


SIGMA ENERGY SOLUTIONS

PRESENTATION TO

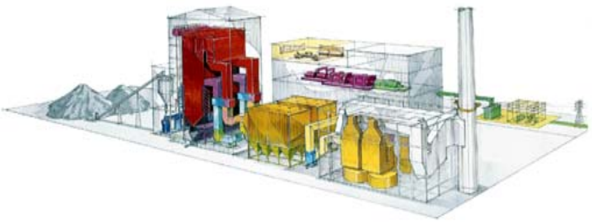
IEEE PES 125 years
Power & Energy Society™
1884 – 2009

Optimizing Fossil Plant Asset Value



ADDING VALUE WITHIN MARKET CONSTRAINTS

- Efficiency: Can we improve our Heat Rate?
  – Modified ASME approach identifies enhanced operation
- Capacity Upgrades: How much power is available?
  – Release constrained power/Ensure full predicted uprate
- RAM: How should we invest in the coming years?
  – Streamlined FMEA achieves targeted O&M spend
- Flexibility
  – What is the future for fossil plants in a renewable market?



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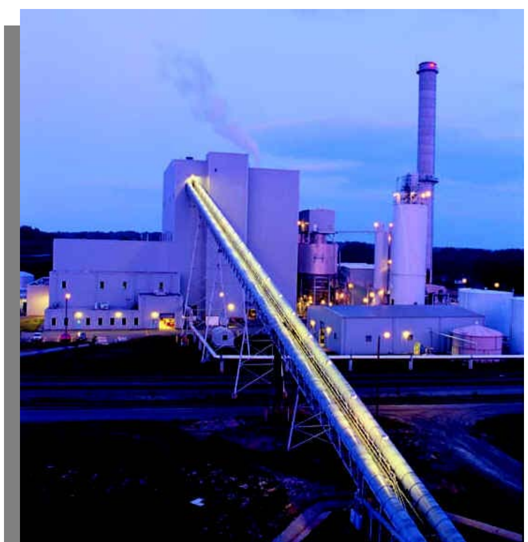
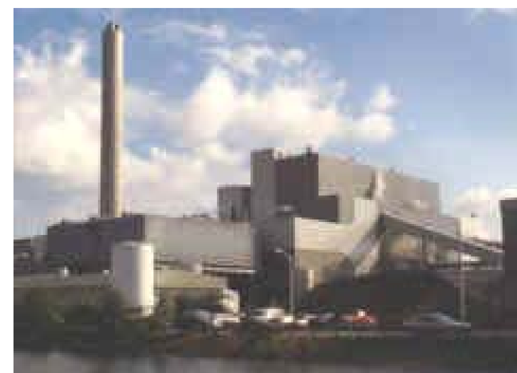
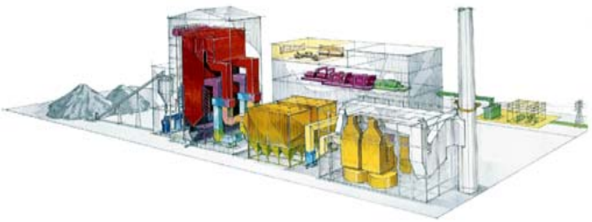
The AO Process

