INTRODUCTION

In May of 2003, the 3,150 TPD Pinellas County Resource Recovery Facility (PCRRF), the largest waste-to-energy plant in the United States, reached its 20-year milestone. The PCRRF is located in St. Petersburg, Florida, on a 705 acre (1.1 square mile) site owned by Pinellas County and known as “Bridgeway Acres”. The PCRRF has been owned by Pinellas County, operated by Wheelabrator Pinellas, Inc. (WPI) and monitored by HDR Engineering, Inc. since its inception. In addition to the PCRRF, the County operates both Class I and Class III landfills on the site.

In 2000, following a successful 4-year Air Pollution Control (APC) Retrofit Project, the County embarked on a major facility upgrade, entitled “Capital Replacement Project” (CRP), in order to renew certain critical and aging equipment, maximize the operating performance and prepare the facility for a new operating contract upon the current contract’s expiration in May, 2007. The main component of the CRP was the redesign and rebuilding of each of the three 1,050 TPD boilers. This was done during 16-week periods, September through December, in 2001 (Unit 2), 2002 (Unit 1), and 2003 (Unit 3). Acceptance tests were performed during the January following completion of each boiler, and the final acceptance test was certified by Pinellas County in February, 2004. This paper reviews the scope of work for the CRP, acceptance test results, and operational statistics for pre and post CRP periods.

Project History

Two boilers (Units 1 and 2) and a 50 MW turbine generator (T/G 1), along with all ancillary equipment, commenced operation in 1983. In 1986, a third boiler (Unit 3) and a 25 MW turbine (T/G 2) became operational. All boiler units were designed to produce superheated steam to the T/Gs at 615 psig and 750°F. However, after 13 to 16 years of operation, the boilers required frequent cleaning due to gas-side fouling and severe corrosion caused by the high temperatures. Also, high economizer gas exit temperatures and off-design superheater outlet temperatures resulted in loss of turbine efficiency and generator capacity. Thus, there was an obvious need to redesign and reconstruct the boilers in order to ensure reliable facility operation beyond 20 years.

The Agreement between Pinellas County Utilities with Progress Energy Florida (PEF) for power purchase has a significant capacity component as well as an energy component. The Agreement requires the continuous maintenance of a monthly rolling average capacity factor equal to 70% of the declared capacity of 54.75 MW. During some prior periods of lower facility availability, the capacity margin was below desired levels, although it never reached the 70% threshold. The CRP implementation was spread out over a 3-year period in part to coincide with available curtailment windows from PEF.

CRP Scope of Work

Two-thirds of the $56.5 million CRP cost was devoted to reconstruction of the boilers, from the furnace gas exit to the economizer gas exit. (See Figure 1) The remaining expenditures were for the following activities:

- Replacement of two electric-driven boiler feedwater pumps (BFPs), rebuilding of the existing pump and installation of the overhauled BFPs in the steam drive (standby) positions.
- Complete rebuilding of three refuse cranes, including increased rating from 11 tons to 15 tons.
- Replacement of numerous components of the five-cell cooling tower, including selective replacement of damaged fill in all cells, new drift eliminators in three cells, replacement of mechanical equipment, fan deck, hot water distribution boxes and risers, and selected replacement of deteriorated structural framing.
- Replacement of the original dual-bed demineralizer system for boiler makeup water production.
- Substantial modification of the Martin grate instrumentation and control system with the latest technology.
- Upgrade and modernization of the plant control room and control systems to expand the distributed control system (DCS) and replace obsolete control and monitoring equipment.
- Expansion of the tipping floor and modification of the traffic pattern from in/out at both ends to seven new entrance/exit doors on the north side of the building. This facilitated a faster flow of truck traffic delivering MSW to the facility.

BOILER REDESIGN
Babcock Borsig Power, Inc. designed the boiler modifications, incorporating changes to address the significant operational problems, namely, flue gas path cleanliness, achievement of rated final steam temperatures, and lower economizer exit gas temperatures. The heating surface of the boiler was increased to produce superheated steam temperatures in both the clean and fouled conditions. Table 1 lists the changes on heating surfaces.

Referring to Figure 1, the spacing between the tube bundles was increased to reduce the potential for fouling. The evaporator pass incorporated long flow elements with 20-inch spacing, and a mechanical rapper that shakes the tube panels. The superheater has retractable sootblowers and 10-inch spacing. The economizer has rotary sootblowers and 4½-inch spacing. Even with sootblowers, it is necessary to clean the boiler for maintenance. The boiler surface areas and access doors were positioned to optimize access to the sections of the boiler (having a tendency to foul) for percussion blast cleaning. Water is not used for boiler cleaning.

The superheater sections utilize dual attemperators in the primary and secondary superheaters to control superheated steam temperatures at varying boiler cleanliness conditions. The secondary superheater section is made of stainless steel tube material, instead of carbon steel, to increase the life expectancy of the superheater section. Tube shields are strategically positioned throughout the superheater and economizer sections to protect exposed tubes from the sootblowers.

All of these changes effectively optimized boiler performance (consistently meet 750°F steam temperatures), and boiler reliability has substantially increased as will be shown below.

ACCEPTANCE TESTING
Following the completion of each boiler retrofit, acceptance testing was successfully completed on Units 2, 1 and 3 over a 7-day period in January 2002, 2003 and 2004, respectively. The following required criteria for acceptance were established:

1. Minimum of 210,000 pounds per hour of steam. (35,280,000 pounds during the 7-day acceptance test period, adjusted upwards for any contribution caused by natural gas consumption).
2. Minimum steam temperature average of 675°F.
3. Meeting all air permit limits, based on the Continuous Emission Monitors (CEMs).
4. Minimum of 6,603 tons of acceptable waste processed.

