Chapter 8
Estimation of Manufacturing Costs

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Estimation of Manufacturing Costs

- Direct Costs
  - Vary with production rate but not necessarily directly proportional
- Fixed Costs
  - Do not vary with production rate but relate “directly” to production function
- General Expenses
  - Functions to which operations must contribute – overhead burden

Direct Costs

- Raw Materials
- Waste Treatment
- Utilities
- Operating Labor
- Supervisory and Clerical Labor
- Maintenance and Repairs
- Operating Supplies
- Laboratory Charges
- Patents and Royalties

Fixed Costs

- Depreciation – cover as a separate topic in Chapter 9
- Local taxes and insurance
- Plant overhead costs

General Expenses

- Administration costs
- Distribution and selling costs
- Research and development

Manufacturing Costs

- Table 8.1
  - Description of items
- Table 8.2
  - Factors for estimating costs

* We relate (historically) the relationship between items in Table 8.1 to direct costs A (RM) , B (WT) , C (UT) , D (OL), and FCI of plant

Manufacturing Costs - examples

- Maintenance and repairs
  - 2 – 10 % FCI
  - Proportional to size of plant
- Supervisory and clerical labor
  - 10 – 25 % C_{OL}
  - Proportional to op. lab
- Depreciation
  - some % of FCI

Use mid-point values from Table 8.2

Note: using the mid-point values from Table 8.2 is a non-biased way of estimating COM but actual COM may be quite different depending on the plant and industry sector

Manufacturing Costs

with depreciation as 10% FCI

$$COM = 0.280FCI + 2.73C_{OL} + 1.23\left(C_{UT} + C_{WT} + C_{RM}\right) \quad (8.1)$$

$$COM_d = 0.180FCI + 2.73C_{OL} + 1.23\left(C_{UT} + C_{WT} + C_{RM}\right) \quad (8.2)$$

COM without depreciation – we use this since we calculate depreciation more accurately in Chapter 9

How Do We Get…..

- *FCI* – Chapter 7 C_{TM} or C_{GR}
- C_{OL}
- C_{RM}
- C_{UT}
- C_{WT}

Look at these separately

Cost of Operating Labor

$$N_{OL} = (6.29 + 31.7P^2 + 0.23N_{np})^{0.5}$$

N_{OL} = the number of operators per shift

P = particulate processing steps

N_{np} = non-particulate processing steps – compression, heating/cooling, mixing, separation, and reaction

Important note – Above equation based on data from chemical plants and refineries where number of particle processing steps is low. For units with more than 2 solids processing steps ignore middle term and add 1 operator per solids step

Example - acetone process

Operating Labor – Acetone Facility

Equipment	Number of	N_{np}
Compressors	0	0
Exchangers	8	8
Fired Heaters	1	1
Pumps	5	-
Reactors	1	1
Towers	3	3
Vessels	4	-
Total		13

Operating Labor – Acetone Facility

- $N_{OL} = [6.29 + (31.7)(0)^2 + (0.23)(13)]^{0.5} = 3.05$

- Number of operators required for one operator per shift = 4.5

↓

= (49 wk/yr)(5 shifts/operator/wk)
= 245 shifts/year/operator
Total shifts per year = (365)(3 shifts per day)
= 1095 shifts/year
1095 / 245 = 4.5 operators (for a single shift)

Operating Labor – Acetone Facility

Total Operators = (3.05)(4.5) = 13.75 $\Rightarrow$ 14

Salary = \$59,580/y (2010 Gulf-Coast average)

$\boxed{C_{OL} = (59{,}580)(14) = \$834K}$

Cost of Raw Materials, Utilities, and Waste Treatment

- Flowrates
  - Get these from PFD – use stream factor
- Costs
  - Utilities and waste treatment - Table 8.3 – see Section 8.6 for utilities estimation
  - Common chemicals – Table 8.4, Chemical Market Reporter, http://www.icis.com/StaticPages/a-e.htm#top

Stream Factor

- Operating hours per year divided by total hours per year
  - Typical 8000 operating hours
  - 0.9 – 0.95 typical

    8000/8760 = 0.913

* Flows on PFD are kmol/operating hour not kmol/hour – why?