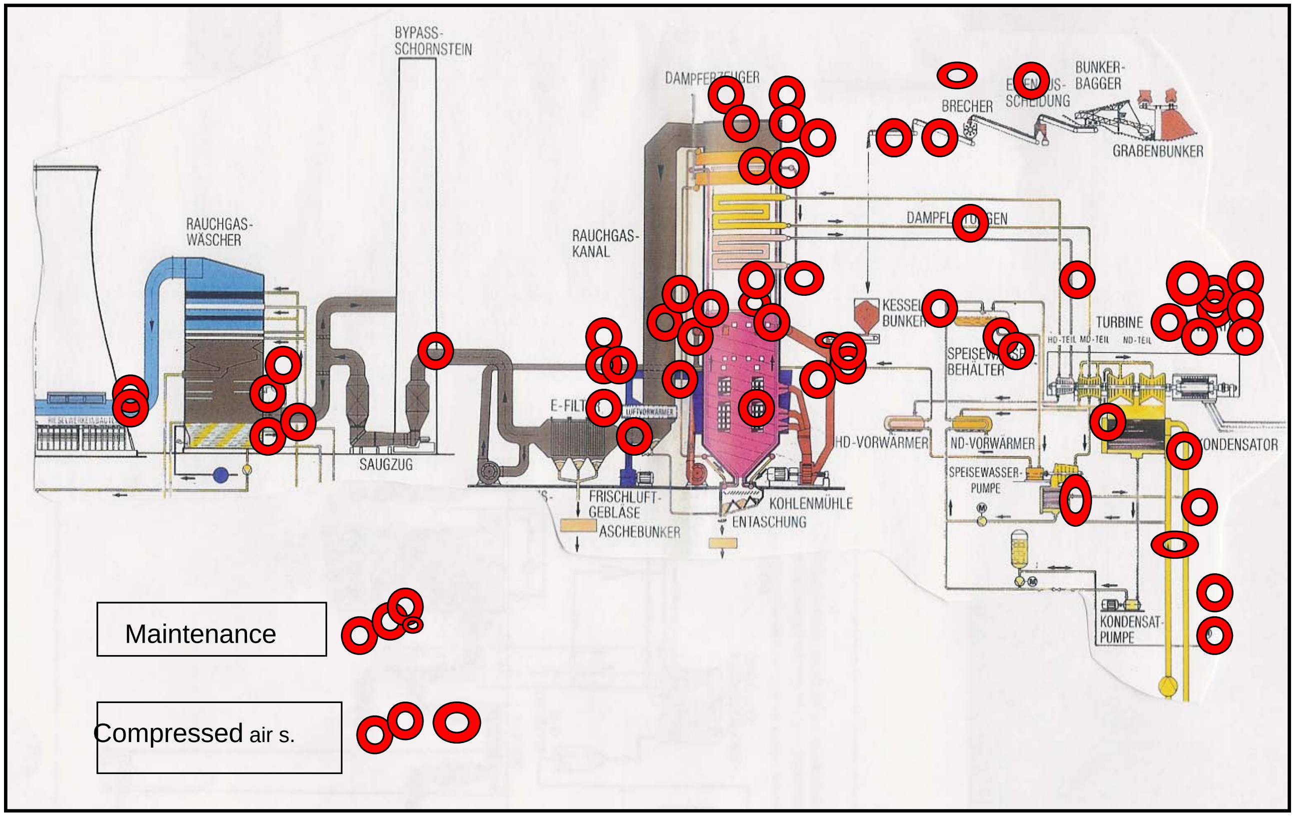


- Define Objectives
- Review Design Basis
- Establish Baseline
- Assess Condition
- Interview Plant Staff
- Benchmark & Evaluate
- Identify Improvements
- Rank Economically
- Plan & Implement
- Validate & Verify
- Monitor & Follow-up

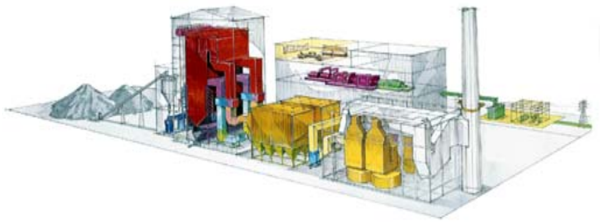




AO Results



Improvements found in all plant systems



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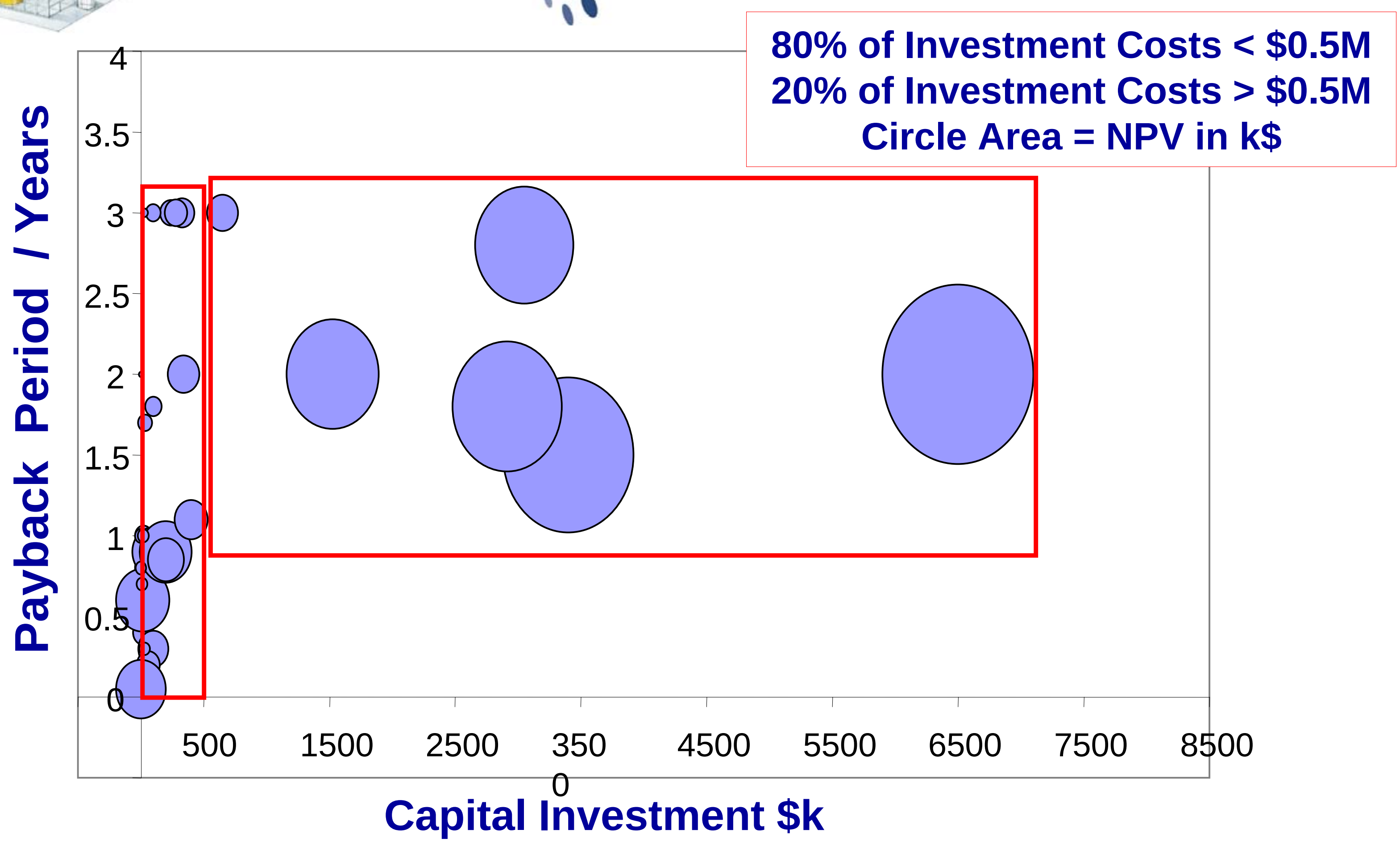
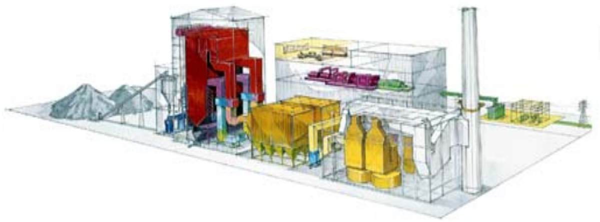
AO Results



