Advances in Emission Control and Monitoring Technology for Industrial Sources
Exton, PA
July 9-10, 2008
Electrostatic Precipitators

Power Solutions
TOPICS COVERED IN THIS PRESENTATION

- Why PowerPlus is a better solution for ESP Power Supplies
- Examples of ESP Performance Using PowerPlus
Precipitator

Collection improvements

with Switch Mode Power Technology

At a lower cost to users
PowerPlus Product Line

- 70 kW with 3 port switch
- 105/120 kW
- 70 kW with bottom exit switch
Why is PowerPlus Better than a Conventional TR System?
# Key Parameter Comparison: PowerPlus 70kW vs. Conventional T/R Systems

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>POWERPLUS 70 (typical)</th>
<th>CONVENTIONAL T/R SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>kVdc</td>
<td>70</td>
<td>65</td>
</tr>
<tr>
<td>mAdc</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Output kW</td>
<td>70</td>
<td>65</td>
</tr>
<tr>
<td>Peak kV</td>
<td>71.8</td>
<td>109.2</td>
</tr>
<tr>
<td>% Ripple kVp-p</td>
<td>3-5</td>
<td>35-45</td>
</tr>
<tr>
<td>Number of phases</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Iline (AAC)</td>
<td>94</td>
<td>227.1</td>
</tr>
<tr>
<td>Power Factor</td>
<td>.94</td>
<td>.63</td>
</tr>
<tr>
<td>Input kVA</td>
<td>78.7</td>
<td>109</td>
</tr>
<tr>
<td>Arc shutdown time</td>
<td>30 usec</td>
<td>8.33 msec</td>
</tr>
</tbody>
</table>
Spark over
Peak KV
AC Ripple
Average DC
Power Factor = \cos \theta = \frac{\text{KW}}{\text{KVA}}

Examples:

- **PowerPlus Unit**
  - Power Factor = .94

- **Equiv. T/R Set**
  - Power Factor = .63

**Power Triangle**

\[ \text{KVA} \quad \theta \quad \text{KVAR} \]

\[ \text{KW} \]

\[ 73.6 \text{ KW} \]

\( \text{(KW out + Losses)} \)

\[ 73.6 \text{ KW} \quad 25.8 \text{ KVAR} \quad 89.7 \text{ KVAR} \]

\[ 78.7 \text{ KVA} \quad 116 \text{ KVA} \]
Intermittent Energization with PowerPlus

On: 0.1 to 10 msec.
Off: 0.1 to 99 msec.
in 0.1 msec increments

PowerPlus IE can switch faster and more frequently than conventional IE. The result is greater flexibility in collecting moderate resistivity dust.

Conventional T/R
Intermittent Energization
(1 half cycle on
1 full cycle off)
PowerPlus Installations

Results and Benefits
PSE & G Mercer Power Plant 2003
PowerPlus installed in Poland
Started with 120 mg/Nm$^3$

NWL & Balcke-Durr Poland
PowerPlus installed in Poland
Before modernization of the ESP the original ESP’s supplier guarantee was 170mg/Nm3 for gas flow 900 000Nm3/h

Guarantee given before work started 50 mg/Nm3 at flow 900 000 Nm3/h. base on the same coal quality.

Performance test results (gravimetric measurements) from Polaniec Plant unit No 7 after modernization
Gas flow at 225MW was 960 000Nm3/h wet gas and outlet dust concentration average 18mg/Nm3 dry gas & 6% O2
Plant Kraft Unit #1 Precipitator
**Kraft 1 SMPS - KW Comparisons**

- **Compare 1-4 to SMPS on Outlet**
  - 77% Increase

- **Compare 1-1 to SMPS on Inlet**
  - 121% Increase
Results of Phase 2
Assist applied to downstream T-Rs by SMPS

Average KW of T-R 1-2 Before SMPS on Inlet  
11.19
Average KW of T-R 1-2 with SMPS on Inlet  
14.38
Increase / Decrease (%)  
28%

Average KW of T-R 1-3 Before SMPS on Inlet  
17.91
Average KW of T-R 1-3 with SMPS on Inlet  
20.34
Increase / Decrease (%)  
14%

Average KW of T-R 1-4 Before SMPS on Inlet  
23.38
Average KW of T-R 1-4 with SMPS on Inlet  
24.96
Increase / Decrease (%)  
7%
SMPS Units on West Side

Conventional T-R Units on East Side
Unit 3 East vs. West KW
(Daily Averages @ >90 Mw)

