Power Plants

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Power - $ billions

World Region	2016	2018	2020	2022	2024	2026	2028	2030
Total	31.5	42	52.5	66.5	84	115.5	154	196
Africa	1.27	1.69	2.11	2.68	3.38	4.65	6.19	7.88
CIS	0.99	1.33	1.66	2.10	2.65	3.65	4.86	6.19
East Asia	16.99	22.65	28.31	35.86	45.30	62.28	83.04	105.69
Eastern Europe	0.91	1.21	1.52	1.92	2.43	3.34	4.45	5.67
Middle East	1.14	1.52	1.90	2.41	3.04	4.19	5.58	7.10
NAFTA	4.06	5.42	6.77	8.58	10.84	14.90	19.86	25.28
South & Central America	0.37	0.49	0.61	0.77	0.98	1.34	1.79	2.28
West Asia	3.25	4.33	5.41	6.85	8.66	11.90	15.87	20.20
Western Europe	2.52	3.37	4.21	5.33	6.73	9.25	12.34	15.70

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Digital Data Generation at the Plant

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$125 Billion/yr. Power Plant IoT Instrumentation, Software, and Service Opportunity

- World electricity consumption is 25,000 terawatt hours per year. Generation of this electricity costs $2.5 trillion per year. Machine to machine communication in combination with remote monitoring and service has the potential to reduce this cost by 5 percent and create a $125 billion dollar per year opportunity. This is the latest forecast in a special ongoing analysis included in N031 Industrial IoT and Remote O&M (formerly Air and Water Monitoring: World Market).
- The opportunity incorporates, smart instrumentation, component monitoring, digital data generation at the plant, software programs, remote monitoring, third party operation and maintenance and a combination of subject matter experts and data analytics.

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Smart Instrumentation

- The opportunity is shaped by the ability of sensors to accurately detect the flow of liquids, gases, air, water and solids. The quality of the flow is also critical. Continuous emissions monitoring systems measure the air contaminants such as NO_x, SO_2 and particulate. New regulations have added the need to measure mercury in the exhaust gas and selenium in the wastewater. The temperature, moisture and particulate levels for lubricating fluids used in the rotating equipment are also important.
- The need for accurate injection extends to corrosion and scale inhibitors, biocides, pH adjusters, polymers for wastewater treatment and many new chemicals needed for air and water pollution control. These include activated carbon, lime, limestone, ammonia and urea.
- Ambient air and water measurement needs include wind measurement for wind turbine optimization, ambient air and water measurement in areas surrounding the plant and many predictive weather measurements for solar and wind operations.
- All of these measurements are being enhanced by the development of smart sensors. Tunable diode lasers allow measurement of O_2 at critical points in the combustion zone. The incorporation of an analysis function within the instrument itself rather than through the distributed control system has cost advantages and more importantly shortens response time.

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Component Monitoring in Power Plants

- **Component Monitoring**
- Condition monitoring of components is well established for lubrication systems for turbines, compressors, etc. The growth opportunities are in measuring not only the health but also the operational information of valves, pumps, filters, separators and other components. Mann + Hummel recognizes this opportunity and has just invested in a large filtration IoT research center in Singapore. Pentair, Flowserve and other pump and valve suppliers are rapidly strengthening their component monitoring capabilities.
- **Digital Data Generation at the Plant**
- GE says that coal-fired power plants could be made approximately 4 percent more efficient with 2.5 percent improvement in efficiencies coming from turbine and boiler upgrades, and 1.5 percent coming from software improvements. The analysis also found that applying all potential upgrades to coal-fired power plants can remove 900 million metric tons of CO_2 (11 percent of total coal power emissions) - more than the annual CO_2 output of the United Kingdom and France combined.
- McIlvaine has conducted nine hours of webinars for PacifiCorp with presentations by GE, Emerson, Siemens and others which pointed the way to large savings with combustion optimization. The reduction in NO_x emissions was particularly significant.
- **Software Programs**
- The software programs include partnerships between power plant system suppliers and specialized software providers. GE says Predix will enable GE to lead the next generation of industrial progress, through improved manufacturing processes and digitally manufactured products, transforming GE into a stronger and more valuable company. GE believes its digital business will grow GE's software and analytics enterprise from $6 billion in 2015 to a top 10 software company by 2020. GE has purchased NEUCO who has developed neural networks to control not only the operation of the furnace but also components such as soot blowers.
- General software participants include large companies such as Intel with its Wind River subsidiary and specialist companies such as OSIsoft and SoftDEL.

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Remote Monitoring

- The large gas turbine suppliers have remote monitoring centers which primarily track the health of rotating parts. This is frequently part of the warrantee program. However, companies such as MHPS are branching out to monitor more of the plant's components. MHPS just opened a remote monitoring center in the Philippines which is monitoring coal-fired power plants. The service center can also provide assistance to power plants not built by MHPS. In addition to its data analysis capabilities, the center can also manage maintenance equipment and dispatch staff in emergency situations. It will, in addition, serve as a training hub for technicians. Every year, around 200 individuals will be picked from both in and outside the company to transfer technical expertise on maintenance and management.
- There is a huge potential for companies such as MHPS and GE to work with other suppliers and incorporate hundreds of individual remote monitoring programs. For example, Nalco operates an around the clock monitoring center on water quality. If companies such as Mann + Hummel can operate filter monitoring centers and, if all the results are integrated for analysis and action, it will greatly improve the support for the operators.
- There is a big potential for interconnection of facilities in large utility organizations. McIlvaine has been involved with a program for Berkshire Hathaway Energy.
- http://home.mcilvainecompany.com/index.php/decisions/28-energy/1185-4s01
- Duke Power has developed central systems which can for example monitor all the pumps at its various stations. However, it is shifting away from the traditional centralized proprietary systems and evolving to support distributed intelligence, interoperability and IoT. Efforts to develop its smart grid have resulted in the enablement of these concepts through what the industry calls OpenFMB (Open Field Message Bus).

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Remote O&M, Data Analytics and Subject Matter Experts

- **Third Party Support for Power Plant Operations and Maintenance**
- Third party operation and maintenance represents the biggest revenue opportunity for IoT in the power industry.
- GE Energy is one of the world's largest third party providers of plant Operation and Maintenance services, currently with more than 16,000 MW at 60 sites in 17 countries under O&M contract. Global resources combined with over 20 years of O&M experience, enable GE to provide complete plant services across the turbine island and balance of plant—for both GE and non-GE equipment.
- Siemens, MHPS, IHI and other turbine suppliers also offer similar services. There are a number of companies specializing in O&M including large companies such as Wood and smaller companies such as Ethos Energy and Proenergy. Uniper and India Power have formed a joint venture to support operations and maintenance at Indian power plants.
- **Data Analytics and Subject Matter Experts**
- The generation of large amounts of data is not of value unless it is properly analyzed for action. XLMPR recommends hybrid data analytics marrying the experience based models with ones based on physics and data. The IoT greatly increases the capability for database models but this data needs to be molded by experience. Subject matter experts are needed to provide the niche expertise in each of thousands of areas. The pool of recently retired people can be tapped for their unique combination of knowledge and availability for short engagements.

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AEP Monitoring with IBM Maximo and Siemens PrismMoni

- American Electric Power, but only recently has the technology advanced enough to justify the investment. “The potential is huge,” says Tim Riordan, whose company is deploying both IBM’s Maximo asset management platform and Siemens’ Prism system to monitor its fossil fuel plant performance. But he cautions that “to truly integrate all of this, to take it to a grand level.”
- Decisions on whether and when to retire plants for good “go all the way to senior leadership,” says Michael Reid, the general manager of technical programs for fossil and hydro operations at Duke Energy. Duke has retired or converted to natural gas 16 coal plants since 2011 and plans to shut down nine more by 2020. Digital technology can improve the efficiency, flexibility, and emissions profile of aging plants, Reid adds, but “substantial design changes are required to make significant gains in these areas.”
- Digitizing power plants can help integrate renewables onto the grid by making existing fossil fuel plants more flexible and better able to respond to fluctuations in power.

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GE says Software Improvements can Reduce CO2 by 1.5 Percent

GE recently released a first-of-its-kind analysis of global power plants, which found that carbon dioxide (CO2) emissions from the world's fleet of coal and gas plants can be reduced by 10 percent - the equivalent of removing 95 percent of cars off U.S. roads - when existing hardware and software solutions are fully applied.

GE used a proprietary set of data for each coal and gas-fired plant in the world to uncover potential opportunities to improve plants' heat rate and lower carbon emissions. The analysis comes as countries around the world are looking for climate saving solutions that will help them transition to a lower carbon energy future.

Potential for Coal Plant Upgrades

- Coal power plants could be made approximately 4 percent more efficient with 2.5 percent in efficiencies coming from turbine and boiler upgrades, and 1.5 percent coming from software improvements.
- The analysis also found that applying all potential upgrades to coal power plants can remove 900 million metric tons of CO2 (11 percent of total coal power emissions) - more than the annual CO2 output of the United Kingdom and France combined.
- China (296 MT) and India (143 MT) are two countries with big opportunities in the coal power sector.

