Detailed Energy Assessment at Oil Refinery: Tools and Results

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Synopsis

- First Time Pinch Analysis was applied in SA Refinery (2003)

- Expected Savings ~ 10-15% of Baseline Energy Cost

- Actual Savings Identified ≈ 37% (despite low fuel/power costs)
Introduction

• SA management adopted Energy Policy in 2000 with the goal of 50% reduction in corporate energy index over 10 years

• Energy Systems Unit was established to help plants w.r.t. technology transfer
Scope of Work

- Fuel Savings via Heat Recovery optimization (using Pinch Analysis)
- Power Reduction via ASDs
- Optimization of Combined Heat & Power (CHP) design and operation
- Development and deployment of on-line Energy Indices (Solomon EII)
Pinch Analysis - Scope

- Overall Plant Energy Balance

- Thermal Targets and HEN design for:
  - CDU (retrofit)
  - HSRN hydrotreater (retrofit)
  - DHT complex (new)
  - CCR (revamp)
  - LSRN hydrotreater and Isomerization (new)
Pinch Analysis – Procedure

- Prepare reconciled HMB from RIS for existing units (using Data Recon s/w package)
- Confirm HMB with PMT for new units
- Develop proposed new HEN designs
- Discuss with refinery/FPD/PMT for agreement
- HX sizing
- Capital cost estimating
- Project feasibility analysis
- Report preparation
Composite Curves – CDU

ΔT_m = 20°F
### Target Savings – CDU (details)

<table>
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<tr>
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<th>Actual PFD</th>
<th>Pinch Target</th>
<th>Savings Potential</th>
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<td>Energy Cost, K$/yr</td>
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K$/yr savings:
- Total heating duty: 13.5
- Total cooling duty: 12.0
- Fuel supplied: 13.5
- Steam: 100.0
- 60 Steam Gen: 100.0
- Air cooling: -9.4
- Sea Water cooling: 93.6

Total energy cost savings: 1829.3 K$
Composite Curves for others ...
## Overall Thermal Energy Targets

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<tr>
<th>Unit No.</th>
<th>Name</th>
<th>Normal feed rate</th>
<th>Optimum DT, °F</th>
<th>Actual Energy Consumption</th>
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<td>Heating MMBtu/h</td>
<td>Cooling MMBtu/h</td>
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<td>V-05</td>
<td>DHT + ARU</td>
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<td>V-11</td>
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<td>V-32</td>
<td>Utilities (CHP)</td>
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**Blue** = New Unit  
**Purple** = Revamped Unit  
**Black** = Existing Unit  

**SURPRISE!** Significant Cost Savings Potential even in new licensed processes!!
<table>
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<tr>
<th>Name / Service</th>
<th>Crude vs Naphtha</th>
<th>Crude vs Kero</th>
<th>Crude vs LDO Product</th>
<th>Crude vs No 1 LDO P/A</th>
<th>Crude vs No 2 LDO P/A</th>
<th>Crude vs HDO Product</th>
<th>Crude vs Cold Red. Crude</th>
<th>Crude vs HDO P/A</th>
<th>Crude vs Hot Red. Crude</th>
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<td>Area per shell, ft²</td>
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**Hot stream**

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<tr>
<th>Description</th>
<th>Crude vs Naphtha</th>
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<th>Crude vs No 2 LDO P/A</th>
<th>Crude vs HDO Product</th>
<th>Crude vs Cold Red. Crude</th>
<th>Crude vs HDO P/A</th>
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<td>m³/h</td>
<td>m³/h</td>
<td>m³/h</td>
<td>m³/h</td>
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<td>63</td>
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<td>Klb/h used</td>
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<td>553</td>
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<td>414</td>
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</table>

<p>| Specific gravity | 0.660 | 0.717 | 0.792 | 0.789 | 0.789 | 0.859 | 0.949 | 0.865 | 0.949 |
| Liquid density, g/cc | 0.607 | 0.642 | 0.660 | 0.642 | 0.642 | 0.596 | 0.788 | 0.582 | 0.594 |
| Temp In | 149.0 | 173.0 | 226.2 | 239.7 | 239.7 | 316.4 | 227.7 | 324.2 | 353.6 |
| deg F | 300 | 343 | 439 | 463 | 463 | 602 | 442 | 616 | 668 |
| Enthalpy, Btu/lb | 156 | 186 | 246 | 261 | 261 | 360 | 251 | 359 | 369 |
| Temp Out | tag no. | 71.2 | 85.1 | 88.4 | 116.2 | 136.4 | 154.4 | 173.2 | 188.1 | 227.8 |
| mean - µ | deg F | 160 | 185 | 191 | 241 | 278 | 310 | 344 | 371 | 442 |
| std dev - σ | deg F | 75 | 92 | 96 | 126 | 148 | 171 | 131 | 208 | 251 |
| Enthalpy, Btu/lb | Specific heat, Btu/lb-F | 0.583 | 0.597 | 0.605 | 0.605 | 0.605 | 0.614 | 0.612 | 0.614 | 0.612 |
| X = (T1+T2)200, F | 2.30 | 2.64 | 3.15 | 3.52 | 3.70 | 4.56 | 3.93 | 4.93 | 5.55 |
| film h, Btu/h-F | 120 | 121 | 104 | 108 | 109 | 93 | 51 | 94 | 63 |
| Duty MMBtu/h | 147.9 | 20.0 | 83.7 | 35.2 | 44.20 | 74.2 | 70.5 | 87.9 | 162.7 |</p>
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<th>Name / Service</th>
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<td>DS Crude Oil Feed</td>
<td>DS Crude Oil Feed</td>
<td>DS Crude Oil from flash drum</td>
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Errors must be reconciled before optimization
Proposed retrofit – CDU
## Estd Op Cost Savings – CDU

### Energy Savings

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<th>$/hr</th>
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<th>K$/yr</th>
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<td>$/hr</td>
<td>h/yr</td>
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<tr>
<td>Elec power usage Δ</td>
<td>kw</td>
<td>$/kwh</td>
<td>$/hr</td>
<td>h/yr</td>
<td>K$/yr</td>
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<td>Elec power generation Δ</td>
<td>kw</td>
<td>$/kwh</td>
<td>$/hr</td>
<td>h/yr</td>
<td>K$/yr</td>
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</table>

Total savings (net) 685 K$/yr

**37% of New Des**

**Est. Cap Cost = $300 K, Simple Payback < 6 months**
Power Conservation (ASD for Seawater Circulation Pumps)

ASDs are a good option when there is significant flow or ΔP variation.
Proposed ASD Retrofit

Savings = $90K/yr,  Cap cost = $200K
Summary and Status Report

- 35 projects were identified & evaluated
- 6 were accepted by Plant Mgmt
- Savings potential = $9.7 MM/yr (35%) for Cap Cost of $41 MM
- Implemented savings = $0.5 MM/yr
- Rest delayed for political or legal reasons
Thank You