

POLK POWER STATION - 6TH COMMERCIAL YEAR OF OPERATION

by

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and

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PRESENTED AT

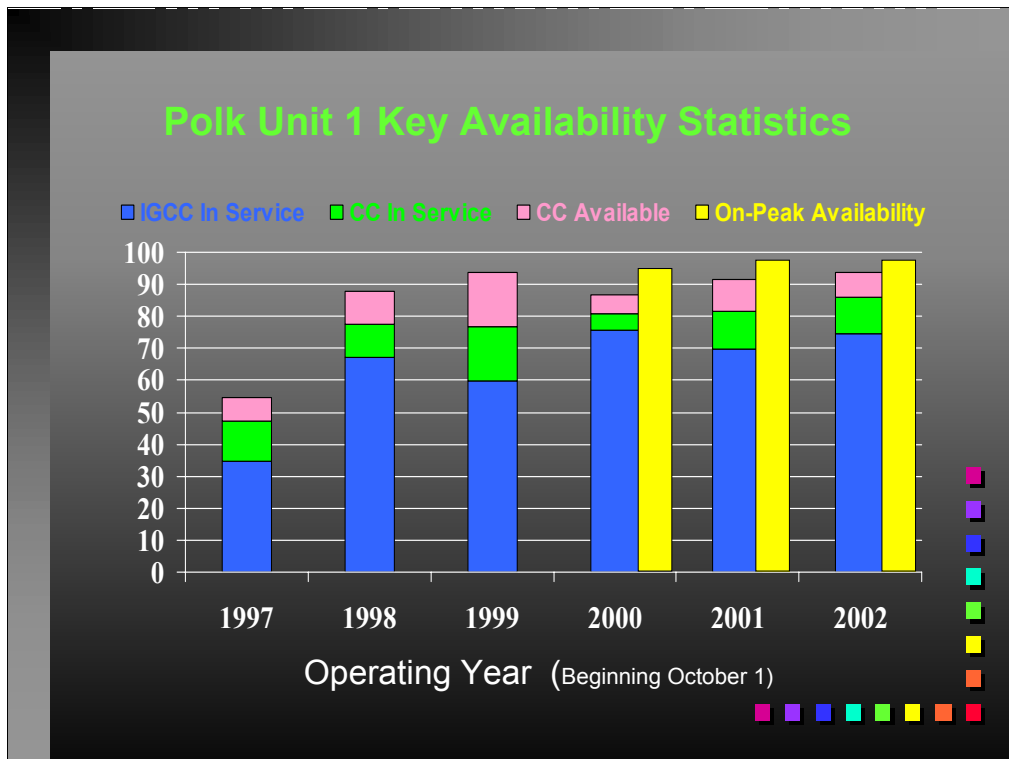
2002 GASIFICATION TECHNOLOGIES CONFERENCE

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Polk Power Station recently completed its 6th year of commercial operation.

Today's presentation will contain:

- Polk's operating statistics prescribed by the GTC's guidelines,
- Summary of the major outage causes encountered in year 6,
- Discussion of significant accomplishments in year 6.



This slide shows the key overall plant performance statistics.

The combined cycle is always operated on syngas fuel when available. The combined cycle was firing syngas fuel (IGCC In-Service) about 75% of the time during the 6th operating year which ended October 1, 2002. Although this is good and it reflects improvement over last year, we believe we can do better since we have eliminated 75% of the plant's recent outages causes as we'll discuss later.

The Combined Cycle has been in service on syngas or distillate fuel (CC In-Service) an average of about 80% of the time during the last few years. However, it is not always operated on distillate fuel when the gasifier is down since distillate fuel is more expensive, so the combined cycle's availability is always higher than its In-Service factor. The combined cycle availability has averaged about 90% for several years. 2002 was near the top of the range for both combined cycle in-service factor and availability.

On-peak availability has averaged 98% the last two years. (This important parameter has only been tracked for a little over the last three years, so there is no data prior to 1999/2000.)

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Subsystem Availability

(Service Hours + Reserve Shutdown Hours) / Period Hours

	Year 6 (2002) Availability	Expected Availability
ASU	96	96-98
Power Block	94	94-96
Gasification	77	80-90

The subsystem statistics provide more insights than the overall plant statistics.

