Reducing Water and Fuel Consumption Through Optimization of Plant Cooling Systems
Half of population already live in urban areas

2.6 billion lack basic sanitation

1.3 billion lack access to clean water

1.4 billion lack access to electricity
Energy-Water Nexus

- ASME’s initiative via the ASME Energy-Water Interdisciplinary Council
- Modern society is driven by a plethora of industrial, agricultural, and residential activities involving the consumption of energy and water.
- The energy-water nexus covers a broad array of activities and technologies.
Water demands could almost triple from 1995 consumption for projected mix of plants and cooling.

Carbon emission requirements will increase water consumption by an additional 1-2 Bgal/day.
Recirculating Cooling

Pond Cooling

Research Program for Electric Power Sector

- Improve dry and hybrid cooling system performance
- Improve ecological performance of intake structures for hydro and once-through cooling
- Improve materials and cooling approaches compatible with use of degraded water
- Electric grid infrastructure upgrades to improve low water use renewable technology integration

Hybrid Wet-Dry Cooling System
Surface Cleaning an ACC
Effective Utilization or Optimization of Existing Technology

- For Improvements to Condenser Efficiency by:
  - Effectively Cleaning the Condenser
  - Using Tracer Gas Leak Detection for Air and Water In-leakage
  - Performing Eddy Current Testing NDE
- Well Maintained Cooling Systems
  Optimize Value of the Cooling Water
- Less Fuel is Consumed
Mechanical Cleaning Options

- Most frequently chosen
- Generally applicable and effective
- Fast and easy to use

More Importantly:
- Improve heat transfer
- Protection from under-deposit corrosion
- Restore flow

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Mechanical Tube Cleaning

- Minimizes unit downtime – normal crew can clean 5000 tubes during a 10-hour shift

- Cleaners are effective on all types of deposits and will remove:
  - Fouling deposits
  - Corrosion products
  - Physical obstructions
  - Tube surface roughness
Spring-Loaded Cleaner in Action

- Color Coded For Quick Sizing
- Radial Designed Blades Match Tube Dimension
- Fouling Specific Architecture
- Spring-Loaded Blades Effectively Eliminate fouling
- Spring-Loaded Blades
- Scale and Corrosion
- Soft Deposits

Conco Services Corp. USA
Innovations in Tube Cleaners

Hex Cleaner

Cal-Buster™

Stainless Steel Tube Cleaning Brush
Tube Cleaning

- Select the most effective tube cleaner.
- Insert the tube cleaners into each tube.
- Utilizing the water gun and pump system the cleaners are “shot” through the tubes.
## Potential Savings from Improving Back Pressure

<table>
<thead>
<tr>
<th>Pressure Deviation (inches Hg)</th>
<th>100</th>
<th>400</th>
<th>600</th>
<th>1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Excess Back Pressure)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>$31,250</td>
<td>$125,000</td>
<td>$187,500</td>
<td>$312,500</td>
</tr>
<tr>
<td>0.2</td>
<td>62,500</td>
<td>250,000</td>
<td>375,000</td>
<td>625,000</td>
</tr>
<tr>
<td>0.3</td>
<td>91,750</td>
<td>375,000</td>
<td>562,500</td>
<td>937,500</td>
</tr>
<tr>
<td>0.4</td>
<td>125,000</td>
<td>500,000</td>
<td>750,000</td>
<td>1,250,000</td>
</tr>
<tr>
<td>0.5</td>
<td>156,250</td>
<td>625,000</td>
<td>937,500</td>
<td>1,562,500</td>
</tr>
</tbody>
</table>

*Source: “Operation and Maintenance of Steam Surface Condensers”, Fossil Plant News, EPRI*
## Typical Results Pre and Post Cleaning

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
<th>Chg.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A Back Pressure</strong></td>
<td>Inches Hg.</td>
<td>3.6</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>B Back Pressure</strong></td>
<td>Inches Hg.</td>
<td>4.3</td>
<td>2.9</td>
</tr>
<tr>
<td><strong>Circ Water Velocity</strong></td>
<td>Ft/sec</td>
<td>5.7</td>
<td>6.5</td>
</tr>
<tr>
<td><strong>Net Generation</strong></td>
<td>MW</td>
<td>659.4</td>
<td>686.5</td>
</tr>
</tbody>
</table>
Additional Benefits

- Economic Benefit
  - Immediate Return on Investment
  - Reduced Costs
- Recovery of lost megawatts or increased generation capacity
- Fuel savings
- Reduction in CO$_2$ emissions
- Extended useful life of the condenser
Quick Calculations