Utilities – Fuel and Electricity

- Fuel for Fired Heaters
  - PFD gives process load (energy balance) but total flow is more due to efficiency – 70-90% from Table 11.11 – item 13.
  - Fuel costs may vary wildly – Figure 8.1

- Electricity for pumps and compressors – Figure 8.7
  - Shaft power – fluid power/efficiency
  - Power to drive – shaft power/drive efficiency

* PFD usually gives shaft power – but be careful!

Cost of Fuel – Utility costs

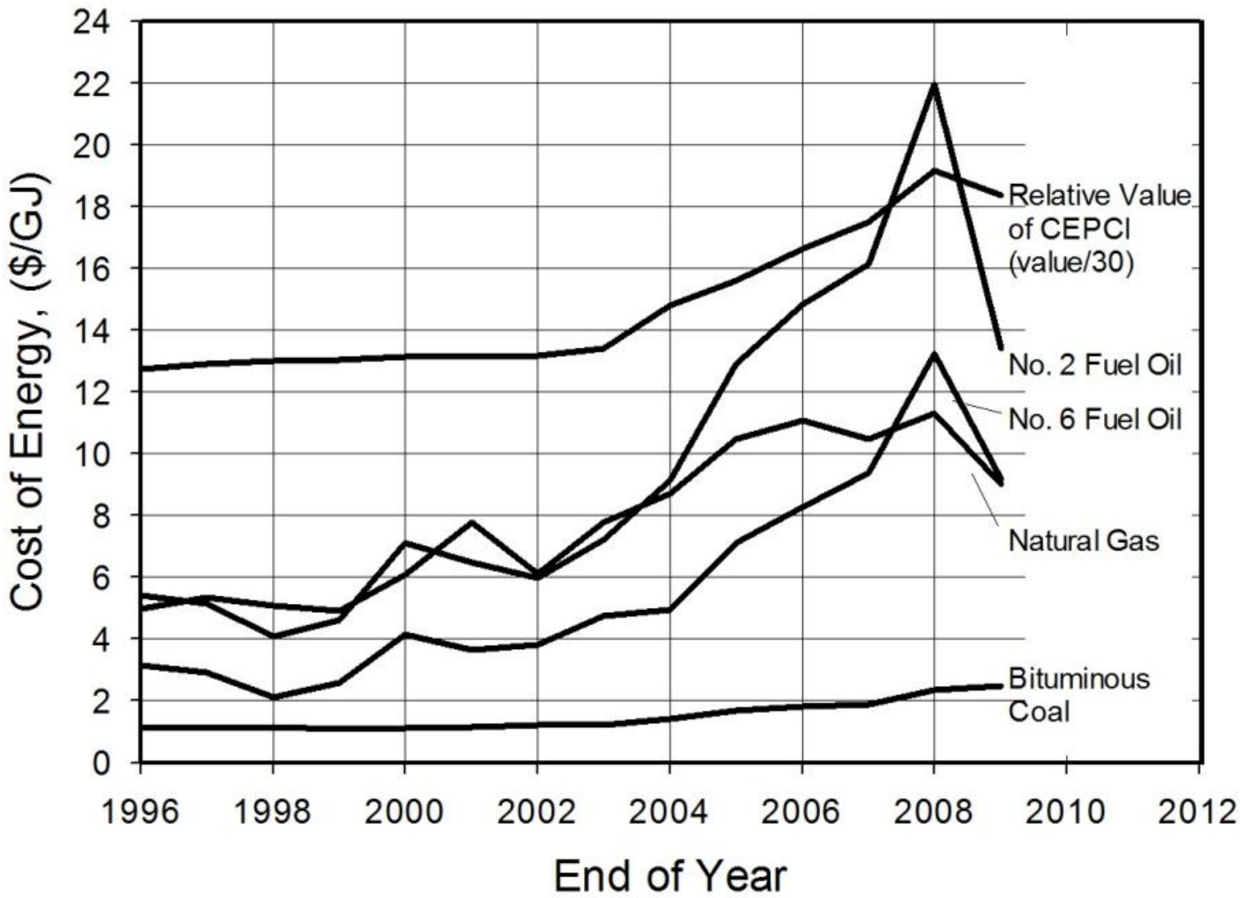


Figure 8.1 Changes in Fuel Prices from 1996 to 2009 (information taken from Energy Information Administration [6])

Utilities - Steam

- Pressure levels
  - Low (30 – 90 psi)
  - Medium (150 – 250 psi)
  - High (525 – 680 psi)
- Available saturated but sometimes superheated

Utilities - Steam

- Large chemical complexes generate high-pressure steam and use excess pressure to generate electricity – Figure 8.6.
- Steam can be used as a drive medium for compressors and pumps
  - Thermodynamic efficiency – Table 8.5
  - Drive efficiency – Figure 8.7

Note: Modern supercritical power plants operate to give steam at 250 bar (3675 psi) and 1075°F (580°C)