Potential for Gas Power Plant Upgrades

- Similarly, GE's analysis estimates that gas-fired power plants could be made approximately 3.3 percent more efficient with 1.8 percent coming from hardware upgrades and 1.5 percent coming from software improvements. These savings could reduce global gas power emissions by 203 metric tons or 8.8 percent.
- Russia (45 MT) and the U.S. (34) are two countries with big opportunities in the gas power sector.
- In response to the findings, GE has set up a dedicated team to provide customers with holistic software, hardware and financing solutions for coal plant upgrades.

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ABB Symphony Plus DCS for Collection and Analysis of Plant Data

- **ABB's Power Generation** unit explains how the intelligent use of data now available in power plants can not only deliver a competitive edge, but provide a solution to current and future challenges .
- Plant owners can lower risks in their projects, reduce costs and throughput times, and improve asset performance and profitability by the careful collection and analysis of plant and engineering data.
- "We believe the success of our power generation customers will be more and more supported by the intelligent use of data generated by ever increasing connectivity of devices. The integration of those data with people expertise and knowledge will create additional services (IoTSP) in a cycle delivering unprecedented knowledge of the behavior and potential of their assets," said Marco Sanguineti, Head of Technology for ABB's Power Generation business unit. "The ability of ABB's Symphony® Plus distributed control system to add customer value by utilizing the data in their systems is the result of our careful analysis of the evolving power generation market, and our customers' changing needs driven by global mega trends."
- Repowering, modernizing and upgrading power plants will prolong plant life and increase efficiency, and the emergence of these dynamics in Asian countries opens the door to limitless opportunities for ABB, where a commitment to 'evolution without obsolescence' protects customer investments.
- Symphony Plus is the latest generation of ABB's Symphony family of control systems. With more than 6,700 systems installed in the past 30 years and more than 50 GW of additional power capacity installed during the last five years, much of it in the power generation and water sectors, ABB has one of the largest installed bases of distributed control systems (DCS) in the world.

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MHPS Supplies Records of Daily Activity and Insights on Performance and Availability

- RMC operators and engineers have the ability to trend all of this information, or display it in tabular form, for quick comparison during troubleshooting exercises and root-cause evaluation. RMC-developed troubleshooting guides and a complete library of unit-specific drawings, procedures, and control logic diagrams are used by the RMC staff to assist the customer in everyday plant operations. A unique set of Customer Relationship Management (CRM) tools, including a web-based journal, service request system, and lessons-learned database, are used to document and track the daily events at each site. Standardized reports are used to give the end-user insight into the performance, availability, and efficiency of their power plant and to provide suggestions on how to improve the operating capacity of the monitored equipment.

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NeuCo, Now Part Of GE Power Digital

- NeuCo - Power Optimization Market Leader
  - Only company 100% dedicated to power optimization software
  - More than 120 active optimization systems
  - 100% technology ownership and strong patent position
  - Two U.S. Dept of Energy projects totaling $38M investment
- GE Power
  - Leader in Industrial Internet design with defined the technical roadmap for exploiting big data
  - Coal-fired boiler OEM and engineering services leader
  - Asset monitoring capability
    - 2000+ units monitored remotely 24 X 7 X 365
    - Local Field Service presence

NeuCo / GE Power technology Operating at Cholla and Jim Bridger

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NeuCo

Schneider Electric is Providing Comprehensive Services for Power Plants

- Invensys is helping the Power Industry meet the challenges of the 21st century • Growth – the increase in demand created by emerging countries and the replacement of existing power plants • Aging – the need to modernize obsolete control & safety systems, and capture the knowledge of an aging workforce • Sustainability – reduce energy usage/carbon emissions, and improve plant safety and reliability • Cost – minimize maintenance costs, optimize production and operating costs, achieve greater productivity and efficiency • Adjust load to demand – economically balance changing demand with the volatility in fuel costs Invensys Solutions • Integrate Instrumentation on Control & Safety Systems for Coal-Fired Power Plants, Combined Cycle Gas Turbines, and Nuclear & Renewables • Rapidly upgrade or migrate existing systems, minimizing disruption to control and protecting Turbo-Machinery • Manage the system lifecycle • Make coal cleaner by using advanced generation technology (IGCC – Integrated Gasification & Combined Cycle, Oxyfiring, Supercritical or Ultra-Supercritical technologies) • Increase overall plant efficiency with Advanced Process Control for optimizing boiler combustion • Coordinate boiler and turbine operation • Reduce and control emissions • Manage the fleet of power generation stations • Increase operator effectiveness with advanced solutions such as Operator Training Simulation and Alarm Management • Provide Enterprise Asset Management

McILVAINE

Bit Stew Systems integrates Data from 2 million BC Hydro Smart Meters

- Bit Stew Systems has built a platform for handling complex data integration, data analysis, and predictive automation for connected devices on the Industrial Internet. Through data-driven automation, Bit Stew removes the complexity of industrial operations and connected machines to give clarity and control back to operations. Purpose-built for the Industrial Internet, Bit Stew's MIx™ product portfolio automates data ingestion, applies machine intelligence to learn patterns in the data, allowing industrial companies to discover actionable insights that optimize operational performance. Bit Stew is a venture-backed private company that is headquartered in Canada with offices in the USA, Australia and Europe.
- With Bit Stew's MIx product portfolio, BC Hydro is able to: Efficiently triage hundreds of millions of data elements every day Quickly integrate data from nearly 2 million smart meters, more than 30 network systems and thousands of network assets See real-time displays of meter outages and geo-spatial views of grid assets Better identify and prioritize issues and alerts Better manage meter-to-grid performance such as voltage issues, system restoration and more Identify and reconcile any data discrepancies across separate systems to ensure data accuracy in all systems

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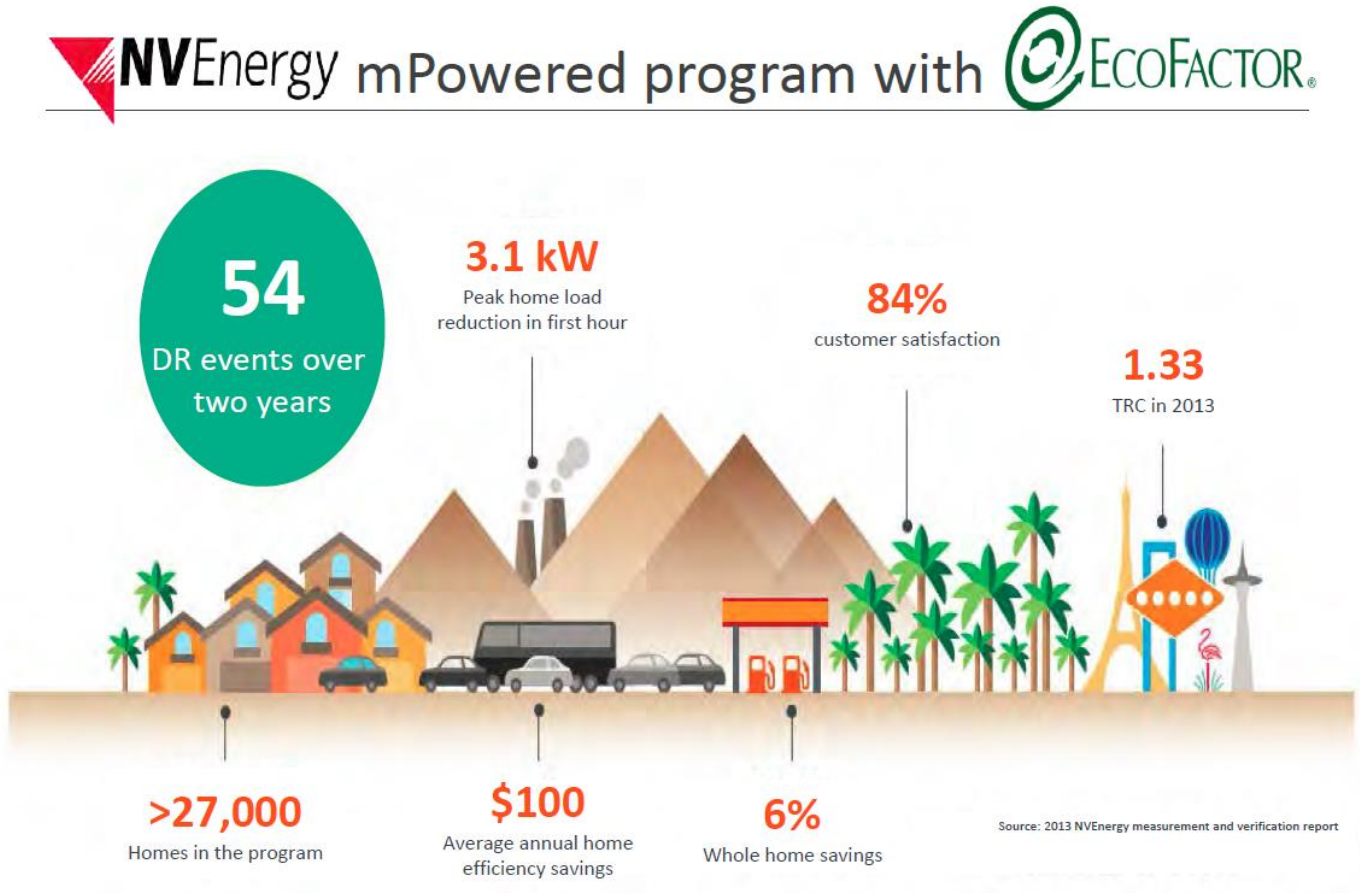
NVEnergy mPowered Program