Date
10/1/02 10/31/02 11/30/02 12/30/02 1/29/03 2/28/03 3/30/03 4/29/03

Kw
250.0
200.0
150.0
100.0
50.0
0.0

Outage

PowerPlus

Standard T/R's

Green: OPACITY
Red: East Kw
Blue: West Kw
Golf Power Lansing Smith unit 1
Gulf Power Lansing Smith 1

Generation (200Mw max)

Outage

Before Opacity

After Opacity
Gulf Power Lansing Smith 1
Before and After SMPS’

Unit 2 Total KVA

T-R Power Consumption
Before Rebuild

SMPS Power Consumption
After Rebuild

0 50 100 150 200 250 300 350 400 450 500
4/23/04 6/12/04 8/1/04 9/20/04 11/9/04 12/29/04 2/17/05 4/8/05 5/28/05 7/17/05

Total T-R KVA  SMPS KVA
Historical Power Consumption: Smith 2 vs. Peer Group

Legend:
- Existing Configuration
- Rebuilt

Notes:
- Power Levels are that required to maintain optimal Opacity
- All data taken at full boiler loads

Test Case (PowerPlus')

Peer Group (T-Rs)

Courtesy:
Calculated SMPS Benefit for Upcoming Installation

<table>
<thead>
<tr>
<th>SMPS EFFICIENCY VALUE</th>
<th>SMPS</th>
<th>Traditional TR</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESP Consumed Power (kW)</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Power Factor</td>
<td>0.94</td>
<td>0.63</td>
</tr>
<tr>
<td>Resulting KVA</td>
<td>212.8</td>
<td>317.5</td>
</tr>
<tr>
<td>KVA Benefit</td>
<td>104.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Unit 8 Accumulated Present Worth (2008 - 2012)</td>
<td>$121,550</td>
<td>$0</td>
</tr>
<tr>
<td>Unit 9 Accumulated Present Worth (2008 - 2012)</td>
<td>$119,770</td>
<td>$0</td>
</tr>
<tr>
<td>Total APW (2008 - 2012)</td>
<td>$241,320</td>
<td>$0</td>
</tr>
</tbody>
</table>

* Based on 2005 Unit Worth of Improvement Data

Benefit will continue for the life of the Units

Courtesy:
Southern Company SMPS Fleet Status

G. Klemm – 7/23/07
Smith 1

Performance History at Full Load

- T-R Operation
- SMPS Operation After Rebuild
- Pri. KVA – 415
- Sec. KW – 152
- Pri. KVA – 301
- Sec. KW – 237
- Opacity – 7.5% (X10 Multiplier)
- Opacity – 3.4% (X10 Multiplier)

Legend:
- T-R Op X10
- T-R KW
- T-R KVA
- SMPS Op X10
- SMPS KW
- SMPS KVA
### Smith Performance Summary

#### Degradation over Time

<table>
<thead>
<tr>
<th>T-Rs</th>
<th>Test Period</th>
<th>Cdttn</th>
<th>Op</th>
<th>KW</th>
<th>KVA</th>
<th>SMPS'</th>
<th>Test Period</th>
<th>Cdttn</th>
<th>Op</th>
<th>KW</th>
<th>KVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6/2/-25/06</td>
<td>Base</td>
<td>5.5</td>
<td>178.2</td>
<td>467.4</td>
<td>5/25/-29/07</td>
<td>Base</td>
<td>2.7</td>
<td>227.1</td>
<td>288.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8/25/-9/17/06</td>
<td>Advanced</td>
<td>8.0</td>
<td>152.2</td>
<td>337.4</td>
<td>6/21/-24/07</td>
<td>Advanced</td>
<td>3.7</td>
<td>243.9</td>
<td>328.6</td>
<td></td>
</tr>
</tbody>
</table>

| Change (%)   | 46% -15% -28% | Change (%) | 39% 7% 14% |
| Change (Pt)  | 2.5 -25.9 -130.0 | Change (Pt) | 1.0 16.9 40.3 |
| Change/day (%)| 80 0.6% -0.18% -0.35% | Change/day (%) | 30 1.3% 0.25% 0.47% |
| Change/day (Pt) | 80 0.031 -0.324 -1.624 | Change/day (Pt) | 30 0.035 0.563 1.343 |