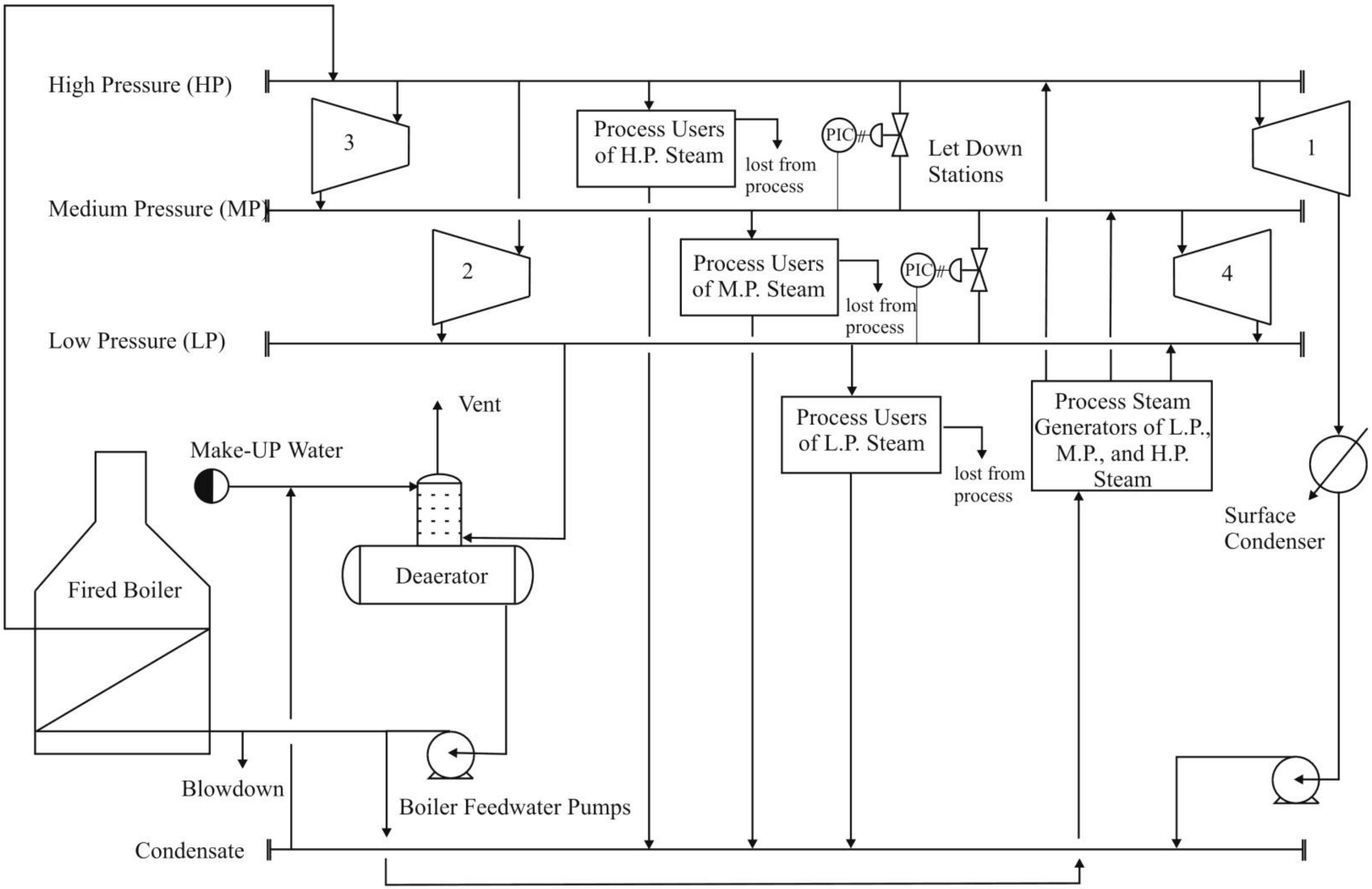