Acceptance test guarantees and results for all three boilers are listed in Table 2.

PERFORMANCE RESULTS
Implementation of the CRP has resulted in significant performance improvements. These improvements cover four broad categories:

1. Availability Improvements
2. Efficiency Improvements
3. MSW Throughput Increase
4. Electricity Production Increase

Availability Improvements
Overall facility average boiler availability has improved significantly. During the 3-year period of project implementation (2001 through 2003), facility availability was obviously impacted negatively by the 16 week boiler reconstruction schedule on one unit each year. However, as each refitted boiler was returned to service, its availability improved considerably. Comparison of the pre-CRP period to the post implementation period is shown in Table 3.

The boilers typically have an annual scheduled outage rotation of two short duration (5 day) outages for grate inspections, boiler cleanings, refractory repairs, and one longer (approximately 7 to 8 days) outage for major maintenance, as required. Intermediate on-line percussion cleanings are conducted as required, currently bi-monthly.

The boiler availability improvements during 2004 were responsible for a significant portion of the MSW throughput increase of over 14% (refer to Figure 2). Related factors contributing to the increase in MSW consumption were higher average steam load during on-line hours, and lower waste heating value. The net electrical generation increase of over 29% was attributable to a combination of the turbine efficiency improvement and the availability increase, in approximately equal shares.

Efficiency
The implementation of the CRP has increased both boiler and turbine-generator efficiency. The increase in boiler efficiency is manifested in lower economizer gas exit temperatures and in higher main steam temperatures. Both of these factors result in more energy becoming available to perform useful work from each ton of MSW combusted.

Prior to CRP implementation, exit gas temperatures from the economizer were in the range of 525°F to 650°F. This represents energy effectively wasted up the stack. Post CRP flue gas exit temperatures range from 475°F clean to 550°F dirty, on average.

In the pre-CRP period, main steam temperatures were in the range of 640°F to 675°F, compared to an original design of
750°F. Implementation of the CRP has resulted in the ability to maintain steam temperatures consistently at 750°F, using a small amount of superheater attemperation spray. The achievement of rated steam temperatures has resulted in major improvements in turbine efficiency on both of the turbines. This is demonstrated by Table 4, which shows the amount of steam required to generate one kw of electricity prior to and after the CRP implementation. The improvement in T/G No. 1 is 10 percent, and in T/G No. 2, 10.4 percent. These values are consistent with the calculated improvement from the increased turbine inlet steam conditions of temperature and enthalpy.

SUMMARY
Figures 2 and 3 show graphically the PCRRF performance for the past 10 years. Calendar year 2004 performance reflects record performance for both MSW processed and net electricity delivered to the grid. As of this writing (January 2005), rolling average capacity has increased to nearly 97% (also a historical record). And, the PCRRF is now positioned to enjoy many more years of productive service for the benefit of the citizens of Pinellas County, FL.
### Table 1
**PCFFR – Boiler Heating Surface Comparison**

<table>
<thead>
<tr>
<th>Boiler Sections</th>
<th>Old Heating Surface</th>
<th>New Heating Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaporator</td>
<td>7,750 ft(^2)</td>
<td>18,824 ft(^2)</td>
</tr>
<tr>
<td>Superheater</td>
<td>15,779 ft(^2)</td>
<td>19,813 ft(^2)</td>
</tr>
<tr>
<td>Economizer</td>
<td>27,000 ft(^2)</td>
<td>32,186 ft(^2)</td>
</tr>
</tbody>
</table>

### Table 2
**Acceptance Test Guarantees and Results**

<table>
<thead>
<tr>
<th>Test Guarantees</th>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Unit 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiler Steam Load</td>
<td>210,000 pph (min.)</td>
<td>226,227 pph</td>
<td>222,346 pph</td>
</tr>
<tr>
<td>Steam Temperature</td>
<td>675°F (min.)</td>
<td>750.8°F</td>
<td>749.8°F</td>
</tr>
<tr>
<td>Air Permit Limits</td>
<td>Maintain CEM compliance</td>
<td>Met</td>
<td>Met</td>
</tr>
<tr>
<td>Acceptable Waste Processed</td>
<td>6,603 tons (min.)</td>
<td>7,312 tons</td>
<td>8,514 tons</td>
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</table>

### Table 3
**Boiler Availability**

<table>
<thead>
<tr>
<th></th>
<th>Pre-CRP Availability, %</th>
<th>Post-CRP Availability, %</th>
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</thead>
<tbody>
<tr>
<td>Boiler No. 1</td>
<td>82.5</td>
<td>92.2</td>
</tr>
<tr>
<td>Boiler No. 2</td>
<td>84.5</td>
<td>87.6</td>
</tr>
<tr>
<td>Boiler No. 3</td>
<td>86.2</td>
<td>93.2</td>
</tr>
<tr>
<td>Facility Total</td>
<td>84.4</td>
<td>91.0</td>
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</table>

### Table 4
**Specific Steam Consumption of Turbine Generators**

<table>
<thead>
<tr>
<th>Boiler No. 1</th>
<th>Turbine 1 Specific Steam Consumption, lbs per kwhr</th>
<th>Turbine 2 Specific Steam Consumption, lbs per kwhr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-CRP (CY 2000)</td>
<td>10.47</td>
<td>11.41</td>
</tr>
<tr>
<td>Post-CRP 1 year average</td>
<td>9.42</td>
<td>10.22</td>
</tr>
</tbody>
</table>
Figure 1
Boiler Cross-Sectional View

SECTIONAL R.H. SIDE ELEVATION
WHEELABRATOR PINELLAS INC.
UNITS #1, #2, & #3
THREE @ 244,000 lb/hr - 615 PSIG OPERATING - 750°F

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Figure 2
Annual MSW Throughput

Figure 3
Annual Net MW Generation