#### Performance Comparison

<table>
<thead>
<tr>
<th>T-Rs</th>
<th>Test Period</th>
<th>Cdttn</th>
<th>Op</th>
<th>KW</th>
<th>KVA</th>
<th>SMPS'</th>
<th>Test Period</th>
<th>Cdttn</th>
<th>Op</th>
<th>KW</th>
<th>KVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6/2/-10/8/06</td>
<td>Base</td>
<td>7.5</td>
<td>152.0</td>
<td>415.3</td>
<td>5/21/-6/24/07</td>
<td>Base</td>
<td>3.4</td>
<td>237.2</td>
<td>301.2</td>
<td></td>
</tr>
</tbody>
</table>

| Change (%)   | -55% 56% -27% |
| Change (Pt)  | -4.1 85.2 -114.0 |
| KW Savings ($/yr) | $27,781.21 |
Smith 2
Performance History at Full Load

- T-R Operation
- SMPS Operation After Rebuild

- Pri. KVA - 403
- Sec. KW - 310
- Opacity - 11.2% (X10 Multiplier)

- Pri. KVA - 360
- Sec. KW - 281.5
- Opacity - 6.3% (X10 Multiplier)

Graph showing historical data with various metrics for Smith 2.
# Smith 2 Performance Summary

## Degredation over Time

<table>
<thead>
<tr>
<th></th>
<th>Test Period</th>
<th>Cdttn</th>
<th>Op</th>
<th>KW</th>
<th>KVA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T-Rs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/1-6-9/04</td>
<td>Base</td>
<td>9.9</td>
<td>310.0</td>
<td>403.1</td>
<td></td>
</tr>
<tr>
<td>1/28/05-2/13/05</td>
<td>Advanced</td>
<td>12.1</td>
<td>293.1</td>
<td>381.1</td>
<td></td>
</tr>
<tr>
<td><strong>SMPS’</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/20/-11/20/06</td>
<td>Base</td>
<td>5.0</td>
<td>288.6</td>
<td>372.6</td>
<td></td>
</tr>
<tr>
<td>2/28/-3/28/07</td>
<td>Advanced</td>
<td>7.58</td>
<td>281.7</td>
<td>360.1</td>
<td></td>
</tr>
</tbody>
</table>

| Change (%) | 23% | -5% | -5% |
| Change (Pt) | 2.2  | -16.9 | -22.0 |
| Change/day (%) | 0.1% | -0.023% | -0.023% |
| Change/day (Pt) | 0.009 | -0.071 | -0.092 |
| Change/day (%) | 51% | -2% | -3% |
| Change (Pt) | 2.6  | -6.9 | -12.5 |
| Change/day (%) | 0.4% | -0.020% | -0.028% |
| Change/day (Pt) | 0.021 | -0.058 | -0.104 |

## Performance Comparison

<table>
<thead>
<tr>
<th></th>
<th>Test Period</th>
<th>Cdttn</th>
<th>Op</th>
<th>KW</th>
<th>KVA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T-Rs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/2/-10/8/06</td>
<td>Base</td>
<td>11.2</td>
<td>310.0</td>
<td>403.0</td>
<td></td>
</tr>
<tr>
<td><strong>SMPS’</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5/21/-6/24/07</td>
<td>Base</td>
<td>6.3</td>
<td>281.5</td>
<td>360.1</td>
<td></td>
</tr>
</tbody>
</table>

| Change (%) | -44% | -9% | -11% |
| Change (Pt) | -4.9  | -28.5 | -42.9 |
| KW | 40.330 |
| Savings ($/yr) | $10,453.63 |
## Barry 5C&D

### Barry 5 Performance Summary

<table>
<thead>
<tr>
<th>Performance Comparison</th>
<th>T-Rs</th>
<th>SMPS'</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test Period</td>
<td>Cdt</td>
</tr>
<tr>
<td>9/6/-10/16/06 Base</td>
<td>8.1</td>
<td>413.4</td>
</tr>
<tr>
<td>5/21/-6/24/07 Base</td>
<td>5.1</td>
<td>784.0</td>
</tr>
<tr>
<td>Change (%)</td>
<td>-59%</td>
<td>47%</td>
</tr>
<tr>
<td>Change (Pt)</td>
<td>-3.0</td>
<td>370.6</td>
</tr>
<tr>
<td>KW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savings ($/yr)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
General PowerPlus Benefits

We have seen the following general improvements on ESP’s performances after PowerPlus was installed.

Rebuilds
10-15% more KV
20-30% more ma for coal up to $5 \times 10^{10}$ ohms centimeter

New units
15-18% more KV
Up to 50% more ma for coal up $5 \times 10^{10}$ ohms centimeter
Questions?

Thank you very much