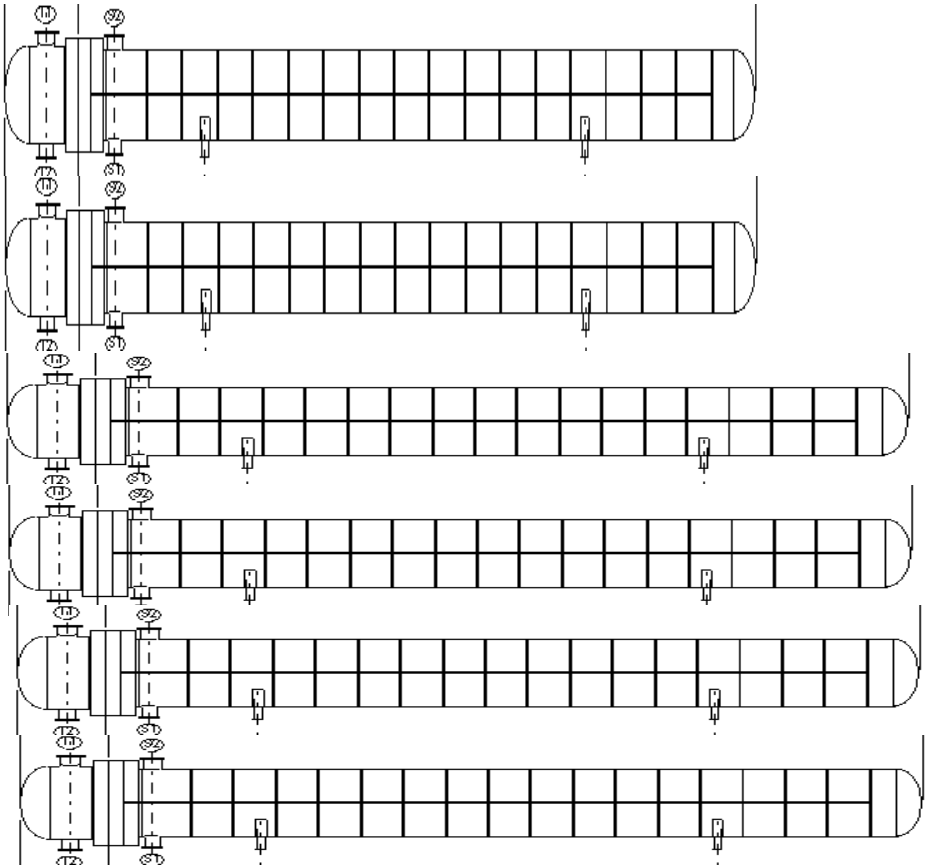


Plate-fin Exchanger Diagram



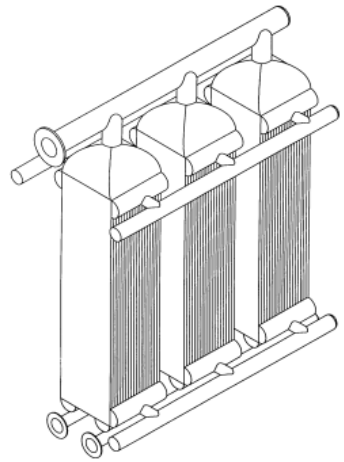
Comparison of configurations

6 Shell & Tube Exchangers



Replaced by

Single Plate-fin



Comparison

		5 deg C approach	3 deg C approach
Exchanger type		S&T exchanger	Plate fin exchanger
LPG recovered	TPH	68.12	69.85
Additional revenue @ $400 / ton LPG	Million $ /annum		5.5
Exchanger volume	m3	264	70
Exchanger weight (empty)	MT	492	100
Exchanger weight (with water)	MT	712	130
Exchanger cost	Million $	5.3	Expected to be less than 5

Conclusion

- LPG recovery operations require efficient heat (cold) recovery to maximize product recovery
  - o Simulation tools allows efficient evaluation of alternatives

- Conventional S&T exchangers difficult to design due to problems of
  - o Temperature cross due to close approach temperatures
  - o Possible vibration in gas-gas exchangers

- Plate fin exchangers fill this need
  - o Simulations help in initial design of plate fin exchanger configurations which will be further refined with vendor input
  - o Process with plate-fin exchangers could bring a about $5.5M/year additional revenue in addition to capital cost savings due to smaller exchanger footprint