Topics for the next 20 minutes

• Estimating capital costs of retrofit
• Some comparisons
• Additional costs of retrofitting
Two approaches

1. Bottom up---build up from design, component costs and installation costs

2. Top down---
   - Establish a range based on known costs of other projects
   - Place in range based on a “degree of difficulty” judgment
Establishing the range

• Correlation of reported project costs
  – 50 plants
  – Coal/gas/nuclear
  – Fresh/brackish/saline water source
  – Wide range of climates

• Circulating water flow used as correlating factor

• Costs fell into three clusters
  – Low; average; high
Graphical correlations

Retrofit Project Costs---Degree of Difficulty

- Easy: ~ $425/gpm
- Average: ~ $165/gpm
- Difficult: ~ $275/gpm

Retrofit Cost, Millions of $
Circulating Water Flowrate, gpm
Things that set degree of difficulty

• Siting tower
  – Relocation of structures
  – Land acquisition
  – Grading of site for gravity return

• Excavation for circ. water lines and sump
  – Interferences
  – Soil conditions
    • Wet, unstable
    • Bedrock
    • Contaminated
More things

- **Noise control**
  - Special fans
  - Wind walls
- **Plume abatement**
  - Higher cost tower
  - Harder to site
Another thing

Base-load plant with long remaining life

– Re-optimize
  • Lower circulating water flow
  • Higher range
– Probable re-tubing of condenser
– Relocation of inlet exit lines
– Extended outage for modifications
Some comparisons

- Maulbetsch Consulting/TetraTech
  - Direct comparison at 15 plants
  - MC/TT = 1.03 (Total for all 15 plants)
Comparison with “Average”

- Maulbetsch Consulting "Average", $ millions
- TetraTech, $ millions

- Scattergood
- Huntington Beach
- Pittsburg

+ 40%
+ 20%
Comparison with “Difficult”

![Graph comparing Maulbetsch Consulting "Difficult" and TetraTech costs with nuclear plants highlighted.](image-url)
Comparison with Estimate

- Maulbetsch Consulting Estimate, $ millions
- TetraTech Estimate, $ millions

Points:
- Pittsburg
- Scattergood
- El Segundo
- Haynes
- Alamitos

Linear regression lines:
- + ~20%
- - ~20%
Plants with differences

- Alamitos: 6 units; 1982 MW; 800,000 gpm
  - MC; rated as “difficult” ($325 million)
    - Plume abatement
    - High circ. water line installation costs
    - Demolition costs

- T’Tech ($210 million; ~ MC “average”)
  - No plume abatement (~ $60 million)
  - 3 towers vs. 6 towers (large savings on circ. line costs)
Plants with differences

• Scattergood: 3 units; 803 MW; 344,000 gpm
  – MC; rated as “average” to “difficult” ($120 MM)
    • Plume abatement
    • One tower per unit
    • Moderate but not severe line costs
  – T’Tech ($160 million; > MC “difficult”)
    • Plume abatement
    • Two towers for Unit 3
    • Costs related to switchyard
    • Noise abatement
Additional (non-capital) costs

- Drift/PM10 offsets
- Plant downtime
- Land acquisition/security zone enhancement
- Permitting time
Drift/PM10 Offsets

• Assuming
  – Seawater make-up
  – Drift eliminators spec’d at 0.0005%
  – All drift solids considered PM10

• For a 250 MW plant operating at 80% c.f
  PM10 emissions ~ 60 tons/year
Plant downtime

- Primarily affected by tie-in to condenser and intake/discharge facilities
- Estimates vary from < 1 month to ~ 1 year
- If condenser is re-optimized, time is **much** longer
- Costs are dependent on scheduling
Land acquisition/security zone

- Situations where insufficient area is available on-site
- Establish a buffer zone from near neighbors
- Special considerations for nuclear plants….
  - Location of tower may extend security zone
  - Additional fencing, perimeter monitors, etc.
  - Increased security staff
Permitting costs

• No basis for estimating but might be substantial
  – Significant time requirements
  – Legal and consulting assistance
Operating costs

• Additional operating power requirements
  – Pumping power
  – Fan power

• Penalty costs—effect of cooling system on plant performance
  – Heat rate
  – Plant capacity
Additional pumping power

- Head losses in circ. water lines
- Getting water to top of tower
- Assume….
  - 1000’ line
  - 40’ rise
- **Pump power ~ 0.5%**
Fan Power

- ~10,000 gpm/cell
- ~200 HP fan
- Fan power ~ 1%
Effect on condensing temperature

Terminal Temperature Difference (TTD)

Circ. Water Flow

Source water temperature

Condenser TTD

Approach

HRR = 0.002p^2 - 0.0006p + 0.9886
Cold water comparisons

Moss Landing Environmental Temperatures

Ocean Water Temperature

Wet Bulb Max

Date

Temperature, F

01-Oct-05 20-Nov-05 09-Jan-06 28-Feb-06 19-Apr-06 08-Jun-06 28-Jul-06 16-Sep-06