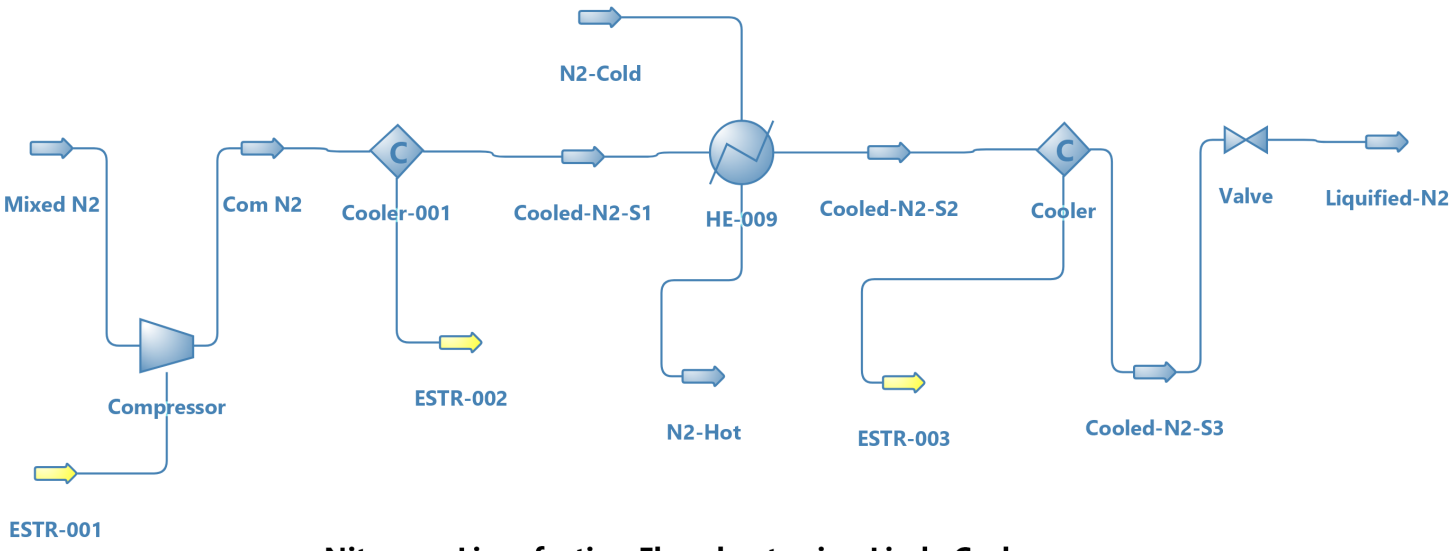
# Nitrogen Liquefaction using Linde Cycle

Priyam Nayak
Indian Institute of Technology Bombay

**Background & Description:**

A process for gas liquefaction, particularly nitrogen liquefaction, which combines the use of a nitrogen auto-refrigeration cooling cycle with one or more closed-loop refrigeration cycles using two or more refrigerant components. The closed-loop refrigeration cycle provide refrigeration in a temperature range having a lowest temperature between about -125°F. and about -250°F. A nitrogen expander cycle provides additional refrigeration, a portion of which is provided at temperatures below the lowest temperature of the closed-loop or recirculating refrigeration cycle or cycles. The lowest temperature of the nitrogen expander cycle refrigeration range is between about -220°F. and about -320°F. The combined use of the two different refrigerant systems allows each system to operate most efficiently in the optimum temperature range, thereby reducing the power consumption required for liquefaction.

Gaseous nitrogen at 80°F, 1 atm is compressed to 25 atm pressure. Adiabatic compressor is employed for this purpose with 50% efficiency which also results in increasing the temperature of $N_2$ stream to 1577°F. The stream is further cooled to -306°F with the help of a series of cooler and heat exchanger. Cooled $N_2$ is further expanded by reducing the pressure to 1 atm using an isenthalpic valve to obtain liquefied $N_2$.




**Nitrogen Liquefaction Flowsheet using Linde Cycle**

## Results:

| **Object** | N2-Hot | N2-Cold | Mixed N2 | Liquified-N2 | |
|---|---|---|---|---|---|
| Temperature | 229.000009 | 77.354723 | 300.000000 | 77.354722 | K |
| Pressure | 1.000000 | 1.000000 | 1.000000 | 1.000000 | atm |
| Mass Flow | 810.000000 | 810.000000 | 1,000.000000 | 1,000.000000 | kg/h |
| Molar low | 28.914114 | 28.914114 | 35.696437 | 35.696437 | kmol/h |
| Volumetric Flow | 9,039.506245 | 2,933.487221 | 14,638.558044 | 317.457296 | L/min |
| Vapor Phase Molar Enthalpy | -2,026.180673 | -6,491.084701 | 46.205128 | -6,491.084717 | kJ/kmol |
| Mass Flow (Vapor Phase) / Nitrogen | 810.000000 | 810.000000 | 1,000.000000 | 82.385093 | kg/h |
| Mass Flow (Liquid Phase 1) / Nitrogen | 0.000000 | 0.000000 | 0.000000 | 917.614907 | kg/h |
| **Object** | Cooled-N2-S3 | Cooled-N2-S2 | Cooled-N2-S1 | Com N2 | |
| Temperature | 85.000000 | 185.421934 | 300.000000 | 1,131.982017 | K |
| Pressure | 25.000000 | 25.000000 | 25.000000 | 25.000000 | atm |
| Mass Flow | 1,000.000000 | 1,000.000000 | 1,000.000000 | 1,000.000000 | kg/h |
| Molar Flow | 35.696437 | 35.696437 | 35.696437 | 35.696437 | kmol/h |
| Volumetric Flow | 21.548744 | 330.795696 | 580.618715 | 2,224.492556 | L/min |
| Vapor Phase Molar Enthalpy | 0.000000 | -3,747.282874 | -130.711665 | 25,876.051649 | kJ/kmol |
| Mass Flow (Vapor Phase) / Nitrogen | 0.000000 | 1,000.000000 | 1,000.000000 | 1,000.000000 | kg/h |
| Mass Flow (Liquid Phase 1) / Nitrogen | 1,000.000000 | 0.000000 | 0.000000 | 0.000000 | kg/h |

Table 1: Streamwise Results for the Nitrogen Liquefaction Flowsheet