ASU and Power Block availability were within their target range in the 6th operating year ending October 1, 2002. The gasification system's 77% availability was disappointing. Key issues were:

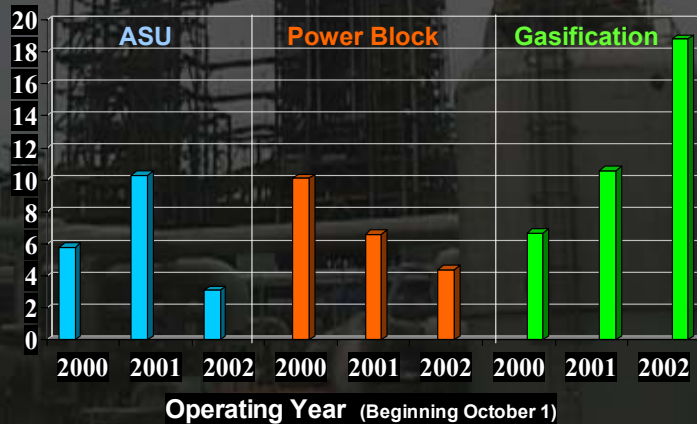
- CSC pluggage and leaks,
- Leaks in syngas piping between the CSC and the syngas scrubbers,
- the variable speed drive of the slurry feed pump,
- a specific heat stable salt in the MDEA system which caused corrosion,
- COS hydrolysis catalyst damage caused by placing the reactor in service too soon after gasifier light-off.

Problems causing 75% of the lost production in the gasification system have been resolved and should not recur, so we expect better performance next year.

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Unplanned Outage Rate

Unplanned Outage Rate = Unplanned Outage Hours / (Service Hours + Unplanned Outage Hours)



The trends of unplanned outage rates of the three main subsystems over the last three years are probably the most revealing of the statistics.

The ASU experienced a serious column leak in 2000 (Year 4) and a main air compressor failure in 2001 (Year 5), unique problems. Its performance in Year 6 at only a 3% unplanned outage rate is more typical of this technology.

The power block is demonstrating good improvement from earlier years when it was plagued by distillate fuel system problems. We still need the capability to fire some distillate fuel during long gasifier runs to prevent these problems from recurring, but the changes to date have clearly had a positive impact.

The gasifier unplanned outage rate is trending upward. We have addressed most of the specific issues which led to the disappointing 18.9% unplanned outage rate in year 6. These issues and their remedies are discussed in the next slides.

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Gasification Unplanned Outage Hours in Year 6

<u>PROBLEM AREA</u>	<u>Unplanned Outage Hours</u>
Convective Syngas Cooler	478
Sulfur Removal	367
Slurry Feed Pump	321
Raw Gas Piping (CSC to Scrubber)	285
Gasifier Burner	13
Black Water Piping	10
Miscellaneous	<u>85</u>
TOTAL	1559

This slide identifies the main problem areas which led to the gasification plant's relatively high unplanned outage rate last year. We will review each in detail in the next slides.

Convective Syngas Cooler

478 Unplanned Outage Hours
269 (56%) Due to Weld Failure in Inaccessible Back-End



Tubesheet

CSC problems cost 478 unplanned outage hours in 3 incidents.

The worst was a weld failure in an inaccessible location which required 269 hours to repair. It occurred at the outlet tubesheet in a tube that had previously been replaced. The tubesheet is to the right of the large flange shown on the photo. It was faster to cut access holes into the double walled CSC exit chamber, make the tubesheet repair, and patch the holes than to disassemble and move the chamber out of the way. We don't expect more failures of this type. The access holes were cut so as to remove the nozzle which was to have been the take-off point for hot gas cleanup. Eliminating that nozzle and the associated dead-leg eliminated a potential point of failure.

The other two CSC forced outages resulted from gas-side inlet tubesheet plugging. The first was late in 2001 while we were still gasifying 100% coal. The second occurred recently while processing the petroleum coke blend. The deposit pattern was different in this latest case, and it was accompanied by a tube leak in an unusual location. This incident is still under investigation.

CSC inlet tubesheet plugging had been much worse in the past, so year 6 was a considerable improvement. However, we can expect some CSC plugging to continue. If the sale of the gasifier to take advantage of Section 29 tax credits proceeds as expected, 100% coal operation will be required. This will probably lead to more frequent CSC plugging than we experienced with the pet coke blend in year 6. Also, the CSC tubes have experienced 6 years of localized erosion, and retubing is planned. But until this is done, we might experience a slightly higher rate of tube failure.

