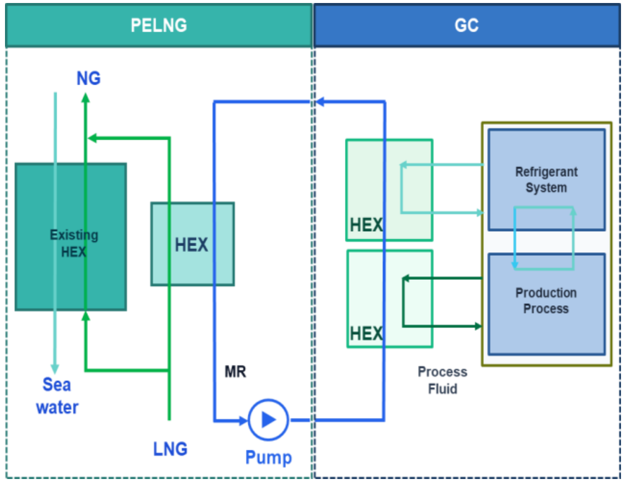
Cold Energy Utilization of Liquified Natural Gas (LNG) in Olefins Process

By Peter Kuzma, Jr. and Piyaporn Pongbhai

Introduction

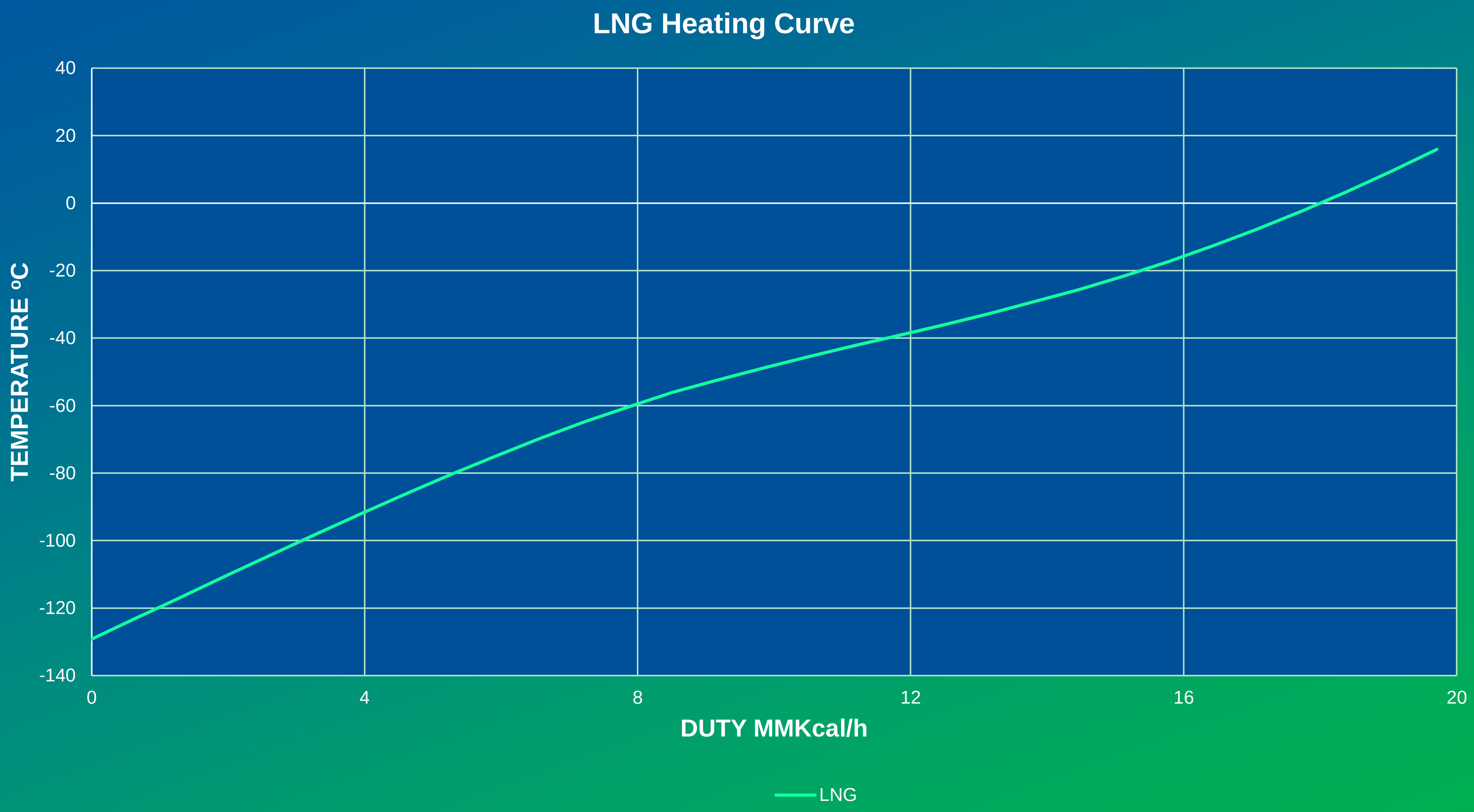


- PELNG's Map Ta Put LNG Terminal 2 (LMPT2)
  - A largest LNG terminal in Thailand
  - Location: Nong Fab, Map Ta Phut, Rayong
  - Capacity: Regasification: 7.5 million TPA
  - Storage Infrastructure: 250,000 cubic meters
- GC's OLE3 plant
  - An ethane cracker
  - Location: Nong Fab, Map Ta Phut, Rayong
  - Capacity: 1 million TPA of Ethylene
- The close proximity of these two facilities allows for the integration of -160 °C LNG cold energy into the Ethane Cracker's -103 °C refrigeration cycle, driving significant energy efficiency through inter-plant cooperation.

Design Challenge Statement

- Units are several kilometers apart
  - Long pipelines between units are required
- LNG is supplied at low temperature and high pressure
  - High pressure rating stainless steel piping is required
- LNG is at supercritical conditions
  - Duty is spread over an extended T-Q curve
  - Maximum energy recovery requires capturing refrigeration at multiple levels
- LNG must be heated to over 15°C
- Minimal modifications to both units
- Units must be able to operate independently if the system is not available