The Wealth is Spread Around

SAVE™ System/Asset Value Enhancement



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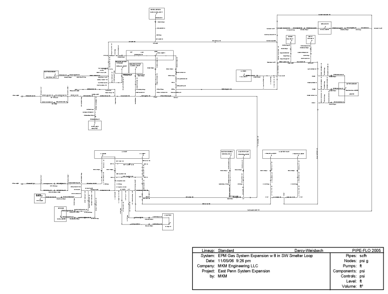
Where do we start?

Review Design Basis/Establish Baseline

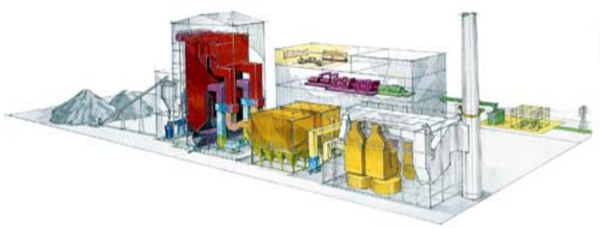
Engineering Evaluation

- Plants operating for many years with staff turnover
- Plant modifications may not have been integrated
- Current operations to be optimized with design
- Plant configuration control brought up to date
- New perspectives bring potential energy savings



Unit Performance Testing

- VWO Test with Senior Consultant in Control Room
- Move unit to determine equipment constraints
- Identify suspect instruments by closing heat balance



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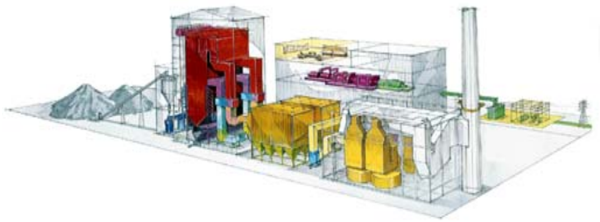
Energy Efficiency?

- Emissions compliance
  - degrades efficiency/increases auxiliary loads
- GHG Regulations
  - Efficiency/Process/Equipment Performance Improvements
  - Boiler tuning/furnace exit gas heat recovery
- CO2 Registries
  - Identifies potential regulatory/environmental targets
- DOE
  - Efficiency is cheapest way to reduce CO2 emissions



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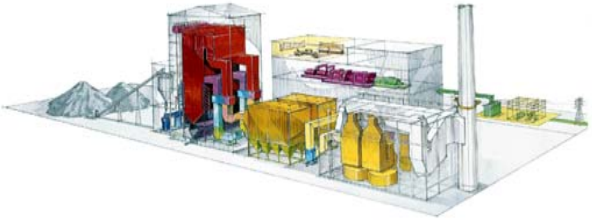
AO is Performance

- **Energy Assessment/Thermal Cycle Analysis**
  - **Engineering & Economic Evaluation**
    - **Design basis review**
    - **Plant staff interviews**
    - **Performance test results review**
    - **As-Found vs. Design Heat Balance comparison**
  - **Point solutions on a $/BTU/kWh pick-up**

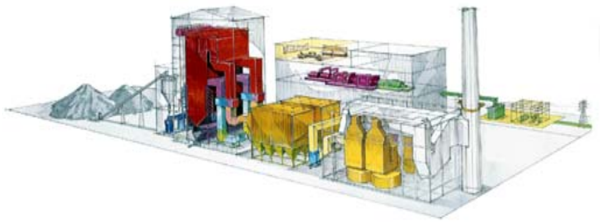


SIGMA ENERGY SOLUTIONS

AO is Performance

- **Energy Assessment/Thermal Cycle Analysis**

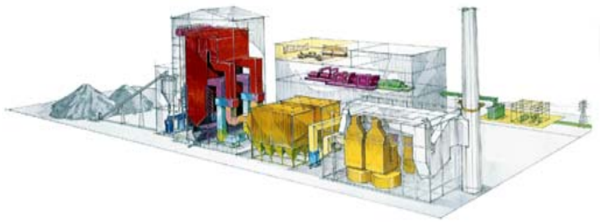
Choose the Appropriate Tools



SIGMA ENERGY SOLUTIONS

AO is Performance

- Energy Assessment/Thermal Cycle Analysis
  - Practical Approach
    - Maximize use of Station Instruments
    - Use Test Instruments on only key points
    - Validate Data using Engineering Principles
    - Audit approach serves as check and balance