C3IoT Platforms used at all 24 ENGIE Business Units

- Global energy leader ENGIE is implementing an ambitious digital transformation strategy that is vital to the Fortune Global 500 company's plan to confront the major challenges posed by climate change and promote people's access to reliable, innovative, socially responsible, low carbon, and decentralized energy. To do this, ENGIE plans to invest €1.5 billion in new businesses and digital over the next three years.
- After a thorough review process, ENGIE selected C3 IoT as its strategic partner to provide the technology foundation for its enterprise-wide digital transformation. Since the joint press conference in Paris announcing the agreement in June, ENGIE and C3 IoT have initiated an aggressive roadmap enabling ENGIE to immediately leverage C3 IoT's high-performance, integrated, enterprise-scale IoT analytics and application development platform. In addition to using C3 IoT's pre-built SaaS applications, ENGIE will develop and deploy custom applications on the C3 IoT Platform across all of ENGIE's 24 business units worldwide.
- This unified application suite and shared IoT platform will accelerate business integration and leverage economies of scale by capturing functional best practices and expertise within and across business lines and providing the ability to benchmark, rationalize, and share the benefits of comprehensive data across geographies and industries.
- Additionally, ENGIE and C3 IoT are partnering to establish ENGIE's Digital Factory, a global Center of Excellence that unites highly skilled data scientists, developers, and business analysts to create a self-sustaining group of 100 experts knowledgeable in analytics and data – as well as ENGIE's organization and operations – to propagate techniques and expertise across ENGIE worldwide.
- C3 IoT is training a dedicated ENGIE team to become expert implementers of the C3 IoT Platform and applications in order to meet ENGIE's goal of increasing shared functional expertise, unifying product strategy, and delivering operational data consistently across ENGIE's lines of business.

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Coal Fired Power

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SKF Services for Coal Fired Power Plants

On-line motor monitoring and analysis

The SKF NetEP Online Motor Analysis System represents a breakthrough in the ability to monitor and manage critical motor health and performance from anywhere in the world with an Internet connected computer. The NetEP is a permanently-installed networked device that can monitor up to 32 motors on a continuous basis. With the NetEP, maintenance personnel can: • Continuously monitor with alerts on more than 100 parameters of motor health for each connected motor • Connect to motors using up to seven different voltage busses • Acquire time waveforms, torque/time waveforms and torque spectrum data • Perform current signature analysis • Acquire, monitor and analyze trend information to improve maintenance decisions.

SKF's Asset Efficiency Otimization (AEO) methodology

Combines the in-depth knowledge, broad industrial experience, global service and consulting capabilities from SKF with their world-class products and technologies. The end result? A clear understanding of the customer's business goals, combined with an unmatched ability to offer unique solutions that deliver real value.

Feedwater pump and motor:

SKF works with manufacturers and end-users to develop reliable, cost-effective solutions for critical and semi-critical rotating equipment in power plants.

Coal mills:

SKF has provided bearings, seals, lubrication systems and condition monitoring for coal mills worldwide. SKF works with OEMs and power plant owners to provide the most reliable and cost effective solutions to extend the life of coal mills from design specifications to bearing remanufacture – and every stage in between

Lubrication Systems :

SKF and Lincoln brand centralized, automatic lubrication systems for industrial applications provide the precise amount of lubrication at the right time to extend bearing and machinery life. Designed to lubricate individual machines or complete plants, SKF automatic lubrication systems provide the exact lubrication needed for all lubrication points on equipment while in operation

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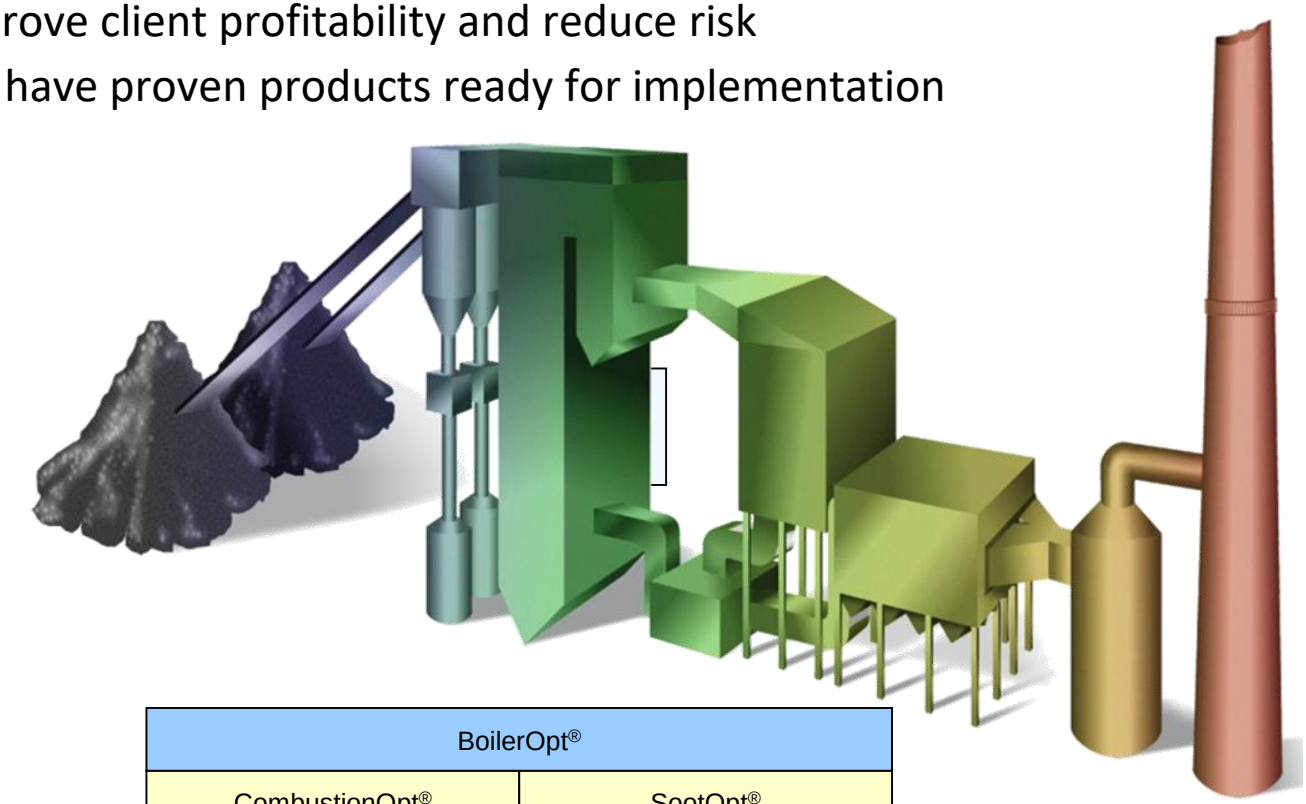
Boiler Optimization

- Coal units are tightly regulated and unique
- NeuCo and GE collaborating on advanced artificial intelligence and controls to improve client profitability and reduce risk
- We have proven products ready for implementation

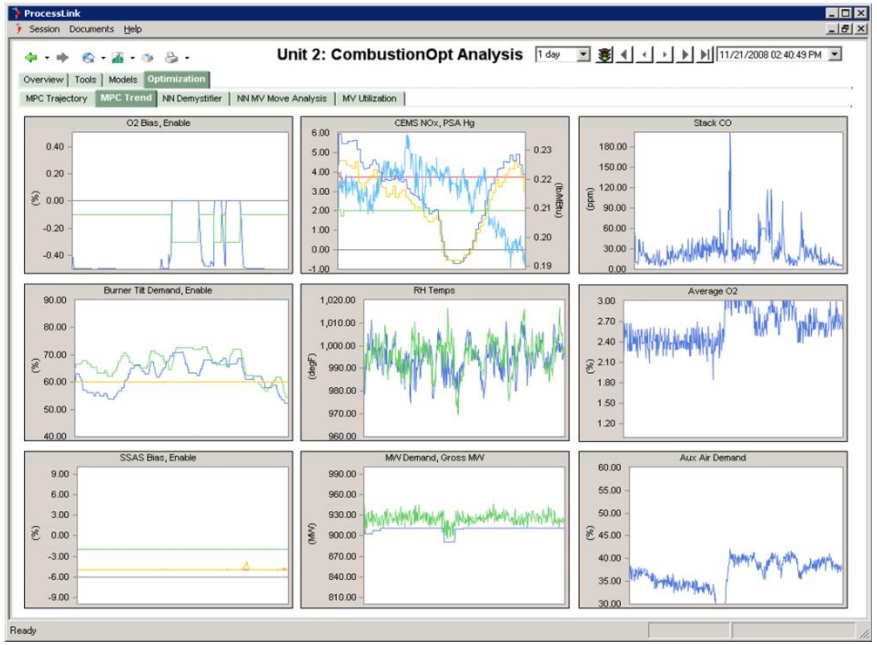


BoilerOpt®	
CombustionOpt®	SootOpt®
Optimizes fuel and air mixing to reduce emissions and improve efficiency	Dynamically directs boiler cleaning actions to achieve unit reliability, efficiency and emissions goals

ProcessLink® Platform

NeuCo's CombustionOpt

- Results achieved through Optimal mixing of fuel and air through MPC, adaptive neural networks and condition-based rules
  - NOx reductions of 10-15%
  - Boiler efficiency increase of 0.5% - 1.5%
  - CO controlled to desired limit
  - Better ramping and load-following performance
  - Reduced opacity excursions
  - Better control of LOI
  - Better adherence to fan and mill amp limits
  - Improved situational awareness and process insight
  - Avoided tail-chasing behavior



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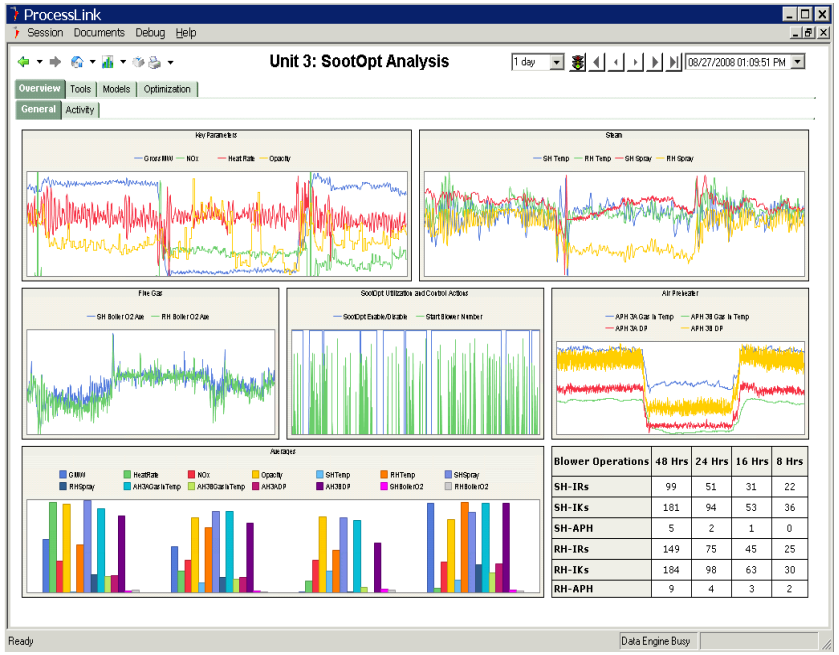
NeuCo's SootOpt ®

- Real-time closed-loop optimization of boiler cleaning equipment using expert rules, thermal calculations and neural networks

  - Reduced and more tightly controlled APH temperatures
  - Improved SH and RH steam temperature control
  - Reduced attemperation sprays
  - Heat rate reduction of 0.75% - 1.50%
  - Incremental NOx reduction of 2.5% - 5%
  - Avoided opacity excursions
  - Reduced blowing of 10% - 35%
  - Avoided thermal stress from blowing
  - Fewer tube-leak failures
  - Improved situational awareness insight



Standardize to Improve Fleet Performance

- Best operator performance 24 X 7
- Fleetwide KPIs and best practices instantiated in software
  - KPI tracking common to all units
  - Helps newer operators to master operating processes
- Lower NOx and heat rate with less stress improves reliability
  - Reduces tube leak related unplanned outages
  - Minimizes volatility of operations
- O&M flexibility and lower O&M cost
  - Lengthens interval between required MATS testing, tuning and repair
  - Advanced analytics enable early problem detection
  - Secure web interface enables leverage on GE engineering expertise

Chehalis Power Project and Currant Creek Power Plant operation supported by GE monitoring center outside Atlanta, Ga.

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NOx Reduction with Emerson Ovation at Midwest Power Plant

- Substantial NOx reductions with Ovation combustion optimization at Midwest coal plant
- Emerson and a Midwest Power plant benchmarked pre-project NOx, O2, and steam temperature levels and burner tilt performance. Two improvements were identified, the addition of separated OverFire air (SOFA) dampers & tilts and combustion optimization in the plant's Ovation control system. The OverFire air process redistributes air within the boiler combustion zone and injects additional air above the combustion zone to complete the combustion process. Decreasing the air within the burner zone lowers stoichiometry, which lowers the flame temperature and reduces thermal NOx. This also reduces the tendency of fuel-bound nitrogen to oxidize to nitrous oxides. To compensate for temperature excursions caused by rapid changes in SOFA positions, advanced control strategies were developed. These control strategies were based on an advanced non-linear, fuzzy-neural NARMAX (FNM) algorithm. The team followed a multi-step process, which included a study of the current combustion process, DCS control improvements, parametric testing, model development, open-loop testing, closed-loop testing, and commissioning. For this project's optimization model NOx and CO were the control variables. Manipulated variables included the OFA and SOFA dampers, SOFA tilts, O2 trim, auxiliary air dampers, window-to-furnace differential pressure, fuel air dampers, and feeders. The disturbance variables included load, ambient temperature, total air flow, and burner tilts demand. Over the multi-year process that included the combustion optimization, followed by the SOFA equipment, followed by the advanced control optimization of the SOFA equipment, the plant reduced annual NOx output from over 1400 tons to under 600 tons.

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Combustion Optimization Module Interaction

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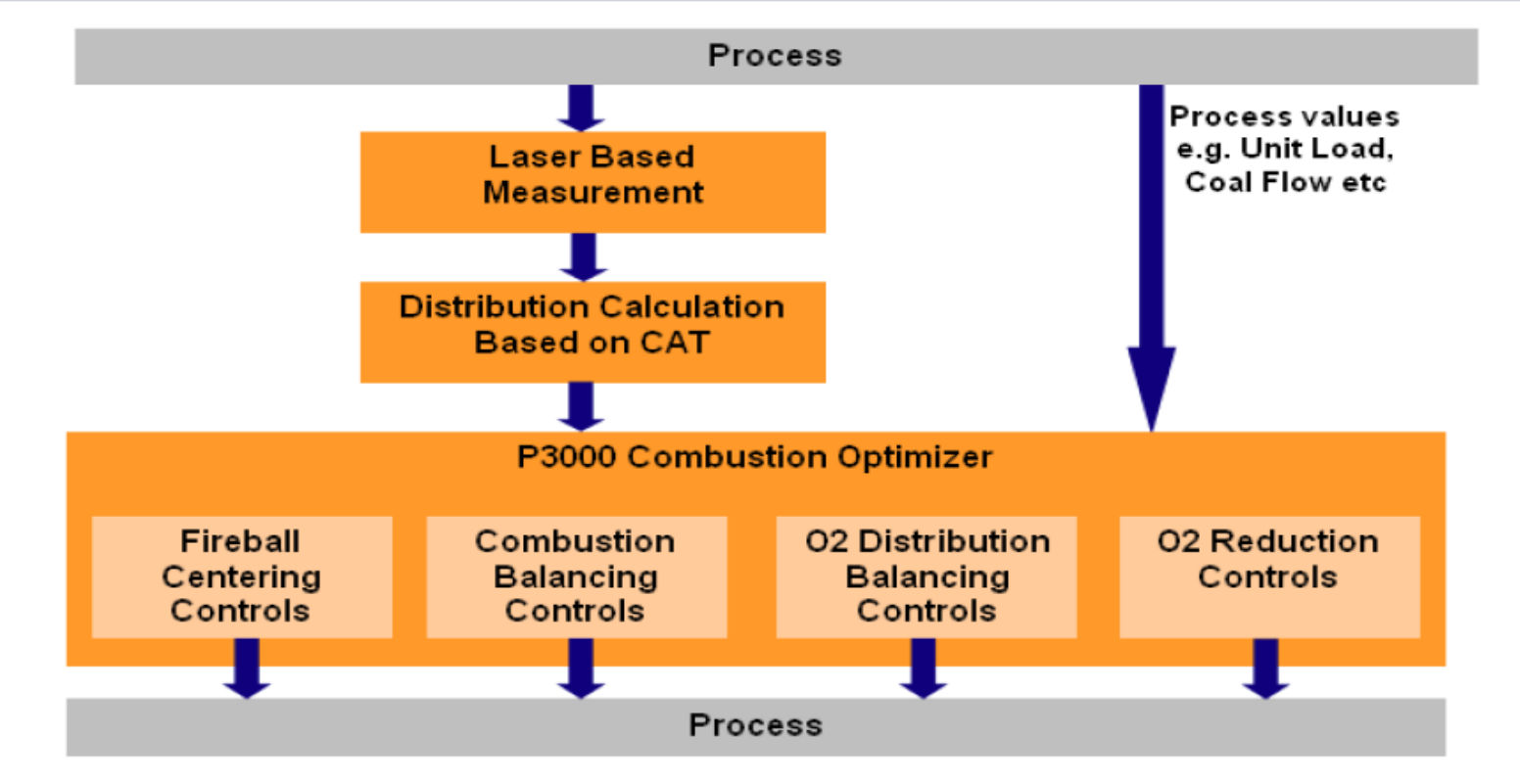