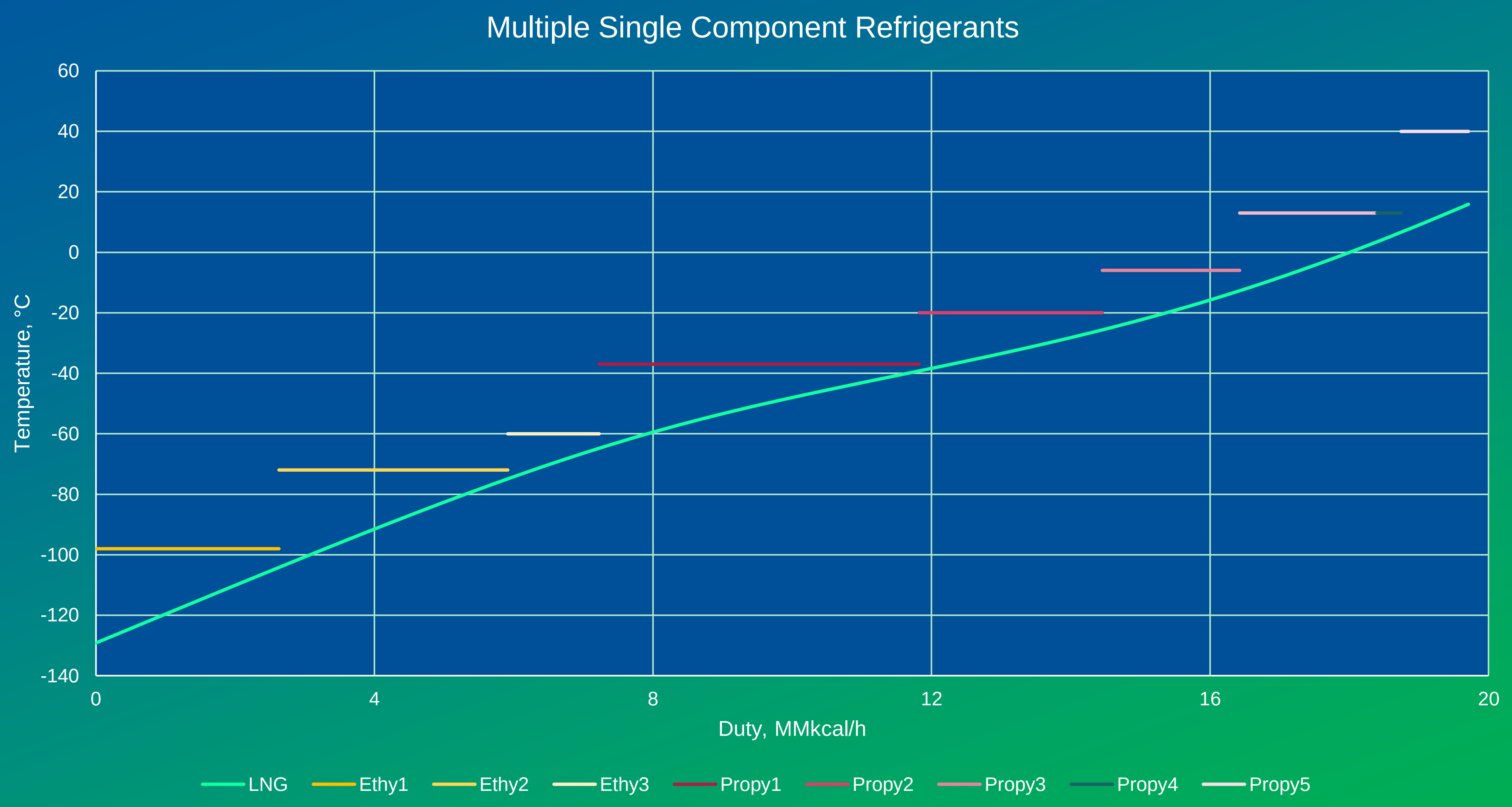
LNG Heating Curve



Options considered

- Sending LNG between units
    - Long, high pressure, stainless steel pipeline required to deliver LNG to the cracker
    - Lower pressure carbon steel line required to return vaporized natural gas to the LNG plant
- Multiple pure component refrigerants
    - Lower pressure pipelines required, but still stainless steel supply lines for the lowest refrigeration levels
    - Multiple pipelines, accumulator drums, pumps, and heat exchangers required
- Single mixed refrigerant system
    - One system – pipeline, drum, pump. Multiple heat exchangers required due to multiple users in the cracker
    - Lower pressure stainless steel supply line
    - Need to prevent “pool boiling” in heat exchangers so refrigerant composition does not vary.

