Design Problem 5 – Process Economics in CHEMCAD

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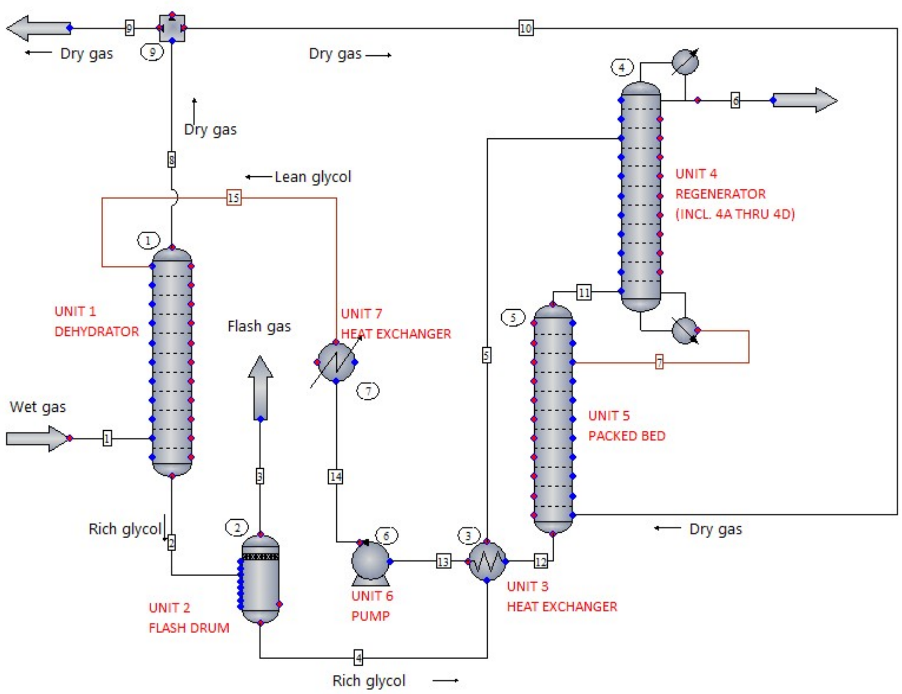
Objectives

1. Use sizing and heuristics to determine the purchase cost of a variety of equipment.
2. Perform an economic analysis of a process.

Background and Problem Statement

The background for this problem was presented in Design Problem 4 and is briefly summarized here. As stated in that problem, natural gas is an important source of both fuel and chemicals, and the first step in natural gas processing is dewatering the gas. The CHEMCAD process flow diagram shown below simulates a typical gas dewatering plant.



The process works as follows: Wet natural gas (wet gas) enters the absorber column (unit 1) at the lower left corner of the diagram, where it is contacted with water-lean triglycol (lean glycol). Unit 1 removes most of the water from the wet gas. The resulting dry gas product (dry gas) is then removed from the process in the upper left corner of the process. The water-rich triglycol (rich glycol) is then recycled through a series of water-removing steps to regenerate the triglycol. First, since the rich glycol contains volatile light ends such as methane, CO_2, and H_2S, these are partially removed in a flash drum (unit 2). The rich glycol is then preheated in an energy-recovery heat exchanger (unit 3) and then sent to the top stage of a distillation column (unit 4). The glycol emerges from the bottom of the distillation column (unit 4) and enters the top of a stripping column (unit 5) where it is contacted with some of the dry gas product which was split off from the original dehydrator (unit 1). The combination of units 4 and 5 serves to remove about 91% of the water, producing water-lean triglycol (lean glycol) at the bottom of the stripping column (unit 5). The lean glycol is still quite hot, so it is then sent back through the energy recovery heat exchanger (unit 3) where it is cooled and sent back to the dehydrator (unit 1), closing the recycle loop.

Your task is to complete an economic analysis of the entire process. A working CHEMCAD file for the process has been provided in Canvas. A full list of constraints and specifications in the constraints section of this handout. Use that information and the CHEMCAD file to complete the sizing of the equipment in the process, determine the purchase costs of that equipment, and complete the economic analysis. Enter your results in Table 1 and combine your pricing results to obtain the *total purchased equipment cost* of the regenerator.

Questions:

1. **20 Points.** Use the provided constraints to run the CHEMCAD sizing and costing tools to determine the cost of the dehydrator (unit 1), flash drum (unit 2), heat exchanger (unit 3), packed bed (unit 5), pump (unit 6), and preheater (unit 7). The regenerator (unit 4) was completed in design problem 4. Ensure that the costs are referenced to *February 2026*. Additional guidance follows in the design constraints and specifications section.
2. **20 Points.** Use the provided constraints and CHEMCAD to perform an economic analysis of the process.
3. **10 Points.** A partially completed table entitled "Table 1 - Results of economic analysis of gas dehydration process" is provided below. This table is also provided as a fillable form in Canvas. Complete the table by entering your results. The information is found in the "Reports" section in "Economics." In the conclusions section of the form, use the results in the table to assess the economic viability of the process.