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Laser-based Sensors for Real-time Combustion Optimization

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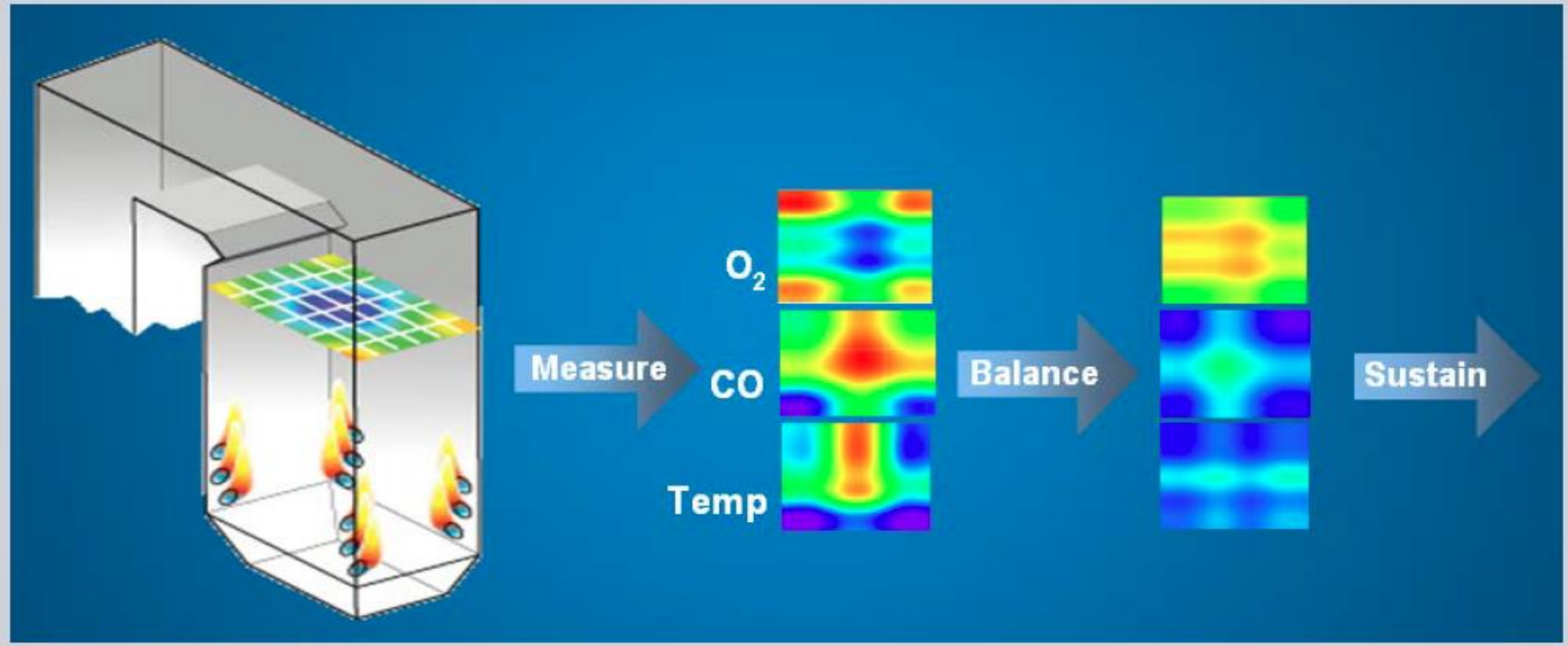

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Combustion Optimization
Dampers and Controls

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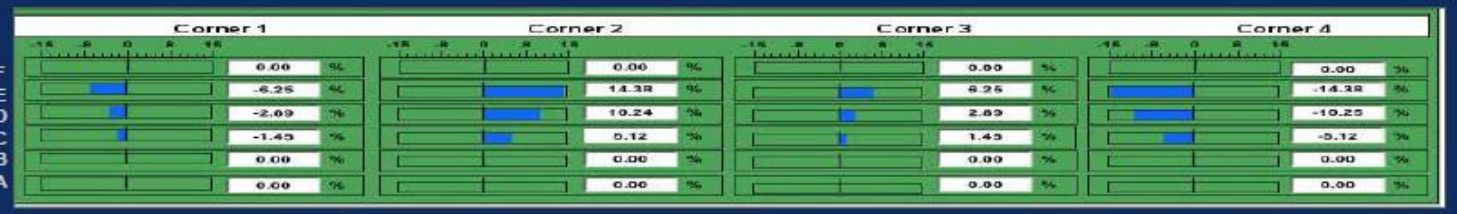
Fireball Centering

By modifying
Secondary Auxilary Air

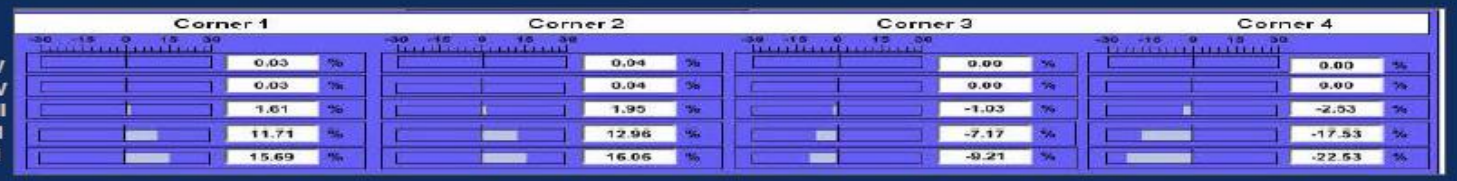


Combustion Balancing

By modifying
Secondary Boundary Air

O_2 Balancing

By modifying
SOFA



O_2 Reduction By modifying O_2 Setpoint

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Optimizer Signal Transfer to DCS

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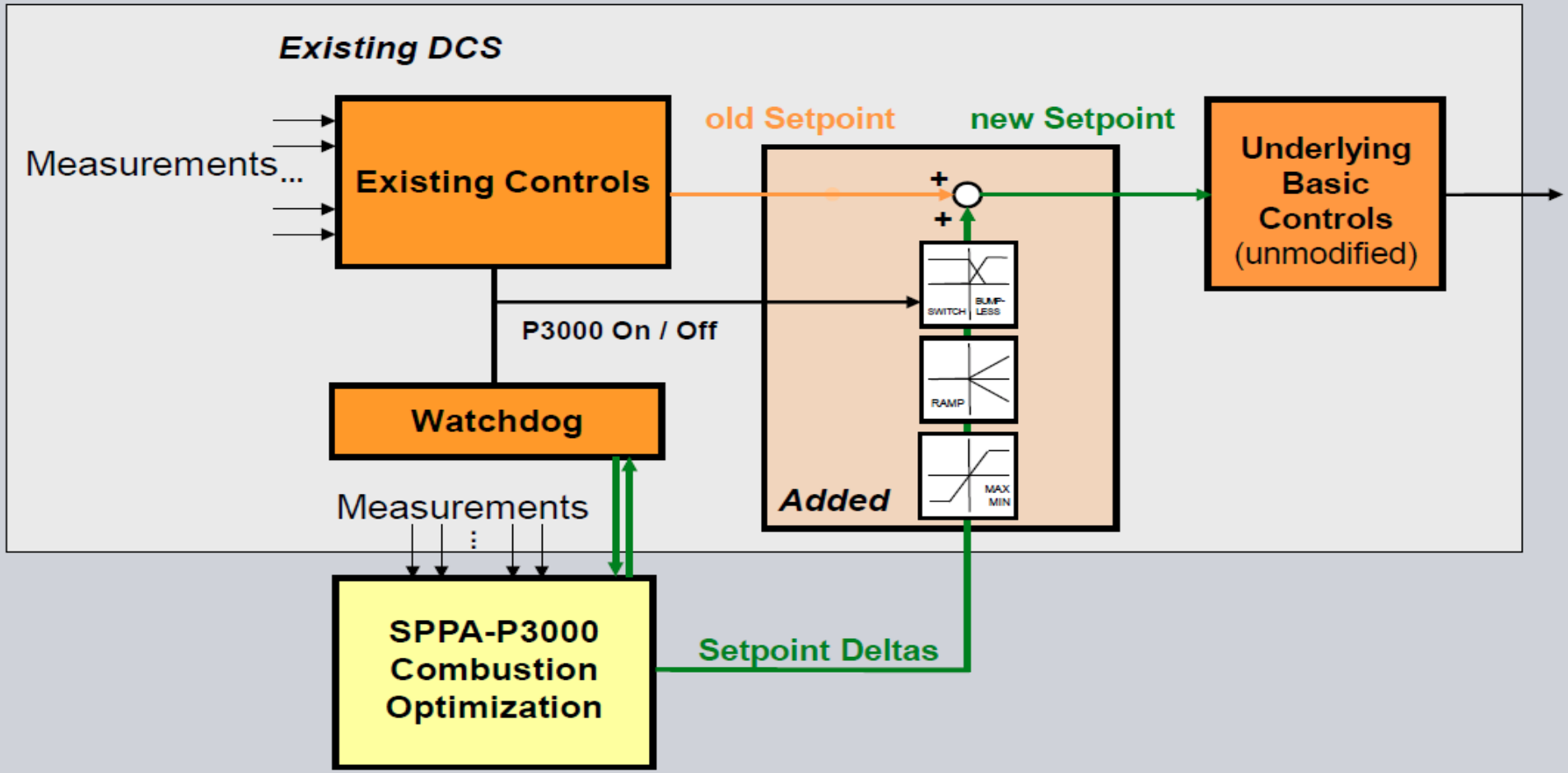