Sulfur Removal

367 Unplanned Outage Hours

281 (77%) Due to Oxilate - Now Removed by Ion Exchange

86 (23%) Due to Placing COS Hydrolysis In Service Too Soon



367 unplanned outage hours were due to 2 sulfur removal issues.

281 hours were lost to due to oxilate corrosion in the MDEA sulfur removal system. Oxilate $\{(CO_2)_2^-\}$ is a specific heat stable salt formed when MDEA comes in contact with traces of oxygen, typically from purge nitrogen or from contact with air in poorly purged tanks. Oxilates have always been present in the MDEA, but they have not been a problem before. Our previous approach to controlling heat stable salts (caustic neutralization plus electrolytic removal) must have preferentially removed the oxilates even at a relatively high overall heat stable salt concentration. The ion exchange system quickly proved effective in controlling heat stable salts generated from formates produced in the COS hydrolysis reactor, but it is apparently less effective on the oxilate salts. The ion exchange unit now controls the oxilates and corrosion coupons and probes indicate no detectable corrosion, but the overall heat stable salt level must be kept much lower. The corrosion was centered in the MDEA reboiler which is being replaced.

86 hours were lost to catalyst damage from placing COS hydrolysis in service too soon after gasifier startup, before stable operation was achieved in the syngas scrubbers immediately upstream. This will be prevented in the future by automatic and procedural controls.

We may experience deratings due to sulfur removal problems but we do not expect to experience further significant down-time. These problems should be behind us.

Slurry Feed Pump

321 Unplanned Outage Hours
244 (76%) Due to Variable Frequency Drive

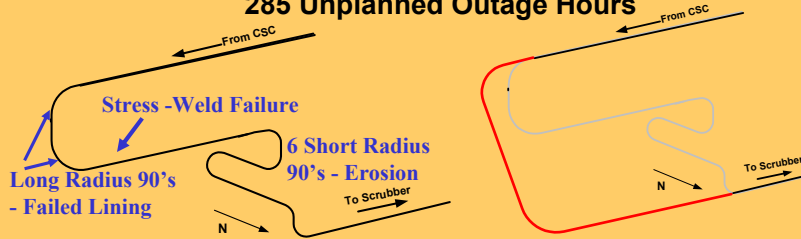


76% of the unplanned outage hours attributable to the slurry feed pump were caused by the variable frequency drive (VFD). All VFD components were replaced when these nuisance shutdowns first began occurring, but this was to no avail. We later discovered that one of the replacement cards was incorrectly wired at the factory. There have been no subsequent VFD-related shutdowns since the defective replacement card was rewired. The factory no longer supports our VFD model, so a complete replacement is on order.

Most of the rest of the unplanned outage hours attributable to the pump were due to check valve damage from foreign objects such as the mine trash shown in the photo, or from suction line obstruction. A 3" to 5" thick layer of hardened slurry occasionally forms on the lower walls of the slurry tanks as shown in the photo. When pieces of it dislodge, they can plug the tank outlet or the long horizontal suction line. We are now learning how to more effectively deal with this phenomenon before it causes a shutdown.

Raw Gas Piping - CSCs to Scrubbers

285 Unplanned Outage Hours



The raw syngas piping run from the outlet of the convective syngas coolers to the inlet of the scrubbers accounted for 285 unplanned outage hours. See the isometric sketch in the upper left corner. The piping run begins at the CSC exit. First is a long straight run which replaced the first gas/gas exchanger shell which was removed in 1997. It then drops down vertically via two long radius 90° elbows through a second long straight run which replaced the second gas/gas exchanger shell. Next were 6 short radius 90° elbows to reduce piping stress. They were hard-faced for erosion protection. These ells were followed by the straight run to the scrubbers.

The long radius 90's were lined with a concrete for erosion protection. Failures in the liner led to 43 unplanned outage hours for a temporary repair. New 90's were procured with what we expect to be a superior lining system (photo lower left).

The piping arrangement created stresses just downstream of the lower long radius 90. This caused a weld crack which led to 28 more unplanned outage hours.

The most serious problem with this piping system was in the short radius ells which caused 194 unplanned outage hours. Their brittle hard-facing would crack and a small piece would spall, leading to local turbulence and accelerated local erosion.