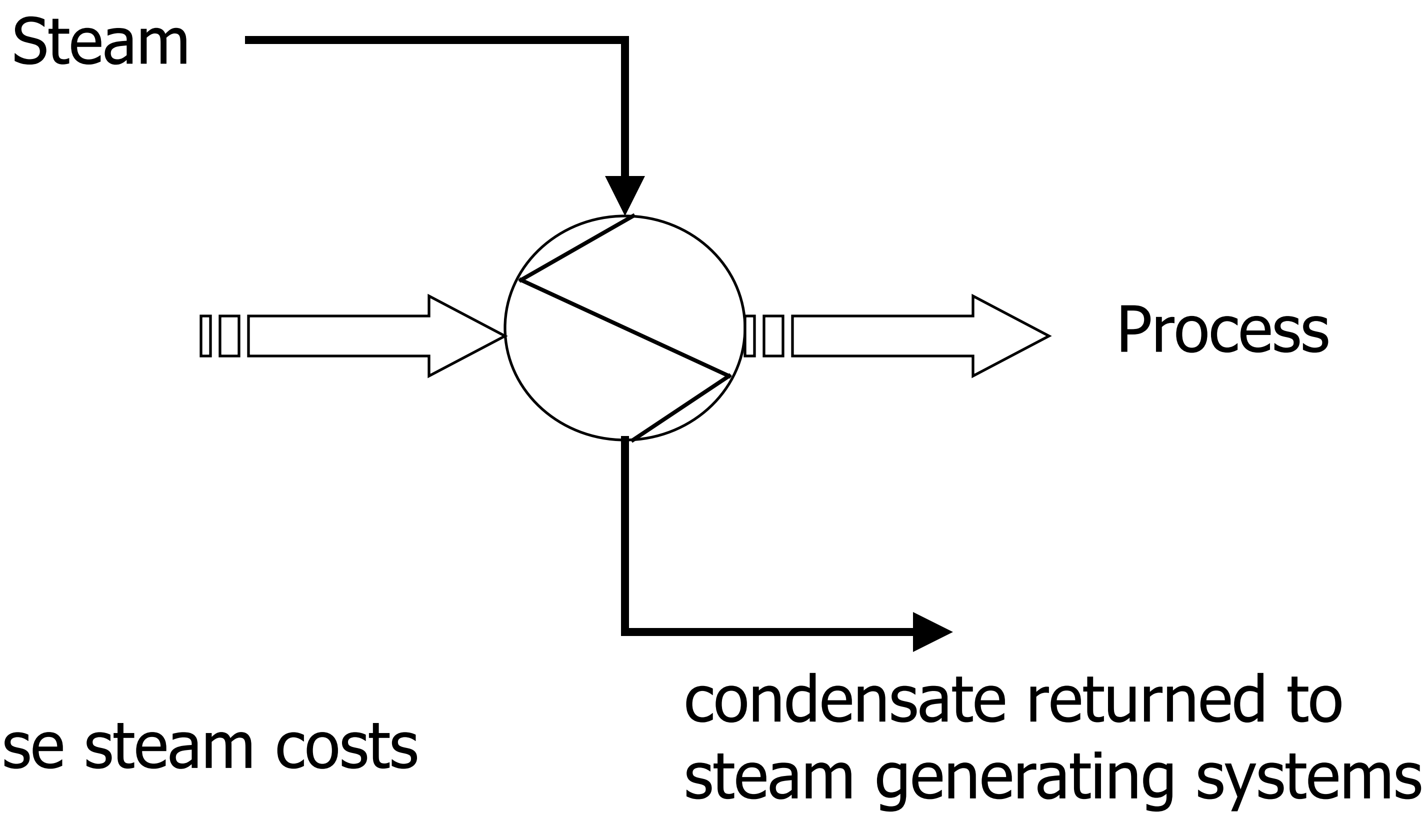