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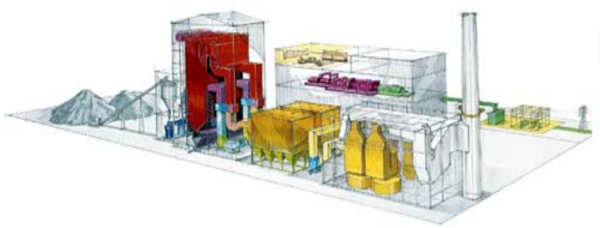
Analysis Techniques

- Mass and Energy Balances
- Graphical Analysis
- Curve Fitting
- Statistics
- Linear Algebra (Mathematical Solutions)
- Sensitivity Analysis
- Comparison of results to physical limitations



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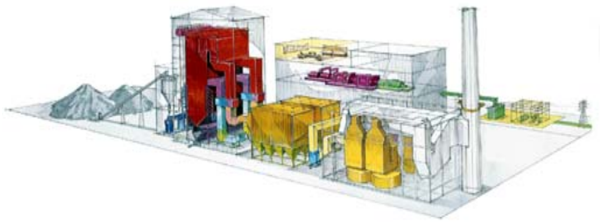
AO is Performance

- **Energy Assessment/Thermal Cycle Analysis**
  - Heat Rate KPI (ASME PTC 46)
    - Basis for Comparison – Current Heat Balance
  - Steam Turbine KPI (Enthalpy Drop)
    - Basis for Comparison - Predicted ST Efficiency
  - Boiler KPI (ASME PTC 4.1 Efficiency)
    - Basis for Comparison - Design Boiler Efficiency
  - FWH KPI (TTDs and DCAs)
    - Basis for Comparison - Design TTDs and DCAs
  - Condenser KPI (HEI: HT Coefficient)
    - Basis for Comparison - Clean HT Coefficient



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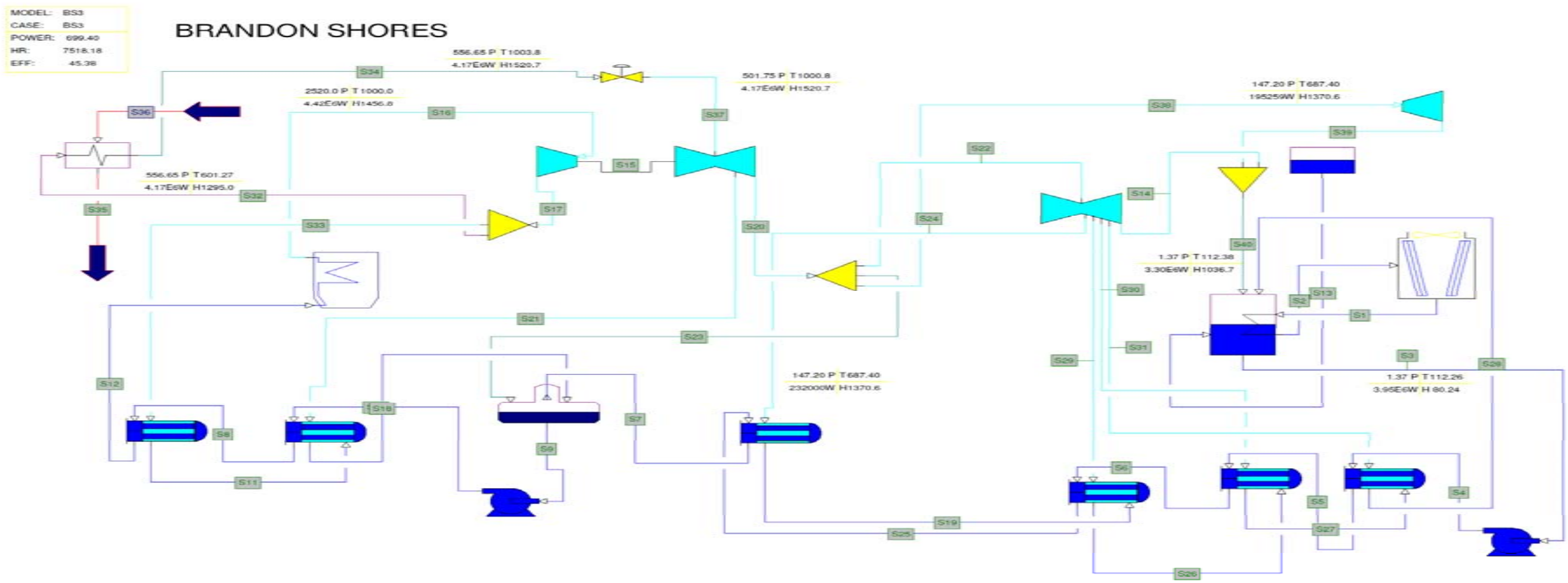
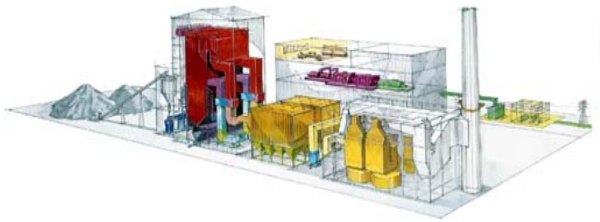
AO is Performance

- **Thermal Cycle Modeled in Gate Cycle**
  - **Establish New Flow/Pressure/Temp Conditions at Components**