The piping system was completely reconfigured (isometric sketch and photo on the right side of the slide) to eliminate the troublesome short radius 90° elbows. An improved support system was included to eliminate the stresses which had caused the weld crack. We believe most problems with this piping system are now resolved.

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Gasification Unplanned Outage Hours in Year 6

<u>PROBLEM AREA</u>	<u>Unplanned Outage Hours</u>
Convective Syngas Cooler	478
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Raw Gas Piping (CSC to Scrubber)	285
<u>Gasifier Burner</u>	<u>13</u>
<u>Black Water Piping</u>	<u>10</u>
Miscellaneous	<u>85</u>
TOTAL	1559

The unplanned outage statistics for the gasifier burner and black water piping are important because of their relative insignificance.

Polk experienced two burner failures, one due to an inappropriate testing procedure before gasifier startup and the other due to a bad weld. Neither was related to service life. However, the important point is that both together only resulted in 13 total unplanned outage hours. The impact was minimal because we have demonstrated the ability to change a burner within a hot restart window (approximately 6 hours). Not only are we achieving excellent burner life (90 days or more indicated), but if we do experience a problem, we can minimize its impact.

Black water piping leaks have been a serious problem in the past, but most have been solved by extensive piping modifications. We experienced 10 forced outage hours in this reporting period due to two black water piping leaks, both in the same location. Both were repaired in a hot restart window. We subsequently reconfigured the piping to eliminate the line segment which caused these outages as we have done with the other black water piping problem areas.

We can expect to encounter occasional problems with the the gasifier burner and black water piping, but their impact should be minimal.

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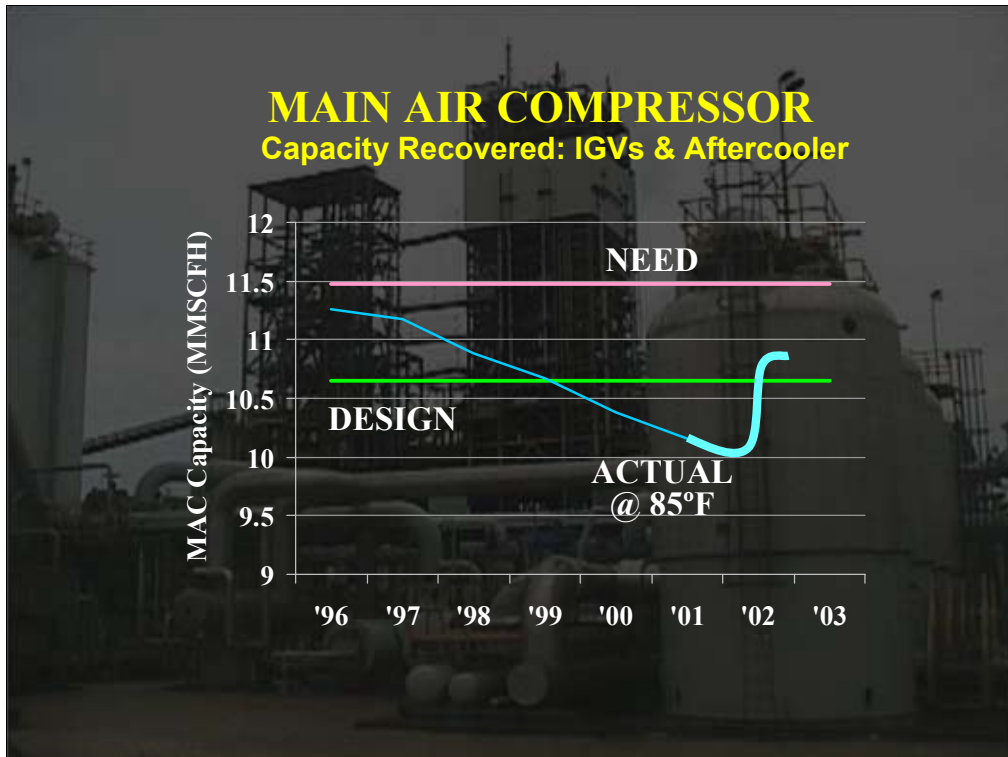
Gasification Unplanned Outage Hours in Year 6

<u>PROBLEM AREA</u>	<u>Hours</u>	<u>Issues Resolved</u>
Convective Syngas Cooler	478	269 (56%)
Sulfur Removal	367	367 (100%)
Slurry Feed Pump	321	244 (76%)
Raw Gas Piping (CSC to Scrubber)	285	265 (93%)
Gasifier Burner	13	0
Black Water Piping	10	10
Miscellaneous	<u>85</u>	<u>26</u>
TOTAL	1559	1181 (76%)

To summarize the previous discussion, of the 1559 hours of unplanned outages in gasification, 1181 hours (76%) were due to problems we don't expect to recur either because we have addressed and solved the problem or we believe them to have been one-of-a-kind issues. Consequently, we expect to see a very significant reduction in the gasification plant's forced outage rate over the next 12 months. With this and steady performance or marginal improvement in the ASU and power block, year 7 performance should be outstanding.