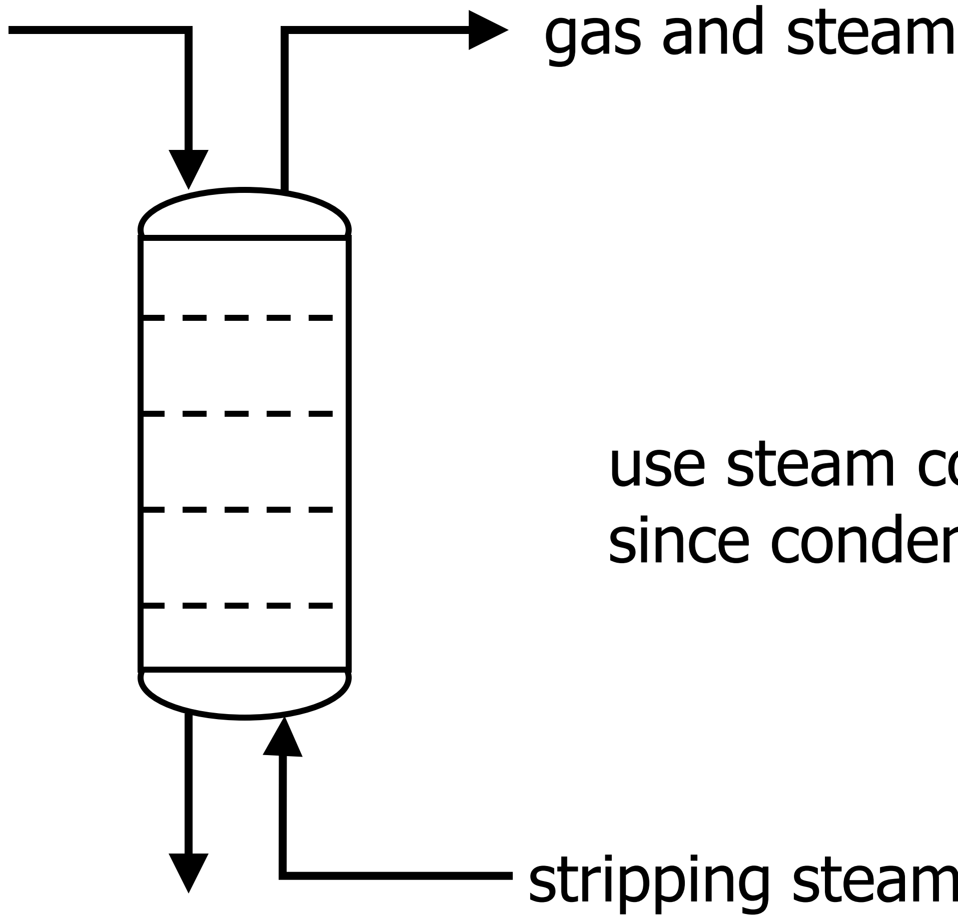
Figure 6.6: Typical Steam Producing System for a Large Chemical Facility