Design Constraints and Specifications

- Overall:
  - Update Cost Index to February 2026.
  - Update convergence to 400 max flowsheet iterations.

- Unit 1 (Dehydrator) Internals:
  - Sizing with sieve trays at 1220 psia.
  - Costing report in "Cost Estimation 1" tab.

- Unit 2 (Flash Drum) Internals:
  - Vertical pressure vessel at 1220 psia.
  - Costing report in "Cost Estimation" tab.

- Unit 3 (Heat Exchanger) Internals:
  - Heuristic - use a value for U (=132.083 Btu/(hr·ft²·°F).
  - Costing report in "Cost Estimations" tab.

- Unit 4 (Regenerator) Internals:
  - Purchase cost override of $284,183 in "Cost Estimation 2," determined in lab 4.
  - Utility cost is 31.34 $/h (cooling water + reboiler steam) in Cost Estimation 2. Flow rates were calculated in lab 4 and costs were determined from the utilities section in the "Cost and Evaluation" spreadsheet.

- Unit 5 (Packed bed) Internals:
  - Sizing at 1220 psia as sieve trays (this is an approximation for now).
  - Costing report in the "Cost Estimation 1" tab.

- Unit 6 (Pump) Internals:
  - Requires utility cost of $0.814/h.
  - Costing report in cost estimation tab.

- Unit 7 (Preheater) Internals:
  - Heuristic - use a value for U (=132.083 Btu/(hr·ft²·°F).
  - Utility cost of $2.415 $/h (cost of steam) in Cost Estimations.
  - Costing report in "Cost Estimations" tab.

- Economics – Create a new case

- Economics - Project Settings
  - Project length: 10 years
  - Operation time: 8400 hrs/year
  - Discount rate: 12 percent
  - Tax rate: 50 percent
  - Depreciation method: straight line
  - depreciation period: 10 years

- Economics - Capital Investment
  - Plant Cost:
    - Delivery: 10 percent
    - Installation: 47 percent
    - Piping: 68 percent
    - Instrumentation: 36 percent
    - Building and structure: 18 percent
    - Auxiliaries: 0 percent
    - Outside lines: 11 percent
    - Engineering and construction: 26.4 percent
    - Contingency: 15.7 percent
  - Other Capital Items:
    - Allocated property: 0 percent
    - Startup expense: 15 percent
    - Salvage value: 0 percent

    - Working capital 0.285 percent
    - Corporate capital allocation: 0 percent

- Economics - Operating Costs
  - Fixed Expenses:
    - Labor: 1,769,700 $/year
    - Supervision: 677,498 $/year
    - Laboratory: 0 $/year
    - Royalty fees: 0 $/year
    - Other expenses: 0 $/year
    - Payroll benefits: 18 percent
    - Office overhead: 50 percent
    - Supplies: 2 percent
    - Property tax: 5 percent
    - Maintenance: 10 percent
  - Variable Expenses:
    - Cost of selling goods: 5 percent
    - SARE (sales, admin, research, and engineering) expenses: 10 percent

- Economics - Equipment
  - General Specifications:
    - Select mode: Get cost from flowsheet
  - Process UnitOps:
    - No changes

- Economics - Utilities
  - General Specifications:
    - Select mode: Get cost from flowsheet
  - Process UnitOps:
    - No changes

- Economics - Feedstocks
  - General Specifications:
    - Select mode: Get cost from flowsheet
  - Process Streams:
    - WET GAS – Price/Mass - 0.0037 $/lb

- Economics - Products
  - General Specifications:
    - Select mode: Get revenue from flowsheet
  - Process Streams:
    - DRY GAS – Price/Mass - 0.0056 $/lb

Submission Requirements

1. PDF of completed Table 1 with signed cover Sheet. Use the fillable form found in Canvas to satisfy this requirement.

2. Completed CHEMCAD file uploaded to Canvas.
3. All work is due NLT 1445 hours (end of lab hour).

Table 1. Results of economic analysis of gas dehydration process. The internal rate of return is also known as the discounted cash flow rate of return (DCFR), the interest rate at which the net present worth is zero.

Capital Investment (millions of dollars)	
Purchased Equipment Cost	
Working Capital	
Total Indirect Costs	
Total Direct Costs	
Fixed Capital Investment	
Total Capital Investment	
Measures of Profitability (N=10 years)	
Return on Investment, %	
Payback Period, years	
Net Present Worth, million \$, at 6% interest	
Net Present Worth, million \$, at 12% interest	
Internal Rate of Return, %	
Profitability Benchmarks	
Bond Rate, after taxes, from Table 7-1, %	
Preferred Stock Dividend, from Table 7-1, %	
Common Stock Dividend, from Table 7-1, %	
Minimum Acceptable Return, from Table 8-1, %	
Ref. Payback Period, at MAR, years, eq 8-2c	

Conclusions: