CHE 477 **Project 2 – Pinch Technology**

You have been assigned to teams of 3 for this project. You will submit 1 group report to Brightspace. Report should be written as a concise technical memo (example memo provided) containing appendices of your calculations.

Before beginning this project, outline the roles and responsibilities of each team member (Chapter 28 – Teamwork). Define and discuss what amount of effort is expected and how your group would work to resolve conflict. Submit the Group Contract. Each member should submit a group assessment form at the end of the project.

The Situation:
Four streams within the ethylene oxide process need to be heated or cooled as given in the table below. We want to use heat integration to reduce the utility costs as much as possible if it makes economic sense. You can use Appendix A to obtain the capital costs for these exchangers. Smaller exchangers can't be predicted well with this relation, so find the cost of a larger exchanger ($100 m^2$) and use the 0.6 scaling exponent. Assume floating head shell and tube exchangers operating at 23barg pressure with stainless steel. You are expected to use pinch technology to design a heat exchanger network.

Table 1. Stream Table for Heat Integration Evaluation

Stream Number	Start Temp. (°C)	End Temp. (°C)	Flow rate m (kg/s)	Heat Capacity Cp (kJ/kg·K)	m·Cp (kW/K)	Boiling Point (°C)	Heat of Vaporization (kJ/kg)
1	155	65	35	4.5	157.5	156	2250
2	225	65	100	2	200	-133	520
3	60	150	100	2	200	-133	520
4	140	155	15	4.5	67.5	154	2250

What approach temperature seems to be optimum, or should you do heat integration at all? (At minimum, you should check 5, 10 and 20 degree approach temperatures as well as a base case).

Specifications for available utilities are given in Table 2. For heating utilities, it is necessary to specify the outlet temperature of the utility. There is a trade-off where lower outlet temperatures lead to increased area (and therefore increased capital cost) while higher outlet temperatures lead to increased utility flow rates (and therefore higher operating costs). Examine this relationship in order to make a recommendation on the optimum heating utility and outlet temperature of this selected utility that you will use in the design of all heat exchangers requiring steam. Remember that steam condenses and most of the energy is imparted during this phase change. Include a graph comparing EAOC values of options you considered.

Table 2. Specifications for available utilities

Utility	**Temp. (°C)**	**Pressure (barg)**	**Heat Capacity Cp (kJ/kg·K)**	**Heat of Vaporization (kJ/kg)**	**Cost ($/GJ)[1]**	**Cost ($/1000kg)**
hps	254	41	4.91	1716	5.66	9.61
mps	184	10	4.42	2015	2.78	5.56
lps	160	5	4.33	2083	2.03	4.22
cw	30°C in, 40°C out	-	4.18	-	0.378	0.0157
rw	5°C in, 15°C out	-	4.2	-	4.77	0.207

Assume 10% internal interest rate and 10 year project life. Calculate and compare the EAOC profitability measure. Use a stream factor of 98% in the year 2022.

Assume an overall heat transfer coefficient of U = 750 W/m^{2}K for all cases.

$$Q = m_c Cp_c (T_{c2} - T_{c1}) = m_h Cp_h (T_{h1} - T_{h2}) = UA\Delta T_{lm}$$

$$\text{if phase change occurs, then: } Q = mCp\Delta T + mH_{vap}$$

$$\Delta T_{lm} = \frac{(T_{h1} - T_{c2}) - (T_{h2} - T_{c1})}{\ln\left(\frac{T_{h1} - T_{c2}}{T_{h2} - T_{c1}}\right)}$$

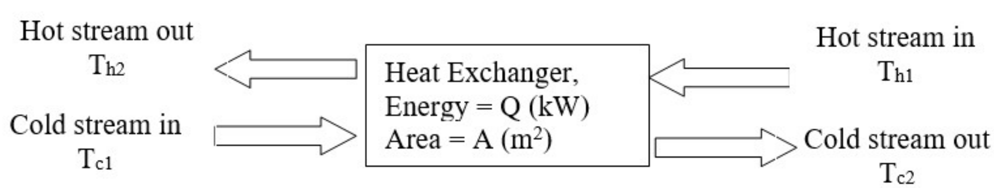

Table 3. Grading Rubric

Subject Area	Points Possible
Stream Tables	15
Exchanger Networks	15
Analysis of Capital Costs	10
Analysis of Operating Costs	10
Analysis of Profitability Criteria	10
Outlet Temp Trade-off Analysis	10
Written Presentation	15
Figures and Tables Presentation	15
Total Points	100

[1] Steam Cost on a GJ basis is assuming energy comes only from condensation. Calculate the required mass flow of steam needed for the outlet utility temperature optimization part of this problem, and use the cost for mass basis