In addition to addressing unplanned outages, the plant has made good progress on some other important fronts, some of which are discussed in the following slides.



As reported last year, Polk's oxygen plant requires about 11½ MMSCFH of air to produce enough oxygen for full load operation on a variety of fuels over the normal ambient temperature range and to simultaneously reprocess enough fines to generate a slag product suitable for cement industry. This is about 8½% more than design.

The main air compressor (MAC) could almost meet these requirements when it was new, but its output had declined at a rate of about 2% per year. Part of this loss was attributable to pluggage of its aftercooler and the resulting backpressure. This was remedied by replacing the aftercooler bundle and coating all carbon steel parts to prevent further deterioration. Another significant part of the loss was found to be binding of the inlet guide vanes. This problem was very difficult to diagnose because it occurred only when the machine was operating - the vanes moved freely whenever we tested the mechanism when the machine was shut down and no forces were acting on the vanes.

Replacing the aftercooler bundle and fixing the guide vanes restored the machine to slightly above the design point. We are still about 5% short of meeting the overall system requirements under some conditions, so we are investigating ways to debottleneck the machine.

SLAG PILE - SLOWLY SHRINKING



Slag has been a significant problem throughout Polk's operating history. The Charah system, discussed in another paper at this conference, is separating the accumulated slag into three components, two of which are useful. Refer to their paper for the details on their process. This enables us to remove a significant fraction of the slag from site at a cost significantly lower than landfilling, and the slag pile is slowly receding.

The fines is the third constituent of the slag for which no use has yet been found. Consequently, the fines continue to accumulate as indicated in the above photo. Now that some of the MAC capacity has been restored, we have the opportunity to try to return some of this material to gasification. Tests are scheduled to begin in early November.

The slag problem is not solved, but at least we are making some progress.

BRINE CONCENTRATION NEW BACK-END



Polk is a zero process water discharge facility. Without the ability to discharge process water, there must be some way to handle chlorides in the fuel which would otherwise build up in the process water. Polk's brine concentration system serves that purpose in a two step process: a front end vapor compression cycle to efficiently evaporate most of the water in a small blowdown stream, and a back-end direct heating and crystallization step which produces a solid ammonium chloride salt. Improvements to the front-end vapor compression cycle were discussed at previous years' conferences. While that work was in progress, the back end continued to function, but its condition had deteriorated significantly. The back-end was recently replaced with a system incorporating all the lessons learned over the last 6 years, including appropriate materials of construction which will survive the extremely corrosive conditions..

MERCURY TESTING

Sample
Conditioning

Collector
Analyzer
Controller

- **Texaco Funded On-Line Analyzer**
- **PSA Analyzer (Gold Trap, Atomic Fluorescence Detector)**
- **Texaco Provided Extensive On-Site & Lab Support**
- **Preliminary: Hg in Raw Gas Lower Than Expected**
- **Testing Hg Sorbents In Former COS Test Reactors**

Mercury emissions have recently been of considerable concern to solid fuel based power generation facilities. Previous experience at some facilities has indicated that IGCC plants can eliminate most mercury emissions more cost-effectively than conventional coal plants. Texaco and TECO have begun a testing program at Polk to generate some relevant hard data. Specifically, Texaco funded the adaptation of an analyzer manufactured by PSA to continuously monitor mercury in the syngas at Polk. Texaco was very thorough in their validation of the on-line analyzer's results to assure that they were consistent with results from conventional collection and analysis methods.

TECO made the COS hydrolysis catalyst test reactors available for mercury sorbent evaluation. The three beds have recently been placed in service with two sorbents treating syngas from immediately upstream of the MDEA acid gas removal system. The analyzer was commissioned and is monitoring the feed stream and the effluent streams from the beds. The beds are being operated at superficial velocities and residence times that would be reasonable for a commercial installation.