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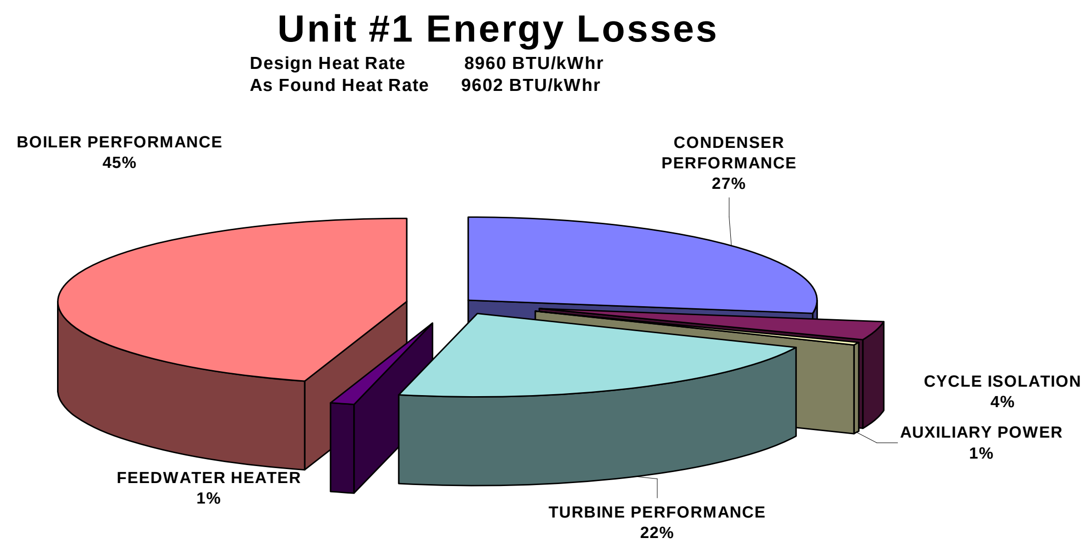
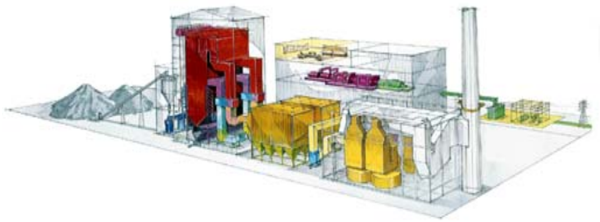
AO is Performance

• Energy Assessment – The Audit Process

Unit 1 Net Heat Rate		DESIGN 8,980		CURRENT 9,602	
Heat Rate Affected Items	**Units**	**Design**	**Current**	**Effect on Heat Rate**	**Yearly $Savings**
1. BOILER PERFORMANCE				317.26	($2,892,679)
AHTR Exit Gas Temperature	Deg F	274	341	145.19	($1,323,821)
Excess Oxygen (O2)	Percent	3.57	4.00	0.00	$0
Coal Moisture	Percent	6.58	6.58	10.50	($95,693)
Unburned Carbon Loss	Percent	0.30	0.44	13.39	($122,103)
Boiler Efficiency - Other	BTU/NKwHr			5.93	($54,110)
Blowdown + Boiler Leakage	Percent	0.0%	0.0%	0.00	$0
SH Desuperheater Spray	Lb/Hr	0	237,717	0.00	($10)
RH Desuperheater Spray	Lb/Hr	0	63,255	136.00	($1,239,976)
SH Steam Temperature	Deg F	1,000	999	0.85	($7,716)
RH Steam Temperature	Deg F	1,000	996	5.40	($49,249)
2. TURBINE PERFORMANCE				168.52	($1,536,462)
HP Turbine Efficiency	Percent	89.96	87.47	34.47	($314,290)
IP Turbine Efficiency	Percent	85.79	87.23	-16.54	$150,821
LP Turbine Efficiency	Percent	87.08	83.80	150.59	($1,372,993)
3. CONDENSER PERFORMANCE				191.55	($1,746,505)
Condenser Back Pressure	In Hg	2.51	3.82	186.45	($1,699,934)
Condenser Subcooling	Deg F	0.00	1.00	5.11	($46,571)
4. CYCLE ISOLATION				25.53	($232,807)
Steam Line Drain Leakage	Percent	0.00	0.05	9.00	($82,059)
Extraction Drain Leakages	Percent	0.00	0.00	0.00	$0
Heater Drain Leakages	Percent	0.00	0.00	0.00	$0
Make-up Water Flow	Percent	1.80	0.69	16.53	($150,749)
5. FW HEATER PERFORMANCE				7.83	($71,391)
Feedwater Heater TTDs	Deg F	0.00	1.54	7.83	($71,391)
6. AUXILIARY POWER USAGE		0.04	0.04	5.03	($45,842)
Auxiliary Power Use	MW	31.00	31.42	5.03	($45,842)
Totals - Estimated Difference	716	BTU/kW Hr	($6,525,687)		
Measured Difference	622	BTU/kW Hr	($5,667,970)		





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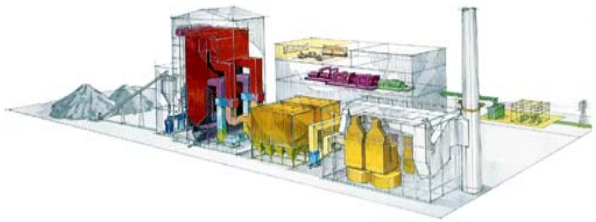
AO is Capacity

BOP Capacity Constraint Release
(current configuration)

Step 1: Identify Low Hanging Fruit
- Collect Test/Operating Data
- Interview plant management & operations staff
- Establish current baseline & model systems
- Lighting/HVAC/Motor/VSD/automation efficiency upgrades