Pure Component Refrigerant Curves

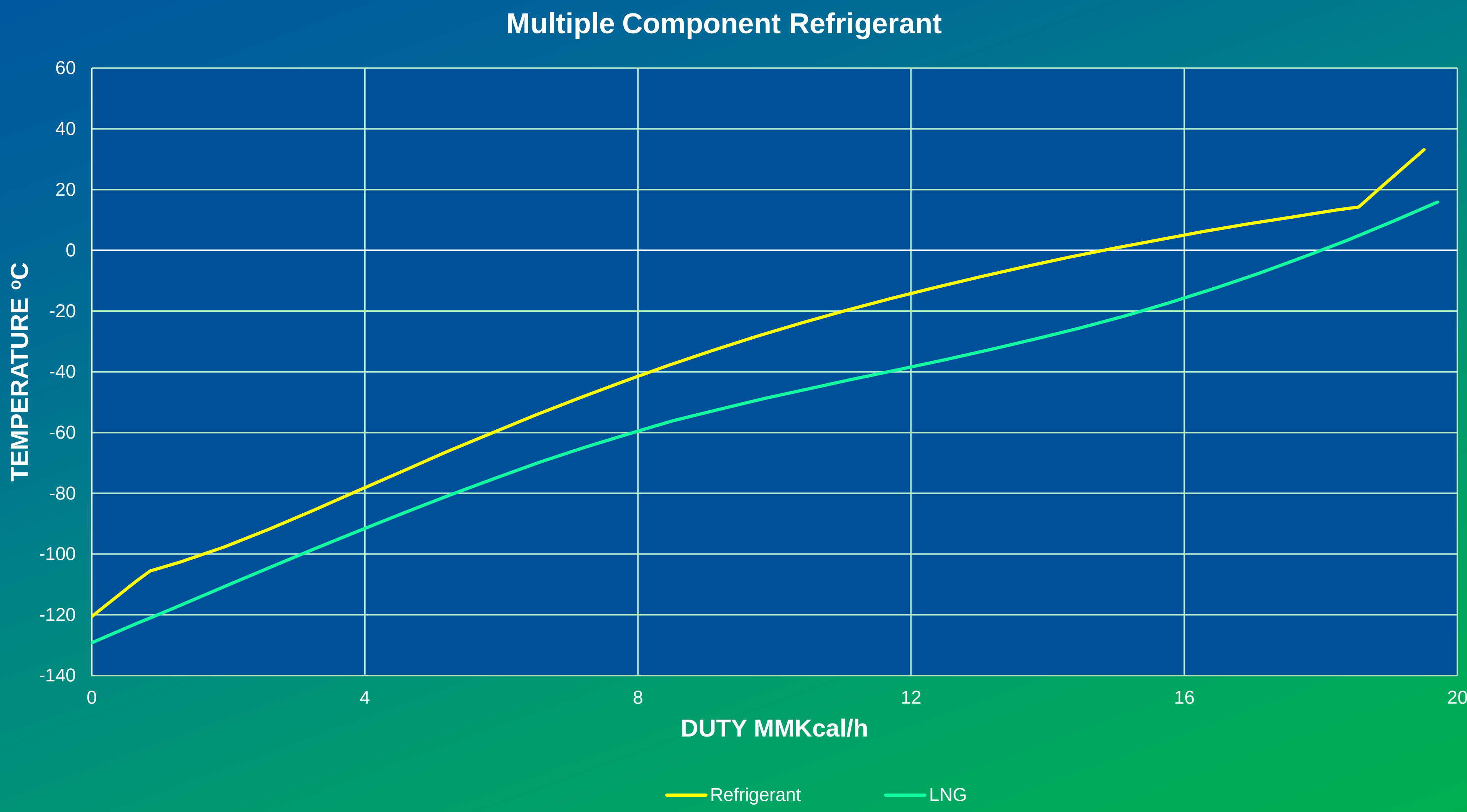


Mixed Refrigerant Composition

Considerations in mixed refrigerant component selection

- Wide LNG supply to return temperature range
  - LNG supplied at less than -120°C
    - Light refrigerant required, i.e. methane
  - LNG heated to more than 15°C
    - Heavy refrigerant required, C4 or heavier
- Significant amount of LNG heating occurs between these temperatures
  - One or more intermediate refrigerants required to have vaporization occurring over the entire temperature range
- Inventory considerations
  - Refrigerant should be produced in the cracked or associated units to ensure adequate supply for refrigeration startup and to ensure recovery of refrigerant upon unit shutdown
    - Long pipelines mean significant inventory will be held in the system, good project economics require minimal losses of hydrocarbons
- Several options were simulated to obtain a refrigerant condensing curve matching the LNG heating curve
- Final selection – 4 component refrigerant
  - Methane – produced in cracker demethanizer
  - Ethylene – produced in cracker ethylene fractionator
  - Propylene – produced in cracker propylene fractionator
  - 1-Butene – available from OSBL