Utilities - Condensate Return and Boiler Feed Water



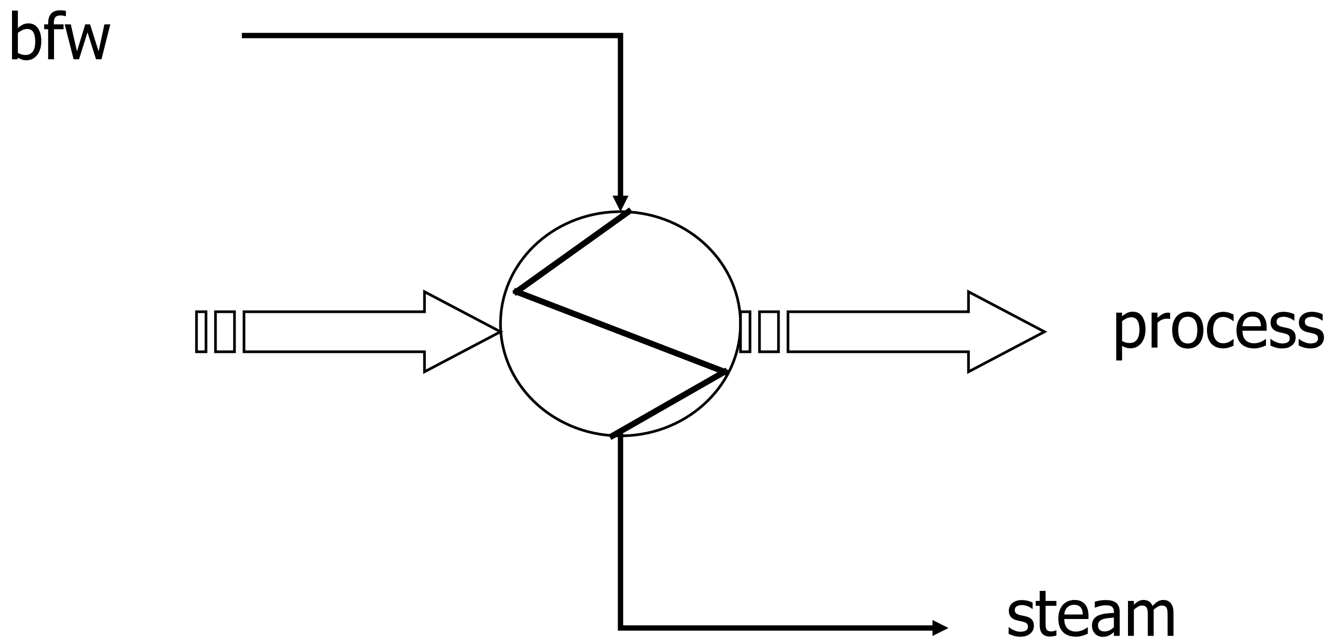
* just use steam costs

If Steam Lost in Process



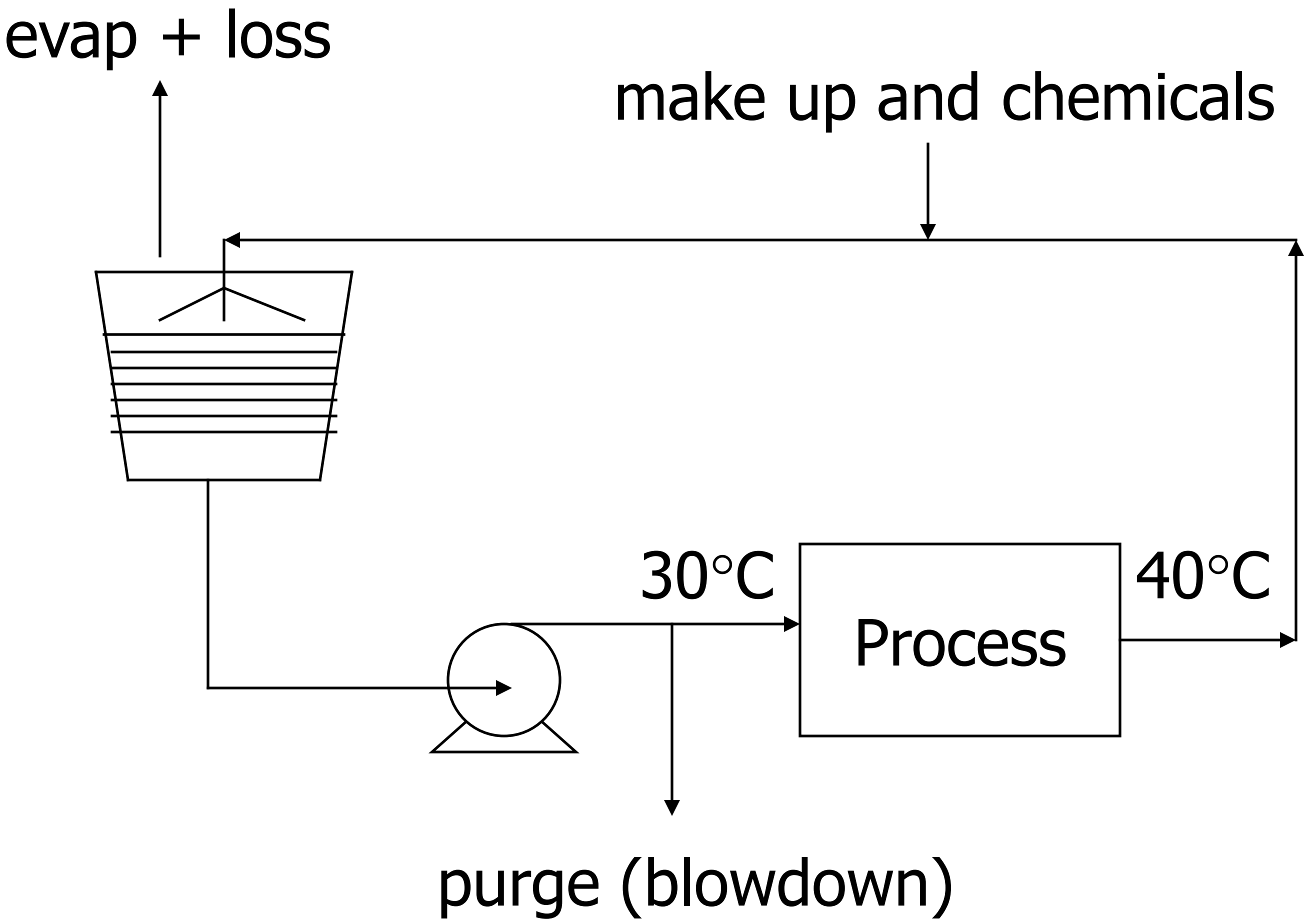
use steam cost + bfw
since condensate is not returned

Steam Generated in Process



* just take credit for steam – unless steam is lost in process

Utilities - Cooling Water



Utilities - Cooling Water

- Make-up based on ΔT (40 - 30) !
- Should charge cw based on energy used
  - Table 8.3
- Does not matter (much) if cw returned at 40°C or 45°C – same energy
- 45°C is absolute max – due to fouling

Utilities - Refrigerated Water

- Same as previous slide in that energy costs are not ΔT dependent – but cost based on 5°C supply temperature
- Figure 8.4 shows cost of refrigeration as a function of temperature