Heat Rate

- Assume .3 hg condenser backpressure is equivalent to 10% improvement in condenser performance
- Each 10% improvement in the condenser correlates to 1% improvement in HR (10,000 btu/kWh) or MW output

MW loss

- 8760 hrs./yr.
- Capacity Factor
- Price per MWh
- MW

Ex: 8760 x .70 x $60.00 x 2 MW = US $ 735,840.00

Ex: .6 hg = 20% CF = 2% HR = 2 MW

Ex: 8760 x .70 x $60.00 x 3 MW = US $1,103,760.00

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Leakage of air or water into the condenser will adversely affect plant efficiency, reliability and availability

- Increased plant heat rate
- Increased risk to turbine components
- High levels of dissolved O$_2$ in feedwater means increased deterioration of boiler and feed systems
When Plants Need to Test

Proactive Testing
- Routine inspection to understand where potential failures will occur
- Before an outage so components in need of repair are scheduled for repair
- After an outage to insure all repairs were made successfully

Reactive Testing
- Emergency inspections as a result of catastrophic failure or because inleakage has exceeded the air removal system capability
Sources of Air Inleakage

- Inleakage to shell
- Rupture discs
- Shaft seals
- Test probe penetrations
- Man ways
- Vacuum pumps
- Flanges
- Bolt holes
Sources of Water Inleakage

- Water box flanges
- Faulty tube plugs
- Leaking hotwell components
- Through-wall penetrations
- Tube to tubesheet joints
Air In-Leakage

- Air and water inleakage continues to cost generators hundreds of thousands to millions of dollars annually.
- Condenser tube leaks cause more than 6,000 forced outages annually and rank as one of the highest concerns among plant chemists.
- In addition to reactive leak detection, a proactive regimen of testing can keep total air inleakage in check.
- ROI for leak detection maintenance dollars spent are usually in the 1000% + range, so don’t wait!
## Typical Weights and Heating Values for Three Major Fuels

<table>
<thead>
<tr>
<th>Fuel</th>
<th>C lb/lb fuel</th>
<th>HV BTU/lb</th>
<th>lbs. CO$_2$ / MBTU loss</th>
<th>lbs. Carbon/ MBTU loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bituminous Coal</td>
<td>0.86</td>
<td>13930</td>
<td>238.1</td>
<td>64.987</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>0.863</td>
<td>18558</td>
<td>179.4</td>
<td>48.950</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0.749</td>
<td>25128</td>
<td>115.0</td>
<td>31.376</td>
</tr>
</tbody>
</table>

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Impact on Emissions

- 1 lb. Carbon produces 3.6644 lb. of CO₂
- The table equates equivalent carbon emissions per MBtu loss

If: the fouling loss is 34.968 MBtu
and the fuel is bituminous coal

Then:

\[
\text{Carbon emissions} = \frac{34.968 \times 64.987 \times 8000}{2}
\]

\[
= 9.09 \text{ million pounds of carbon per year}
\]
Cleaning improves performance

“The cleaning of the tubes using CONCO C4S cleaners was excellent, projecting a new cleaning at the next general maintenance of the plant”. (Andres Gatica, Nexxo)
Production rises considerably after cleaning

Heat Exchanger A
Vacuum pressure before cleaning
280 mmHg
258 mmHg

Heat Exchanger B
Vacuum pressure after cleaning
496 mmHg
711 mmHg

“Due to these new vacuum pressure numbers, the plant was able to obtain a significant improvement on the performance and efficiency of the two heat exchangers, normalizing the factory generation process”. (Jhon Batista, Blastingmar)
"Switching from Hydro blasting to the CONCO technology, provided effective cleaning by removing sand and the entire silica deposits from the tube walls". (Nelson Cansanção Neto, Expander)
Mitee Mouse II, Cal-Busters and C4S Cleaners demonstrated exceptional performance despite extremely hard and compact deposits.

“The DSL group, with the support of Conco, unblocked and cleaned 30,000 tubes in 7 days, recovering the heat exchanger”. (Martin Formoso, DSL Group)
Conclusion

- Optimizing the value of the cooling water will reduce water consumption, incorporating the application of state-of-the-art technologies for condenser cleaning and air in-leakage detection major improvements can be achieved.

- This presentation demonstrates the correlation between improved condenser performance, reduced fuel consumption and a reduction in CO₂ emissions.

- Literally, tons of emissions and fuel have been avoided due to the implementation of these sound practices.

- The technology is available for deployment in South America.