Figure 5.12. Linde liquefaction process schematic. The system boundaries shown on the left

a) Figure 5.12 shows the Linde liquefaction process. Sketch a P/H diagram showing the eight streams of the Linde process. (show 2 and 2’)

b) Make a table for each stream indicating the state (sat. vap. etc.), T, P, H, S, η, q, dm/dt (mass flow rate). Assuming that you have the P/H diagram and that you are given the pressure and temperature for streams 3 and 8. Which streams can be immediately solved for H and how. Fill in as much as you can from the initial information including indicating which streams have the same flow rate, P, T, H, S and how you would use η.

c) Can streams 1 and 2 be initially ignored? Why?

d) The two dashed lines in Figure 5.12 indicate two local balances that need to be considered to solve this design. Show how the System I balance in mass and in energy can yield q for stream 5.

e) Show how q can yield H5.

f) Show how H for stream 4 can be resolved from an energy balance on system II.
Stream 3 & 8 can be solved from the P/H chart
- Streams 6, 8 & 7 cannot be solved
- Imbalance will occur at T8 & SV or SL
c) Streams 1 & 2 can be ignored since they only provide T & P for stream 3.

d) 
\[ m_3 = m_6 + m_8 \]
\[ m_6 = m_3 - m_8 \]  
(1)

\[ H_3 m_3 = H_6 m_6 + H_8 m_8 \]  
(2)

\[ q = \frac{m_8}{m_3} \]

\[ m_1 m_j (1) \text{ in (2)} \]

\[ H_3 m_3 = H_6 (m_3 - m_8) + H_8 m_8 \]

\[ H_3 = H_6 \left(1 - \frac{m_8}{m_3}\right) + H_8 \left(\frac{m_8}{m_3}\right) \]

\[ (H_3 - H_6) = \frac{m_8}{m_3} \left(H_8 - H_6\right) \]

\[ q = \frac{m_8}{m_3} = \frac{(H_3 - H_6)}{(H_8 - H_6)} \]

e) 
\[ H_5 = H + q (H_L - H) \]

\[ \frac{1}{p_0} \]

f) 
\[ H_4 m_j - H_3 m_3 = H_8 m_8 - H_7 m_8 \]

\[ \frac{m_8}{m_3} = q \quad \therefore H_4 = q (H_8 - H_7) + H_3 \]