Utilities – Refrigerated Water

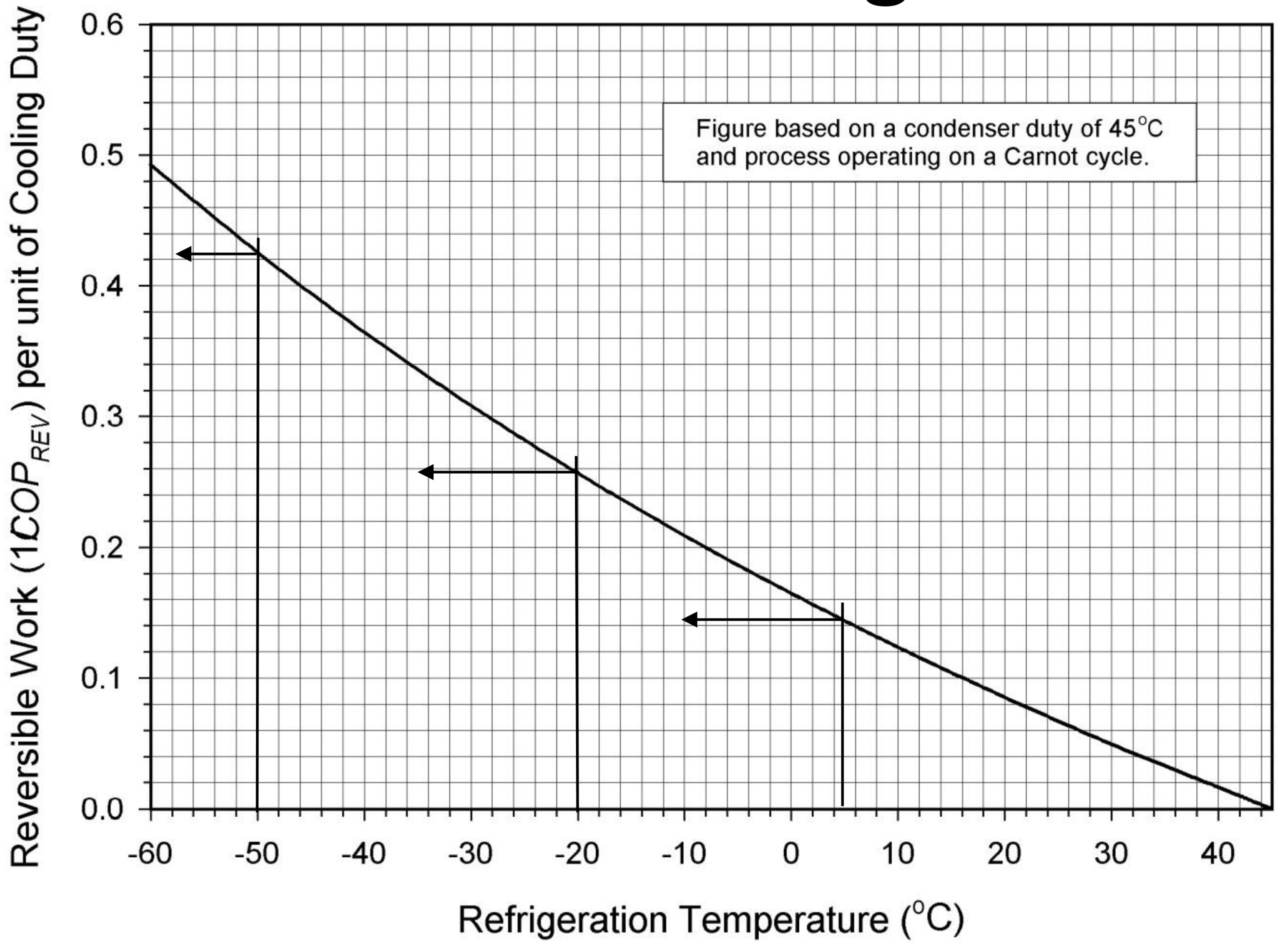


Figure 8.4 Ideal Work for Refrigeration Cycles as a Function of Refrigeration Temperature

Costs ($/GJ)
CW = 0.354
RW = 4.43
-20°C = 7.89
-50°C = 13.11

Summary

- FCI
- C_{OL}
- C_{UT}
- C_{WT}
- C_{RM}

From these get COM_d