- Superior Mass Transfer Capabilities allows comparable performance at reduced L/G ratios

- Design Comparison for 500 MW, 1.2% sulfur, 98% SO₂ removal

<table>
<thead>
<tr>
<th></th>
<th>Open Spray Tower</th>
<th>DFT Tower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorber Diameter, meters</td>
<td>15.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Recycle Tank Retention Time, mins</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Recycle Tank Height, meters</td>
<td>10.1</td>
<td>7.4</td>
</tr>
<tr>
<td>Number of Recycle Pumps</td>
<td>3+1</td>
<td>2+1</td>
</tr>
<tr>
<td>Recycle Pump Flowrate, m3/hr</td>
<td>6,100</td>
<td>6,670</td>
</tr>
<tr>
<td>Number of Trays</td>
<td>Zero (0)</td>
<td>One (1)</td>
</tr>
<tr>
<td>Overall Tower Height, meters</td>
<td>30.3</td>
<td>26.1</td>
</tr>
<tr>
<td>Absorber Power Consumption, kw</td>
<td>1,800</td>
<td>1,310</td>
</tr>
<tr>
<td>Pressure Drop, kPa</td>
<td>1.0</td>
<td>1.4</td>
</tr>
</tbody>
</table>
Capital Cost Advantages for DFT Absorber vs Open Tower

- Absorber is shorter in height
- One (1) fewer recycle pump and piping system
- Smaller absorber area footprint
- Smaller absorber access structure
- Thinner absorber shell steel
- Reduced foundations
- Less auxiliary piping
- Less electrical cable and conduit
- Less instrument and control cable
- Lower construction costs

Identical (to slightly less) operating costs compared to open tower

- Gas pressure drop power offset by lower recycle pumping rates
Dual Flow Tray (DFT) Technology
New Build Wet FGD System

- Maintenance Advantage
  - Designed for Maintenance Loads
  - Initial construction staging platform
  - Installed inspection platform
  - Shorter outages
  - Minimal scaffolding and Lift Equipment reduce outage costs
Performance Improvement Chemistry Options

- Operating pH increase
  - Limited by chemistry concerns
  - Limestone stoichiometry
  - Sulfite to sulfate oxidation
  - Gypsum purity
  - Scaling

- Higher Quality Limestone
  - Smaller grind
  - Higher Reactivity
  - Not typically reasonable option due to cost / availability

Marginal performance improvement (1% - 3%)
Dual Flow Tray Technology
Existing Wet FGD Upgrades

► Performance Improvement by Equipment Modifications
  ► Wall Rings
    ▶ Reduces flue gas sneakage along side walls of absorber
    ▶ Most effective only if spray distribution system is poorly designed
    ▶ Marginal improvement expected (1% - 3%)

  ► Higher Pressure Spray Nozzles
    ▶ Smaller spray droplet / More surface area for mass transfer
    ▶ Higher pumping power
    ▶ Recycle Pump Motor change
    ▶ Droplet coalescence limits improvement

  ► Alternate Style Spray Nozzles
    ▶ Smaller spray droplet / More surface area for mass transfer
    ▶ Droplet coalescence limits improvement
Dual Flow Tray Technology
Existing Wet FGD Upgrades

► Performance Improvement by Equipment Modifications
  ► Additional L/G Ratio
    ► Generally required for significant efficiency improvement (>5%)
    ► Challenging to accomplish with an existing system
    ► Is there plot space available for larger or more recycle pumps?
    ► Is there absorber height available for more spray headers?
    ► Will the recycle pipe size need modification?
    ► Recycle tank retention time concerns
    ► Outage time requirement

► Dual Flow Tray Solution
  ► 1st upgrade in 1991 of four existing open spray towers in USA
  ► Most Recent upgrade done in May 2015 Startup
  ► 42 open spray / packed bed absorbers have been retrofitted with Dual Flow Trays
  ► Efficiency improvements from 80% up to 98%
Dual Flow Tray Technology
Existing Wet FGD Upgrades

► Dual Flow Tray Solution
  ► Ideal for performance improvement of an existing upflow open spray tower

► Full Scale Data indicate as much as 50% improvement in number of transfer units (NTU’s) of existing open spray tower
  ► 80% current SO2 efficiency ➔ 90% SO2 efficiency
  ► 85% current SO2 efficiency ➔ 93% SO2 efficiency
  ► 90% current SO2 efficiency ➔ 96% SO2 efficiency

► 1.0 – 1.5 meters of space required between top of inlet flue gas duct and lowest spray level

► Adequate access into absorber recycle tank needed to install support steel and Tray Sections

► Adequate Fan Capacity for expected 0.4 kpa pressure drop increase