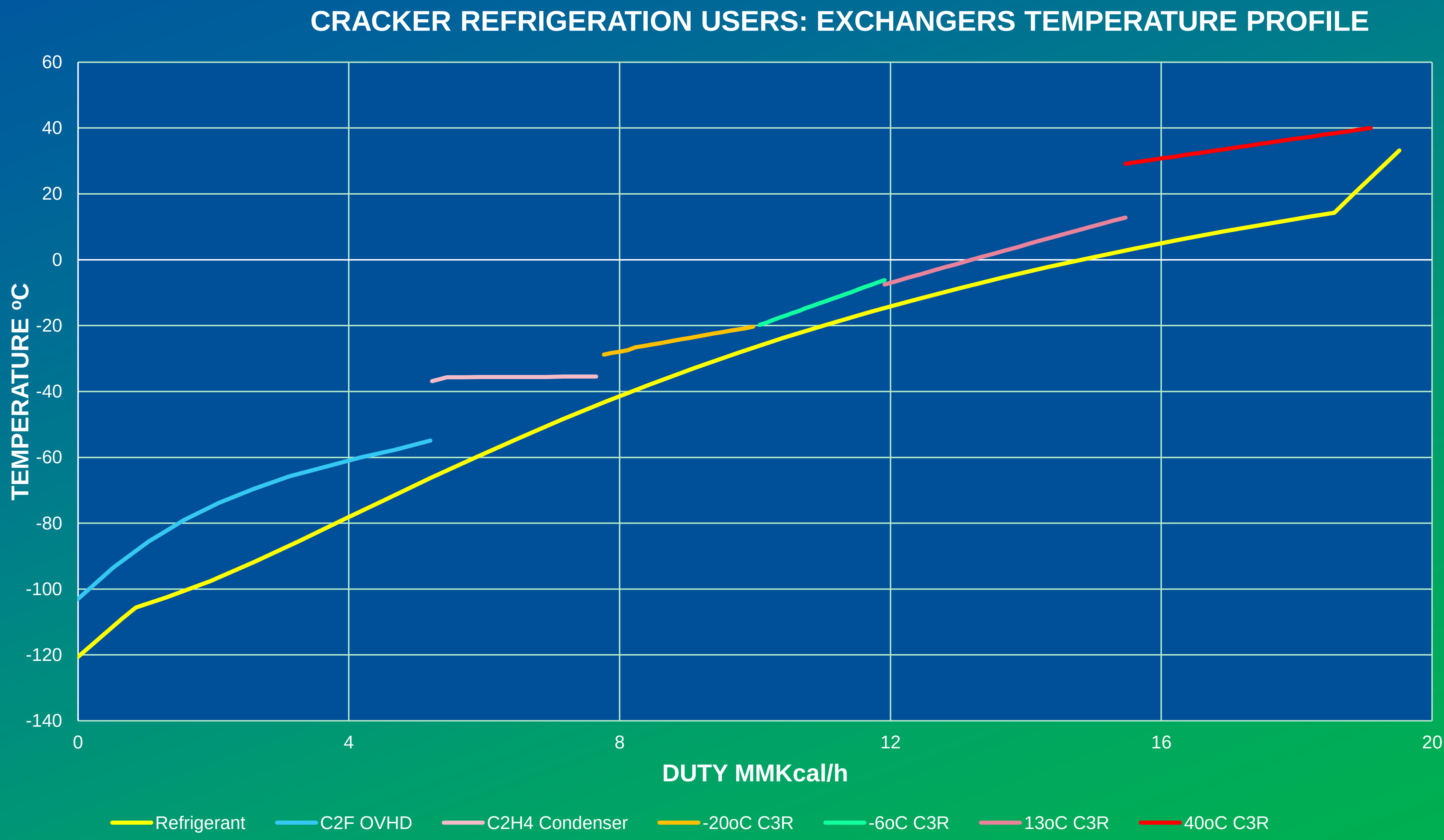
Mixed Refrigerant Curve



Steam Cracker Users

- To maximize efficiency refrigeration must be supplied to the coldest process streams possible
- To provide flexibility to switch between refrigeration system available and not available the mixed refrigerant should not supply 100% of user demand – steam cracker refrigeration must continue to provide the majority of duty for each user
- Steam cracker refrigeration users were studied and six users were identified
  - Four recoups cooling liquid refrigerant
  - Two tower condensers paralleled
- Process temperatures range from 40°C to -103°C
  - Provides efficient utilization of refrigeration provided by the LNG.

Steam Cracker Users



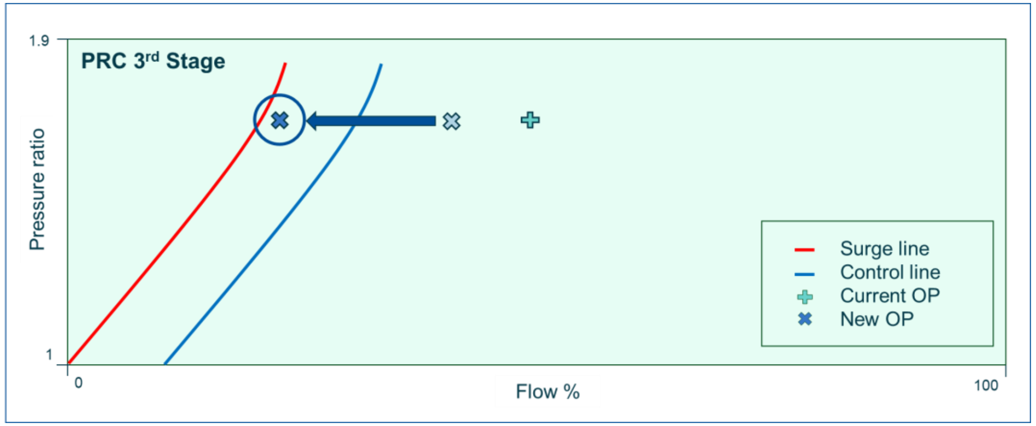
Equipment Design

- Equipment location is split between two units
  - The mixed refrigerant condenser, accumulator, and circulation pump are located in the LNG unit
  - Steamcracker users vaporizing the mixed refrigerant are located in the steam cracker
- Plot area was identified in both units for new equipment
- To prevent pool boiling and to minimize plot area the heat exchanger designs are compact brazed aluminum exchangers
  - High surface area per unit of volume minimizes plot requirement
  - Narrow passages in brazed aluminum exchangers ensure that refrigerant flows through the units, preventing the accumulation of heavier components in a boiling pool.

Propylene Refrigerant System

Surge Prevention

- Propylene refrigerant system
  - Propylene refrigerant system consist of 4 stage compressor, suction drum and instrumentation to supply refrigerant to process users
- Propylene refrigerant compressor surge control
  - Surge Prevention:
  - Maintaining the compressor operating point to the right of the surge control line to ensure adequate response time and protect against mechanical damage.
  - A portion of the discharge flow is recirculated to maintain sufficient volumetric flow across each compressor stage