Step 2: Mitigate Capacity Constraints
- Heat Rate conclusions (quantifies cost of production impacts)
- Develop solutions to unlock constraints
- Identify cost reduction opportunities
- Develop budgetary costs/predicted MW regains

Result: Actionable NPV specific recommendations



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AO is Capacity

BOP Limiting Factors

(support of boiler/turbine uprate)

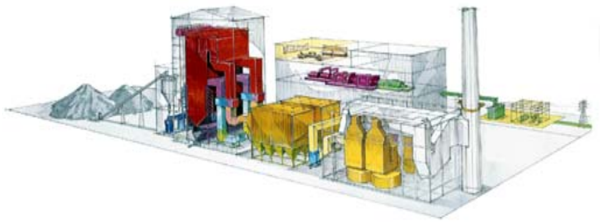
Step 1: Assessment of Current Operating Performance

- Collect Test/Operating Data, Power Uprate Heat Balance
- Interview plant management & operations staff
- Establish Current Baseline
- Model mechanical and electrical systems

Step 2: Assessment & Release of BOP Limiting Factors

- Identify equipment/systems that prevent achieving full uprate
- Develop solutions to unlock constraints
- Develop budgetary costs/predicted MW regains

Result: Actionable NPV specific recommendations



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AO is Reliability

Finding the answer to "What is the best way to improve?"

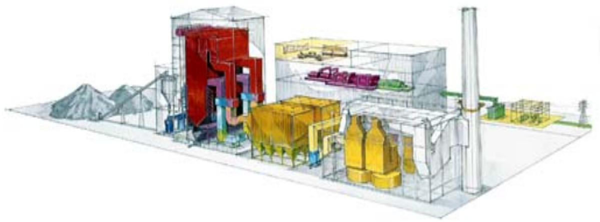
Step 1: Assessment of Equipment Reliability Issues

- Analyze WO & EFOR Data/Plant Monthly Reports
- Interview plant management, engineering and O&M staff
- Review available condition assessment reports
- Benchmark Maintenance Spend/Outages

Step 2: Assessment of Equipment/Systems/Plant Condition

- Identify key systems/components and risks through FMECA
- Assess condition based monitoring programs
- Assess overall maintenance program effectiveness
- Integrate with thermal performance analysis results

Result: Actionable NPV specific recommendations



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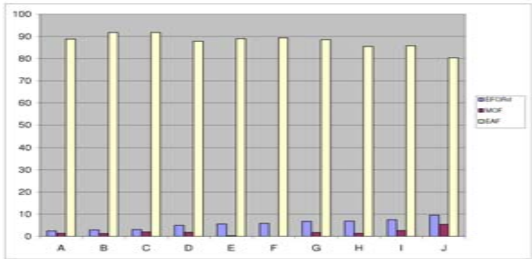
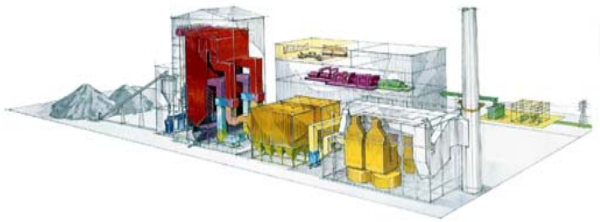
Sustainable Reliability



- **System/Process Reliability Improvement**
  - **Technical & Process Evaluation**
    - **Design review/Staff interviews**
    - **GADS/CMMS Data Analysis**
    - **Inspection results integration**
    - **Integrated Approach**

Frequency \ Severity	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20

      - **FMECA maximizes plant staff contribution/Minimizes time investment**
      - **Statistical analysis of failures/failure predictions (Minitab, Weibull)**
      - **Modeling determines constraints and system/unit reliability (BlockSim)**
      - **ETAP identifies weak spots in the plant electrical distribution system**
  - **Performance & Process Strengths/Gaps/Losses Identified**
  - **Point solutions: Predicted Benefits/Estimated Costs**
  - **Process Improvement: Timeline w/Breakeven Analysis**