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Reduced O_2 for Improved Boiler Efficiency

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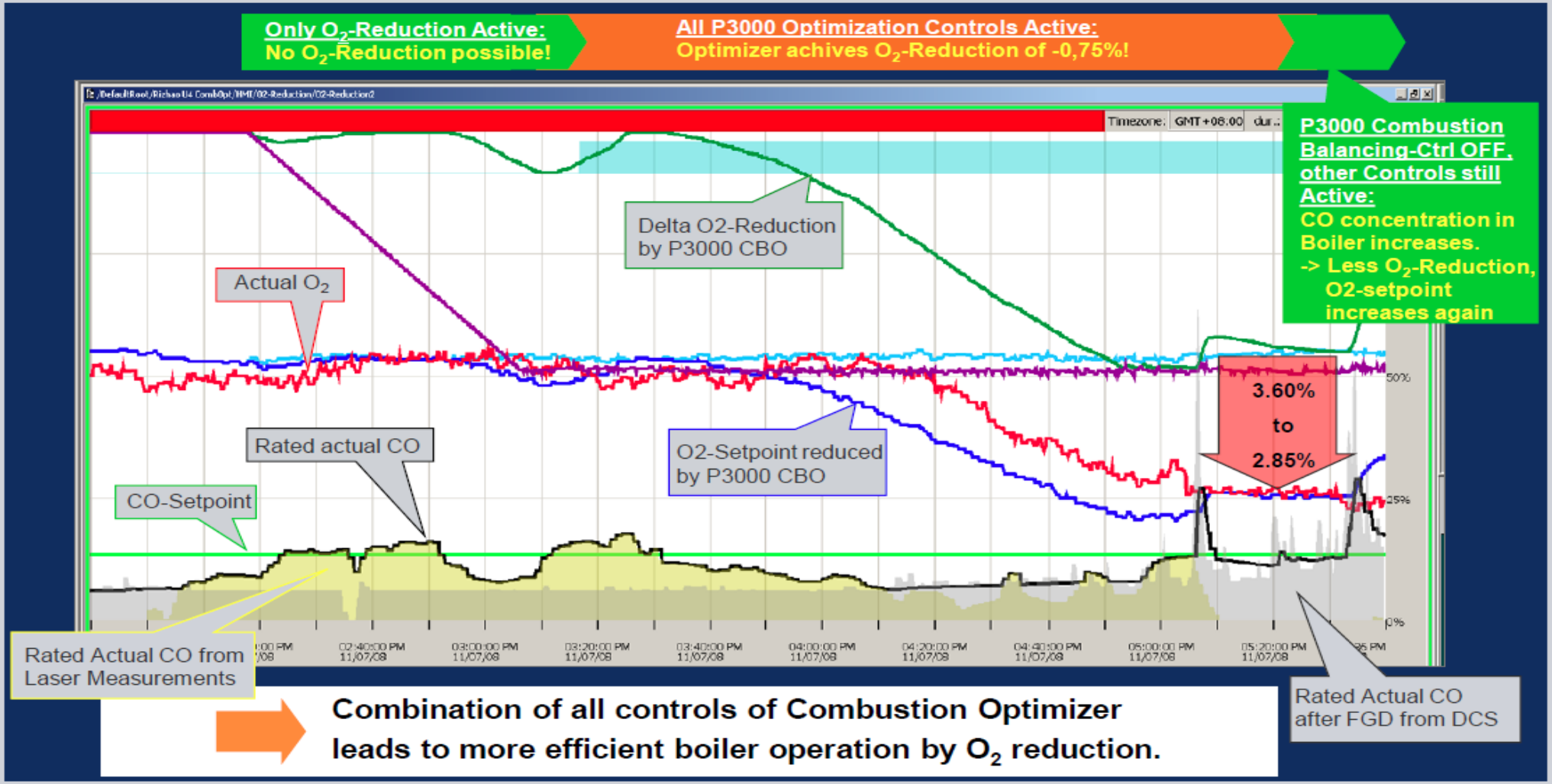

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Luminant Remote Monitoring, Modeling and Diagnostics Center

- Luminant, the largest generator in Texas, has developed a 24 x 7 remote monitoring, modeling, and diagnostics center that supports its entire fleet as well as other customers. Services range from detecting emerging issues to process cycle efficiency to cybersecurity.
- Utilizing over a dozen separate software systems that monitor and diagnose just about any issue that may affect plant operations, the Power Optimization Center has a proven history of helping manufacturing and generating facilities realize maximum asset performance. With power markets nationwide under low price pressures, generators more than ever need a way to analyze unit performance in real time to enhance efficiency, prevent shutdowns and save dollars. Whether equipment resides in the utility industry, manufacturing or any other type of facility, the Power Optimization Center is ready to help.

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Luminant RMC Solves Bearing Rub Problem

- One morning, the Power Optimization Center was actively monitoring a plant startup from hot standby. After the required soak time, the plant began to raise turbine rpm to full speed. Bearing vibration was expected to increase as speed increased, especially as turbine speed enters the critical range where natural harmonics are experienced. After turbine speed passes through this critical range, bearing vibration should return to normal. In this case, generator bearing vibration continued to rise.
- The Power Optimization Center contacted the control room and apprised plant operations of the rapidly rising bearing vibration. Turbine speed was lowered to the previous soak speed. Originally, plant personnel believed the problem bearing to be the indicated bearing based solely on overall vibration readings. Power Optimization Center engineers, through intense scrutiny and evaluation, found the problem bearing to be the coupler-opposite bearing. They determined that a bearing rub, which affected the coupler-opposite bearing significantly more than the indicated bearing, was the culprit. Armed with new information, the plant was able to closely monitor the correct bearing. The turbine ultimately returned to full speed, but only after the offending bearing indicated that the rub was no longer present. Without Power Optimization Center assistance, the plant would have based its corrective actions on the wrong bearing, which would have led to additional delays and possible bearing damage.

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POC Solves Fan Bearing Problem

- The Power Optimization Center received an induced draft booster fan outboard bearing high vibration alarm on the main alarm system. The booster fan provides pressure for the induced draft fan, which draws air and gasses from the furnace, helping to maintain a negative pressure in the boiler.
- Following a swift investigation, Power Optimization Center operators compared bearing vibration parameters for the alarming booster fan to historical values and determined that the increased vibration was not normal and needed immediate attention.
- Power Optimization Center procedures state that plant control rooms should be contacted directly when emergency situations arise, minimizing the time between emergency and remedy. This allows for proper plant personnel to assess the situation and follow their procedures without delay, minimizing risk and maximizing response time.
- The Power Optimization Center contacted the plant and apprised operations of the rapidly rising bearing vibration. Plant maintenance was attempting to reduce fan housing vibration. However, in their attempt, vibration was increased causing a sensing line on a stall probe to fail, which removed plant vibration indication. Plant operations was unaware of the rising vibration. The Power Optimization Center utilizes redundant instrumentation to monitor and diagnose impending failures even when the most relied-upon instrumentation fails.
- Plant operations was able to stop maintenance activities and return fan vibration to normal, preventing permanent damage, an unplanned outage and possible serious injury to those working on and around the booster fan.

McILVAINE

Cooling Water Pumps Optimized in Cool Weather by POC

- In this case, a three-unit power generation facility was experiencing cooler than normal weather. Power Optimization Center engineers initiated a thermal efficiency review and determined all three circulating pumps were needlessly running on each of the three units.
- The third circulating water pump is typically secured as cooling water temperatures decrease during the onset of winter. The third operating pump caused an excessive decrease in condenser backpressure, negatively impacting unit gross generation. None of the three units were turbine limited at the time, resulting in an adverse capacity limit.
- In an ideal world, the condenser removes only that amount of heat needed to change low-energy steam to water, retaining as much heat as possible. A perfectly balanced Ideal Rankine Cycle would then require the boiler to only add latent heat of vaporization. When excess cooling is applied inside the condenser, the boiler must heat the water back to its boiling point before transforming that water into steam, requiring more fuel and auxiliary power to be consumed than what should be necessary.
- The Power Optimization Center contacted plant operations personnel to apprise them of the heat rate impact and recommended securing a single circulating water pump on each unit. Shortly after securing the third circulating water pump, the Power Optimization Center observed optimized condenser backpressure, positive impact on gross generation, optimized total unit auxiliary load, and optimized heat rate for present unit full load condenser operating conditions.
- Analysis revealed that securing the third circulating water pump resulted in 37 BTU/ KWh heat rate improvement for each unit and an additional 3 MWe capacity improvement.