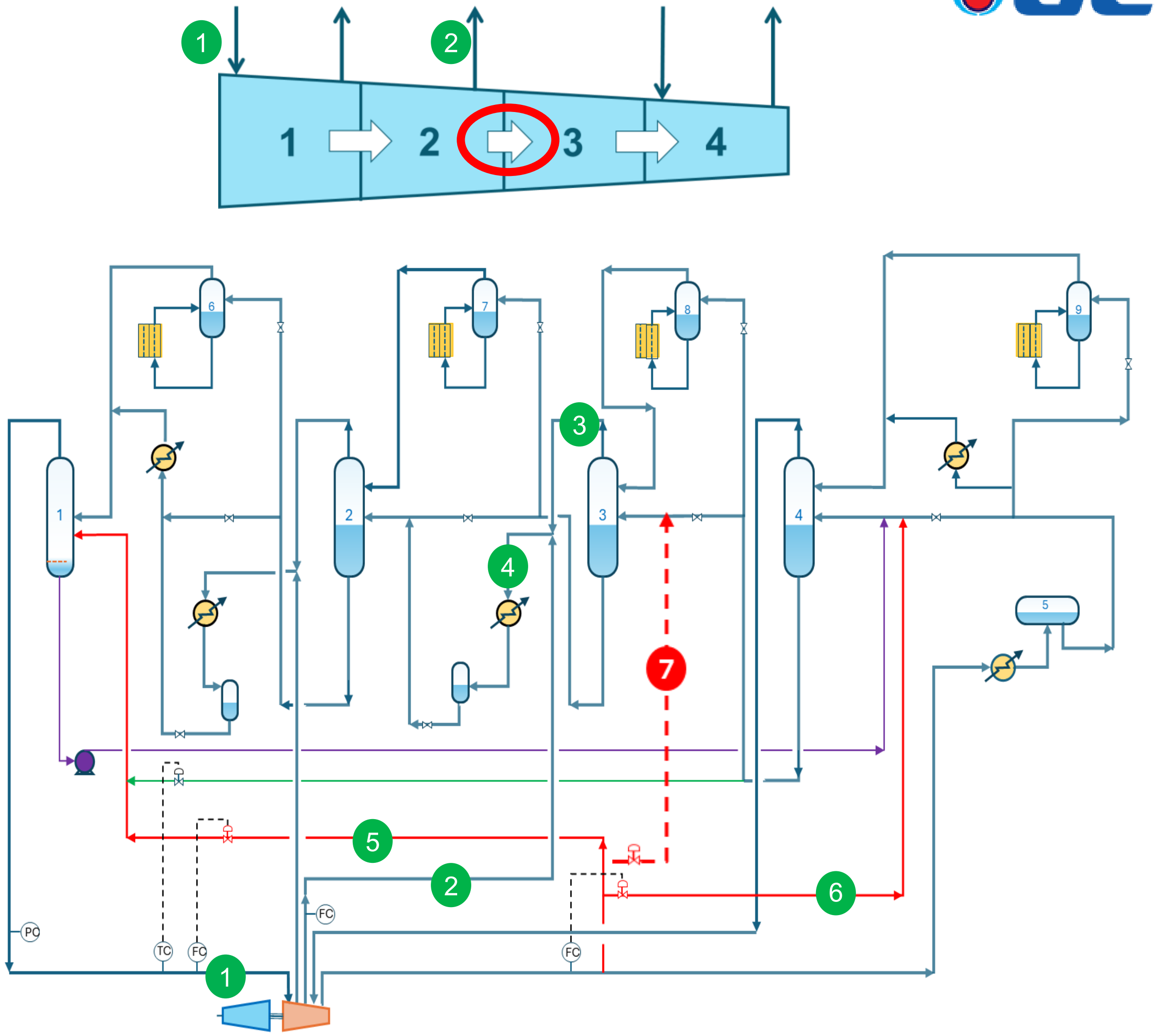


- LNG cold energy integration reduces the propylene refrigerant load, causes Stage 3 & stage 4 flow rates to approach the surge limit (operating left of the control line).