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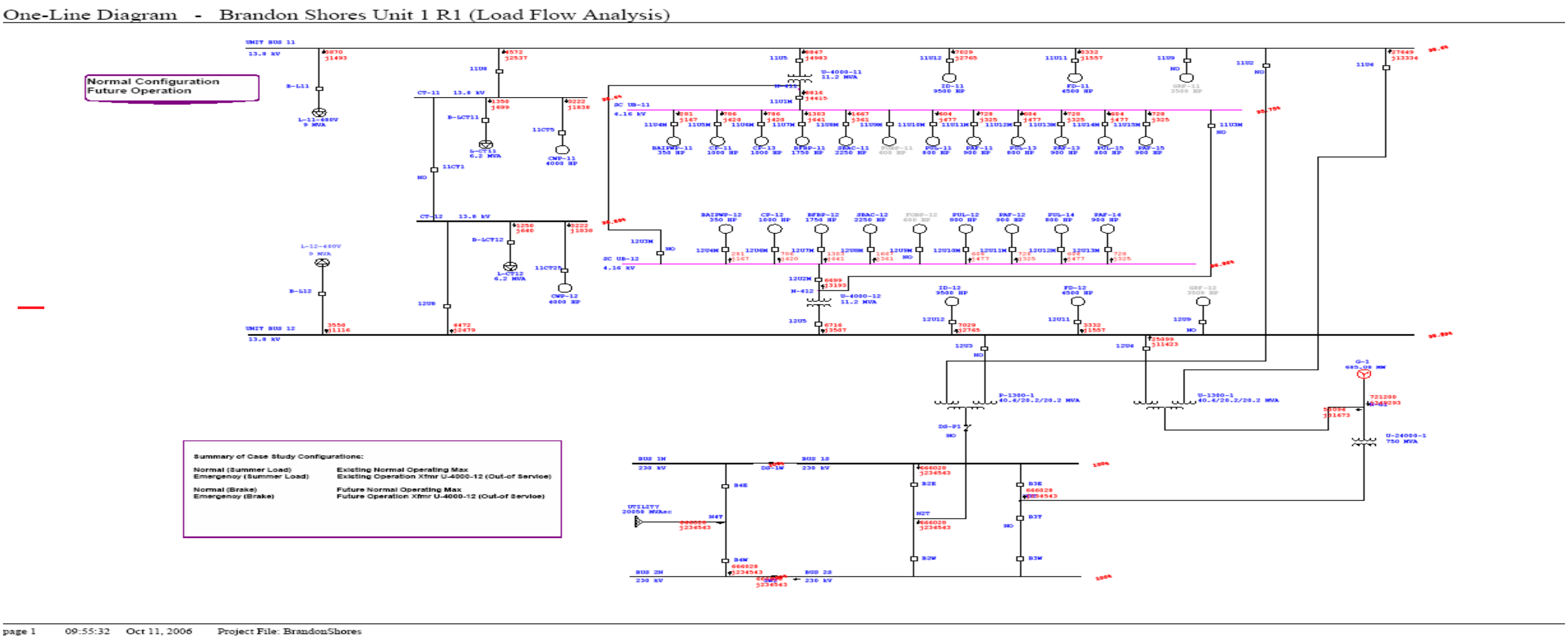
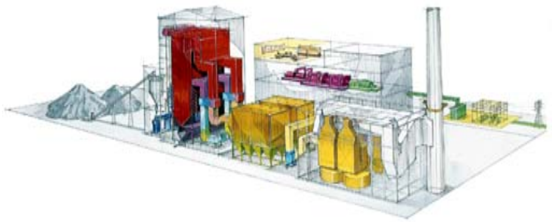
AO is Performance

- **Electrical System Modeled in ETAP**
  - **Load Flow Analysis**





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Asset Optimization
Improve Performance

Midwestern Industrial Power Facility

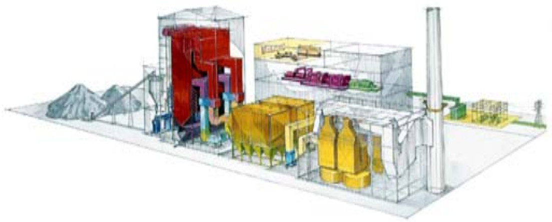
- Installing APCS for SOx Reduction
- Requests Boiler/Turbine/BOP optimization study to determine uprate capacity for three existing 144MW units

The SAVE™ Solution:

- Optimized Plant Retrofit (OPR) Study addresses uprating of boiler and turbine
- Debottlenecking approach analyzes BOP system and equipment constraints

Results:

- 20% uprate (w/HP retro) and 10% uprate (w/o HP retro)
- BOP constraints identified and mitigation plan developed



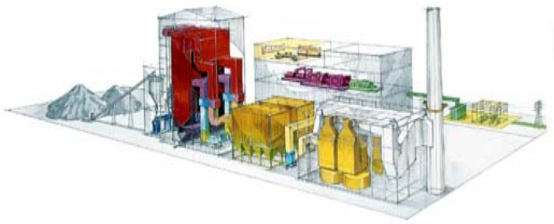
SIGMA ENERGY SOLUTIONS

Asset Optimization
Improve Performance

Industrial Power Facility
- Plant exhibiting high reliability
- Identified need to improve heat rate
- Target underperforming equipment/systems

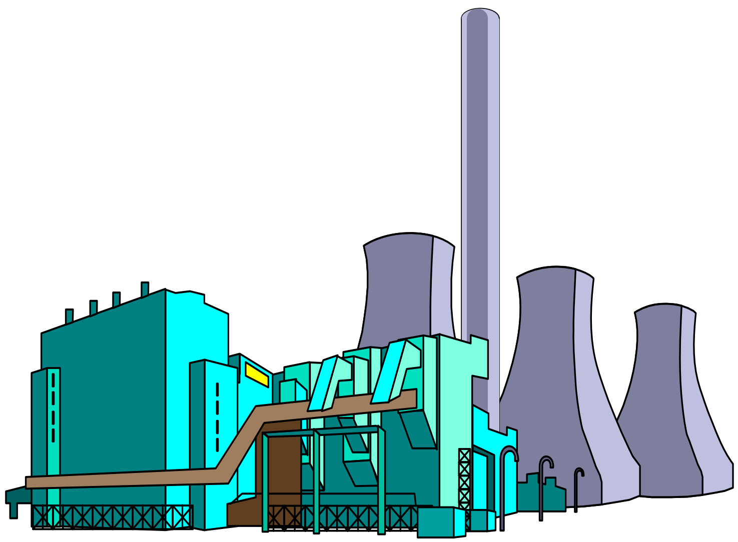
The SAVE™ Solution:
- Integrated steam plant analysis
- Identify, assess and mitigate BOP system and equipment constraints