McILVAINE

Air Heater Lube Oil Problem Detected and Solved by POC

- When a plant was experiencing higher-than-normal bearing temperatures on one of its air preheaters, the Power Optimization Center correspondingly increased their monitoring efforts. Auxiliary cooling was used at the time to help achieve normal bearing temperatures.
- One morning, the Power Optimization Center received a high temperature alarm on an air preheater hot end bearing. The air preheater utilizes excess heat from exhaust gasses to warm cold air coming in from the forced draft fans. If the rotating heat transfer element cannot rotate, the unit must shut down in order to prevent damage to the rotating element.
- The Power Optimization Center contacted the control room and apprised plant operations of the rapidly rising bearing temperature. Plant personnel investigated and found decreased bearing system lube oil pressure, causing higher bearing temperatures. Upon further investigation, the plant found the inline lube oil filter to be partially obstructed. They changed the lube oil filters and bearing temperatures returned to normal.
- Without advanced notification by the Power Optimization Center, plant personnel would have received air preheater bearing temperature alarms when temperatures reached engineering limits. Bearing temperatures were rising rapidly and immediate action by plant personnel would have resulted in tripping the air preheater and thereby tripping the unit offline. Power Optimization Center intervention prevented a unit trip and potential equipment damage.

McILVAINE

Pulverizer Lube Oil Problem Identified and Solved by POC

- At 8:30 a.m., the Power Optimization Center received a pulverizer mill lube oil low-pressure alarm. Plant operations was contacted and lube oil pressure was immediately, but temporarily, corrected and the alarm cleared.
- Then again at 3:50 p.m., the Power Optimization Center received the same alarm. Complacency would dictate that the issue had been remedied and the alarm was a nuisance alarm; however, Power Optimization Center operators are trained to trust their indications unless an instrumentation failure has been proven. The lube oil trend for that bank of pulverizers, along with associated trends, quickly revealed that the plant's adjustment had the opposite effect.
- Lubrication is essential to any rotating machinery. The journal bearings installed in this type of pulverizer utilize a forced-oil system that relies on lube oil pressure and temperature to be within a specific band. When lube oil pressure lowers out of specification, bearing damage is likely to occur. .
- The Power Optimization Center contacted the control room again and apprised plant operations of the decrease in pulverizer lube oil pressure for that bank of pulverizers, especially the 'G' pulverizer. Plant operations made another set of adjustments and 'G' pulverizer lube oil pressure returned to normal.
- If pulverizer lube oil pressure remained low with its slow continuous trend downward, then significant bearing damage would be expected. Replacing the affected bearings would have required a 30-day outage with a 9% power derate for the entire duration of repairs.

McILVAINE

Primary Air Fan Lube Problem Identified and Solved by POC

- One afternoon, temperatures plummeted and the wind strengthened, creating challenging conditions for any power plant.
- Power Optimization Center personnel received a primary air fan bearing temperature high alarm. The operator recognized this temperature signature as an emergency requiring immediate action. Primary air fans provide the required air to carry crushed coal from the coal pulverizers into the boiler furnace. Without these fans, fuel could not be fed into the furnace and the plant would trip.
- Power Optimization Center Procedures state that plant control rooms should be contacted directly when emergency situations arise, minimizing the time between emergency and remedy. This allows for proper plant personnel to assess the situation and follow their procedures without delay, minimizing risk and maximizing response time.
- The Power Optimization Center contacted the control room and apprised plant operations of the rapidly rising bearing temperature. Oil flow to one of the primary air fan bearings was stopped due to freezing weather, causing the bearing to quickly overheat. Due to the timely notification by the Power Optimization Center, plant operations was able to restore oil flow before significant bearing damage occurred, avoiding a fan trip and a subsequent plant trip. Grid conditions are critical during significant weather events and even a single plant trip can be disastrous.
- The primary air fan was added to the Power Optimization Center Watch list for additional scrutiny until the fan bearings could be inspected for damage. Not only did the Power Optimization Center help avert potential failure, but plant outage planning personnel also scheduled this asset for bearing inspection during the next available opportunity. They were able to replace the affected bearings during a scheduled outage rather than taking a forced outage during a time when much-needed generation was required to maintain grid reliability

McILVAINE

Pulverizer Mill Bearing Problem Identified and Solved by POC

- On a hot summer day, the Power Optimization Center received a pulverizer mill outboard bearing high-temperature alarm on the main alarming system. The pulverizer mill crushes coal into a fine powder, allowing for rapid and complete combustion inside the boiler furnace. The mill pinion bearings are essential to mill operation, transferring rotational energy from the mill motor to the mill itself. Large steel balls move loosely inside this style of pulverizer housing, crushing the coal and allowing air from the primary air fans to carry fine coal dust from the pulverizer into the furnace.
- Power Optimization Center operators completed a swift investigation, comparing bearing temperatures for the alarming pulverizer mill to historical values, and they determined that the rising temperatures were not normal and needed immediate attention.
- Power Optimization Center procedures state that plant control rooms should be contacted directly when emergency situations arise, minimizing the time between emergency and remedy. This allows for proper plant personnel to assess the situation and follow their procedures without delay, minimizing risk and maximizing response time.
- The Power Optimization Center contacted the plant and apprised operations of the rapidly rising bearing temperature. Upon further investigation, they determined the pulverizer mill had been recently started and the plant duty shift supervisor found the auxiliary cooling fan breaker tripped. The auxiliary cooling fan indirectly cools the pulverizer mill bearings. If the pulverizer mill bearing became overheated, it would have experienced permanent damage, possibly causing extensive damage to the pulverizer mill itself, resulting in lost generation revenue and maintenance costs for repairs. The plant duty shift supervisor reset the auxiliary cooling fan breaker, which reset the cooling fans, and all pulverizer mill bearing temperatures returned to normal.

McILVAINE

Luminant Technical Center Lubricant Analysis Workshop

- *"Lubricant analysis is one of the many valuable tools in our predictive condition-based-maintenance toolbox," said Dale Higginbotham, TCE director, as he spoke to the workshop group.*
- Condition-based maintenance is a strategy that assesses a piece of equipment's actual condition. The objective is to repair or service it when there is an impending fault or degraded condition. Lubricant analysis helps achieve that goal.
- The 2013 workshop, hosted by Luminant's Power Optimization Center (POC), expanded on the success of last year's inaugural meeting. The event drew over 50 employees engaged in equipment reliability from across Luminant, an increase of more than 40 percent. Employees came from Martin Lake, Monticello, Big Brown, Sandow, Comanche Peak, Oak Grove, GPO, Mining and the POC and TCE. These participants recognized that a lube analysis program can provide critical information for any equipment requiring lubricants.
- The workshop was again co-hosted by Trico, a leading provider of predictive condition monitoring technologies. Garry Waggoner, TCE reliability manager, welcomed the group and highlighted the role of predictive maintenance in the overall ROI (Reliability Optimization Initiative) efforts currently underway. Experts from Exxon Mobil, Fluid Solutions, SKF, Shell, Trico and UE Systems led presentations on hydraulic oils, filter replacements, service reports, bearing applications and maintenance, grease and turbine oils, sample ports and proper sampling, and ultrasound for greasing.
- A highlight of the two days was the technical exchange of real-life case studies by Luminant practitioners. Scott Prejean, Oak Grove; Chris Blackmon, TCE; Frank Rogers, Monticello; and Lindon Collinsworth, Big Brown, all shared specific studies of best-practice lubricant analysis events and practices from their facilities. Collinsworth received his second prestigious award from Trico for using Big Brown's lubricant analysis program to identify abnormal wear on a gearbox, resulting in an ultimate savings of $1.4 million.
- *"We are very intent on improving our awareness of lubricant analysis practices and products and effectively maintaining high levels of equipment reliability at our facilities," said Bill Dockrey, POC equipment reliability manager, who, along with Trico, coordinated the conference.*
- Wanda Osborne, POC administrative assistant, also played a key role in organizing the workshop and carrying out all the logistics needed to assure a successful event. Even before the 2nd annual workshop ended, plans were underway to make next year's seminar even better. Striving for continuous improvement typifies everything Luminant does, whether it's a lube analysis program or a training workshop.