Propylene Refrigerant System

Surge prevention

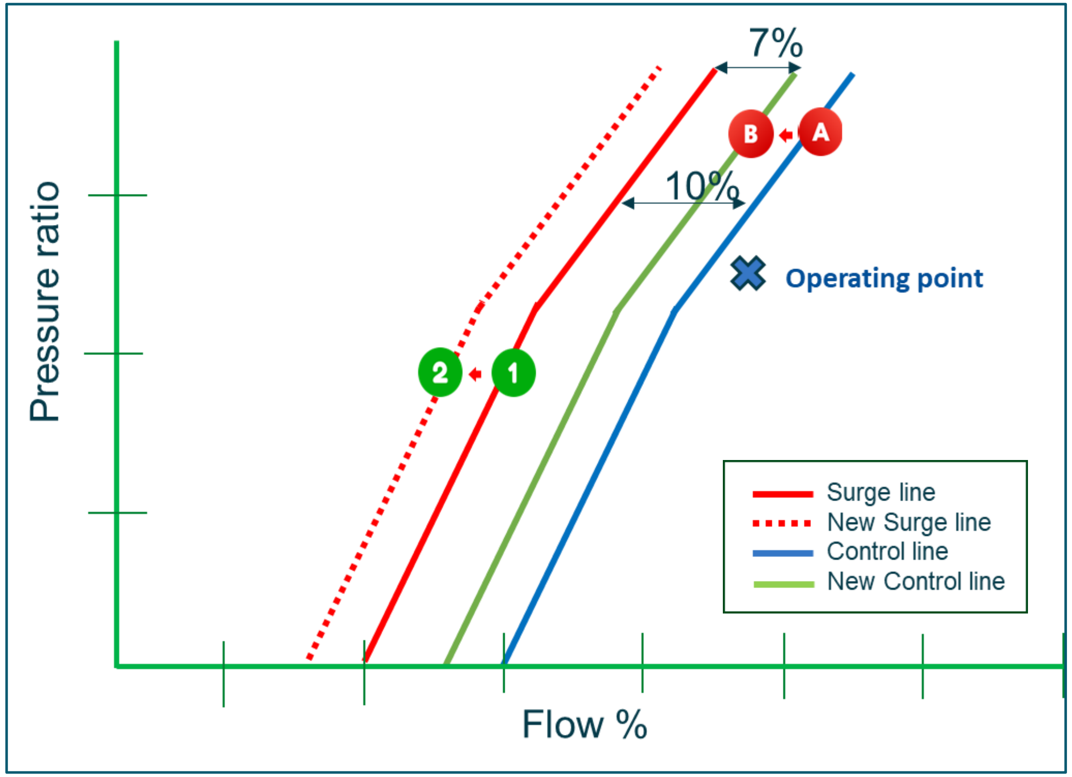
- Stage 4: recycle line 6 is utilized
- Stage 3: there is no direct line to this stage
  - Option 1: recycle line 5 is utilized then flow rate to stage 1&2&3 are increase simultaneously, leading to unnecessary power consumption.
  - Option 2:
    - reduce stream 2 and increase stream 3 to meet the duty requirement of user.
    - Install and additional recycle line to suction drum number 3 to increase stream 3 directly (recycle line 7)
- Installing the new line enable 25 % higher energy saving



Propylene Refrigerant System

Surge prevention

- Opportunity to extend steam saving benefit
  - Conducting the actual surge test at site to determine the actual surge line.
  - Shift the operating line accordingly
  - Decrease the margin, a gap between control line and surge line, from 10% to 7%



Conclusion

- Status of this project
  - The project is during EPC phase
  - It is schedule to be in operation in 2028
- Benefit from LNG cold energy utilization
  - Energy saving: 113 MMBTU/h fuel equivalent
  - GHG emission reduction: 60,000 tonCO_2e per year

- Utilizing LNG cold energy in parallel with existing refrigerants is a 'win-win' for the environment and the plant. This project demonstrates a circular economy mindset, turning a byproduct of gas supply into a utility for petrochemicals.

Innovation Applied. **Performance** Delivered.™

www.LummusTechnology.com