Results:
- Small capital recommendations generated $2.2M NPV
- Included installing condensate return system, FWH



SIGMA ENERGY SOLUTIONS

Asset Optimization Improve Performance



Industrial Power Facility

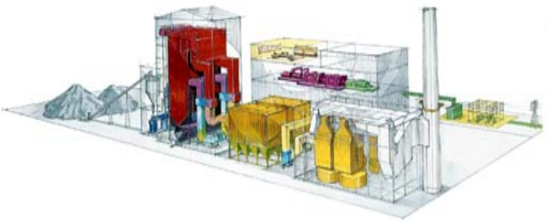
- Combined cycle generation
- Identified need to improve heat rate
- Focus on power block

The SAVE™ Solution:

- Integrated plant analysis
- Assessed third party financial contracts

Results:

- **Recommendations identified ~$4.5M in annual savings**
- **Included installing unit controls and plant-wide EMS**



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Asset Optimization
Improve Performance

AES Warrior Run (180MW CFB)

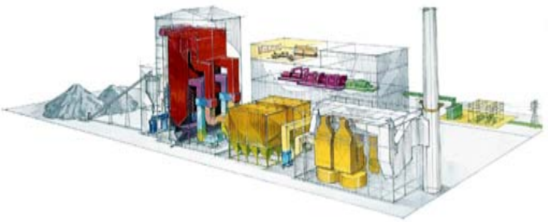
- **Client requested assistance in recovering 600 BTU/kWh degradation from initial as commissioned plant heat rate**

The SAVE™ Solution:

- **Energy Assessment Approach**
- **Evaluated current VWO performance against design basis**
- **Generated Operational, Maintenance and Capital project recommendations**

Results:

- **40-60% of heat rate degradation recovered**
- **Capital project: condensate to dry limestone < 2yr payback**



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Asset Optimization
Improve Performance

Eastern Supercritical PC Units

- Slated for divestiture, investments lagged
- Older plant beyond original design life

The SAVE™ Solution:

- Integrated Reliability/Efficiency Assessment

Recommendations:

- Cycle analysis estimated 1000BTU pick-up
- Recover > 100,000MWH of lost availability
- Developed critical systems equipment plan
- Identified key programmatic issues

Results:

•$21M NPV in Efficiency Improvements
•$3M in Annual Availability Recovery

SAVE™ System/Asset Value Enhancement

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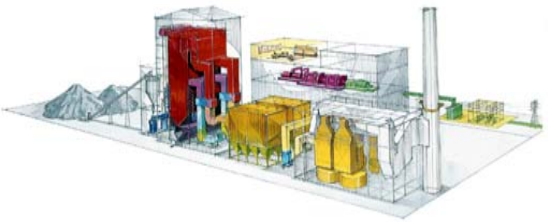


Asset Optimization
Improve Performance

MidAmerican Energy Louisa 1 (758MW)

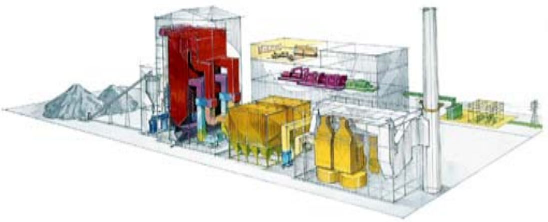
- Installing APCS for SOx Reduction
- Requests IP/LP Retrofit and Boiler/BOP optimization study to recover aux load

The SAVE™ Solution:

- IP/LP retrofit
- Enhanced Optimized Plant Retrofit (OPR) Study addresses boiler issues and upgrades
- BOP analysis identifies CT/CW limitations and back-pressure improvements

Results:

- Total uplift predicted to be ~50-59MW depending upon season
- Enhanced OPR added ~30-40MW to the IP/LP only case



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AO: Performance + Reliability

Eastern PC (SC) Units (800 MW)

- Turbine retrofits made
- BOP improvements targeted

The SAVE™ Solution:

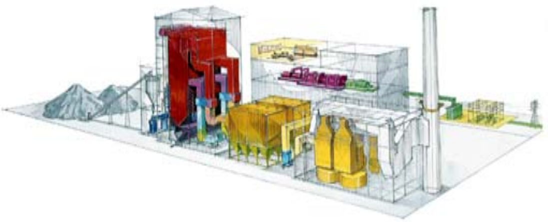
- Integrated Reliability/Efficiency Assessment

Recommendations:

- Enhanced monitoring instrumentation
- Conduct soot blower system maintenance
- Eliminate/mitigate SPOF in SW system

Results:

- 50% of availability recovered upon implementation



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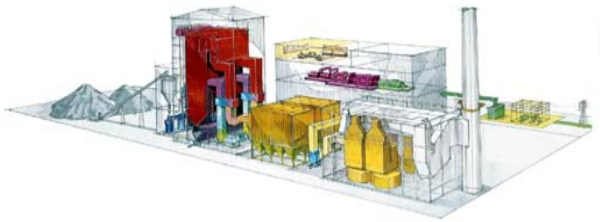

AO: The Next Phase

- Plant|Performance
  - Superheat Temperature Control
  - Flue Gas Heat Recovery
  - Cold End Optimization
  - Peak Power/Thermal Energy Storage
- Plant|Flexibility
  - Turbine Bypass
  - Economizer Bypass
  - Sliding Pressure Control
- Plant|Environmental
  - Water Conservation
  - Solar Boost

Proprietary & Confidential

THANK YOU FOR THIS OPPORTUNITY!

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