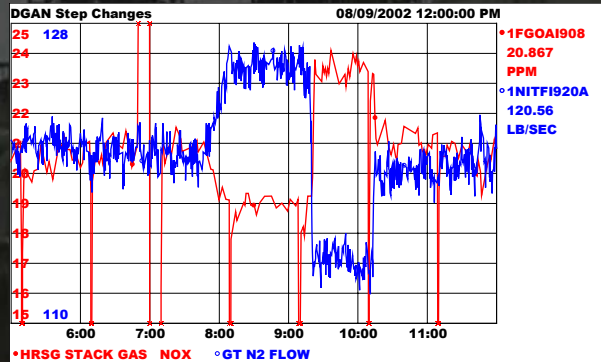
We expect this overall experiment will ultimately produce excellent information on mercury removal and useful information on other trace elements of concern as well as mercury.

NO_x REDUCTION

Saturator To Meet 15 ppmvd @ 15% O₂ (20 ppm)

How Much Water Vapor Needed?

- Statistical Analysis - Thousands of Plant Data Points
- Parametric Tests (DGAN, Nitrogen, CO₂)



In May 2003, Polk will be required to reduce NO_x emissions from the current permit level of 25 ppmv (dry basis @ 15% O₂) to 15 ppmv (same basis) which is equivalent to approximately 20 ppmv as measured in the stack. We plan to meet this requirement by converting an existing column to serve as a saturator which will add water vapor to the syngas as additional diluent. A key question is, “How much water vapor will be required?” We used two approaches in an attempt to answer the question, statistical analysis of thousands of plant data points and parametric testing were we systematically varied the amount of diluent nitrogen (DGAN), nitrogen injected directly into the syngas, and CO₂ in the syngas by adjusting conditions in the MDEA acid gas removal system. The results of varying the DGAN flow are shown in the graph.

NO_x REDUCTION

PRELIMINARY RESULTS

Statistical Analysis and Parametric Test Results Were Consistent:

CO₂: 3.0 ppm / 100 KSCFH

Injected N₂: 1.0 ppm / 100 KSCFH

DGAN: 0.8 ppm / 100 KSCFH

H₂O (Expected): 1.9 ppm / 100 KSCFH

The following are our results from the analysis. The statistical analysis and parametric test results were consistent. CO₂ was most effective, followed by nitrogen injected into the syngas. The relative difference, though large, is not unexpected based on the difference in properties of the gases. DGAN was less effective than nitrogen injected into the syngas. This may be due to imperfect distribution of DGAN and fuel to the turbine's combustors, or it may be because the DGAN is not as well mixed with the gas at the combustors as the injected nitrogen.

Based on this data and the relative physical properties of the gases, we expect the water vapor from the saturator to be intermediate in NO_x abatement effectiveness between CO₂ and injected N₂. This is consistent with GE published data.

This data has been provided to GE, and they are reviewing it as well.

CONCLUSIONS

•Year 6 Was Good

- Syngas to CT 75% of The Time

•Year 7 Could Be Better

- Causes of 76% of Year 6 Unplanned Outage Hours Gone

•Caveats:

- CSCs: Return to Coal (Plugging) & Tube Condition
- Long Planned Outage (Power Block & Refractory)
- Commission Saturator

•Other Year 6 Accomplishments

- Slag Beneficiation - Pile Reduction
- Recovered Most of Lost MAC Capacity
- Burner Change In Hot Restart Window
- Mercury Testing Initiated
- Saturator Design Basis Data
- DOE Final Report Completed

In conclusion, year 6 was a good year at Polk, having supplied syngas to the turbine 75% of the time. Year 7 may be better since 76% of the causes of unplanned outages should no longer be an issue. However, the condition of the CSC tubes are a concern, and CSC pluggage may be more problematical if we return to 100% coal operation. We will have an extended outage next spring for a complete overhaul of the combined cycle equipment and refractory replacement, so it may be a challenge to provide syngas to the turbine 75% of the time. Finally, we will be commissioning the saturator which could pose some unexpected problems.

Besides a good in-service factor, progress was made on several other fronts in year 6. Not mentioned earlier was the fact that we completed and are about to publish the DOE final report on the project. The report is a comprehensive summary of the first 5 1/2 years of operation, and it includes some material not previously presented.



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October 2001 - September 2002

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