McILVAINE

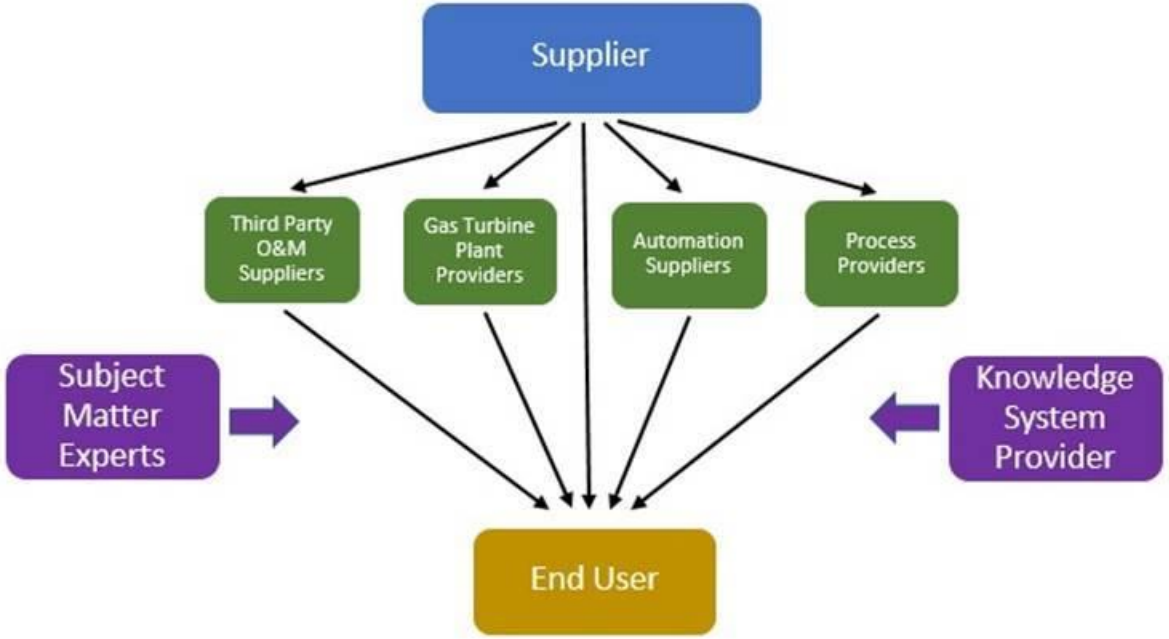
Gas Turbine

McILVAINE

Gas Turbine and Reciprocating Engine IIoT and Remote Markets for Components

There is a new route to market with higher revenues for component suppliers who can expand services subject matter expert revenues by working with five different entities.
The global service, replace, and repair opportunity in GTCC is

- Gas turbines and all components $100 billion/yr
- Liquid cartridge $400 million/yr
- Pumps $1 billion/yr
- Valves $1.5 billion/yr
- Air filters $700 million/yr



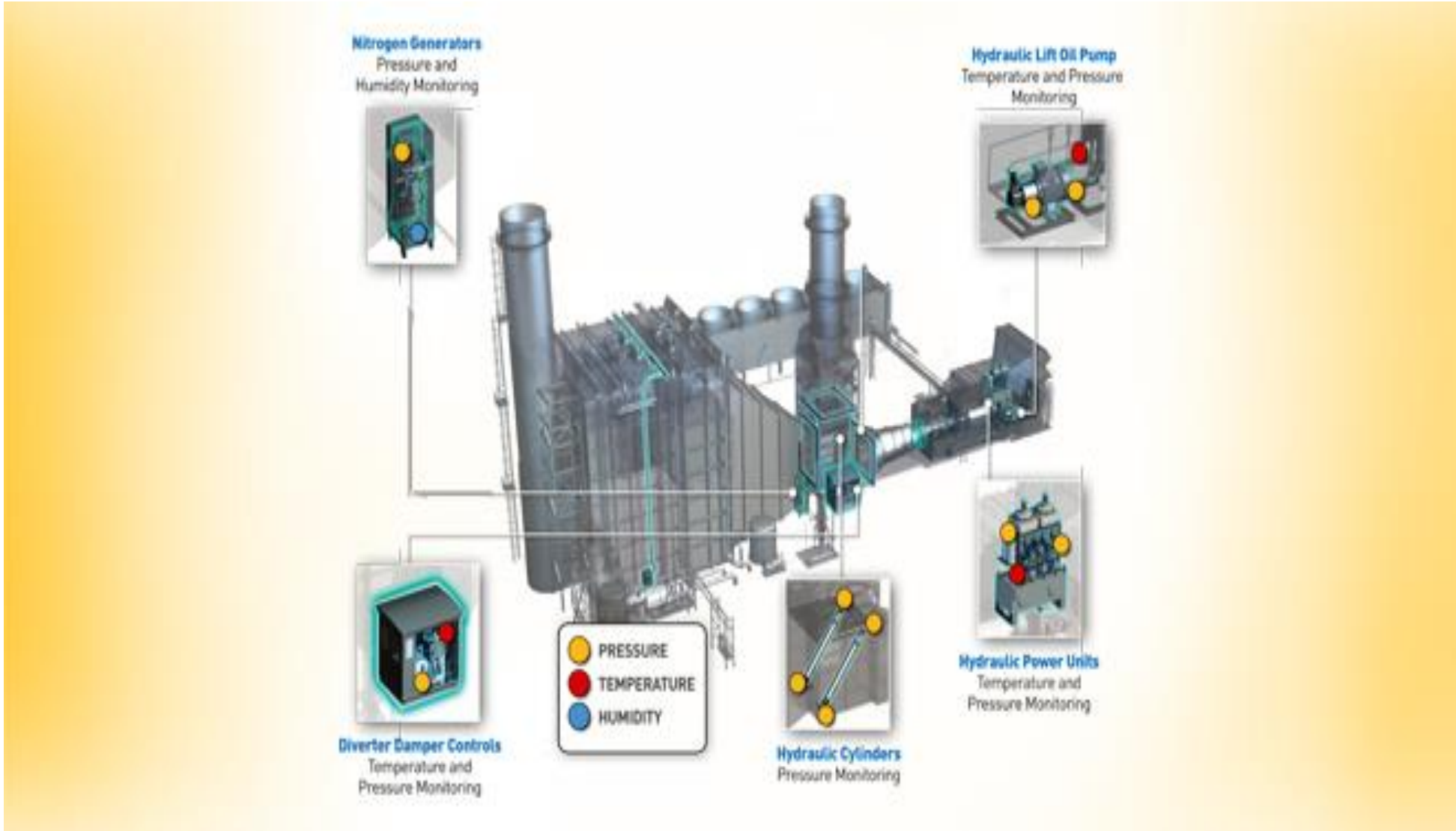
McILVAINE

Parker has Condition Monitoring for Gas Turbines

- Condition monitoring plays a significant role with that. By employing an effective solution that monitors the temperature, pressure, and humidity levels of a plant's assets, operators can diagnose problems or damage to turbines and inconsistencies among processes. Addressing and repairing these issues before they become problems saves downtime and replacement costs.
- Humidity and moisture in the gearbox can cause less than optimal operation of rotary components, leading to corrosion, reduced product quality, and ultimately breakdown. Monitoring a system's performance can be a good indicator of any potential problems with a turbine. By keeping tabs on a system's humidity, as well as the ambient humidity of the plant, operators can gauge any potential effects to a turbine's performance.
- To keep a turbine operating consistently and with minimal chance of overheating, it is necessary to keep components within the gearbox well lubricated and cooled with clean oil. A good filtration package is also important. Monitoring changes of a system's temperature and pressure levels can help operators identify when filters and/or oil in the turbine may need replaced.
- Also, monitoring for increased fuel consumption and/or reduced output could indicate a more serious problem, such as compromised integrity of rotary components within the turbine. Such issues can lead to displacement or damage to toothed gears, blade damage or fatigue failures and other structural damage that will ultimately impact a system's performance.
- Parker's SensoNODE™ Blue sensors and SCOUT™ Mobile software allow users to monitor conditions using multiple sensors simultaneously, each measuring the temperature, pressure, or humidity of specific points within a system. Using Bluetooth technology, the sensors transmit large volumes of data to mobile devices wirelessly, keeping operators out of dangerous situations

McILVAINE

Parker Condition Monitoring for Gas Turbines



McILVAINE

GE Gas Turbine Remote Monitoring Center

- Every day, at its Monitoring & Diagnostics (M&D) Center, GE collects more than 30,000 operating hours of data from a fleet of more than 1,500 gas turbine and generator assets, supplementing a 40-terabyte database representing more than 100 million fleet operating hours
- The Atlanta-based facility features a team of more than 50 engineers that analyze more than 35,000 operational alarms per year. Among the activities monitored at the center are the inlet temperature of a compressor, thermal performance of a gas turbine, temperature of combustion exhaust, dynamic tones of the combustion system, vibration levels of a rotor and the temperature of bearings. On a GE gas turbine unit there are more than 100 physical sensors/300 virtual sensors.
- “Our monitoring and diagnostics team and capabilities, play a key role in helping GE customers operate their power plants at high levels of performance and reliability,” said Justin Eggart, general manager, fleet management for GE’s Power Generation Services business. “Our team takes a holistic approach to what we call ‘predictive maintenance,’ which focuses on helping customers sidestep operational barriers before they occur, no matter what type of equipment they are managing.”
- The ability to foresee and forestall issues is at the very heart of predictive maintenance. Predictivity solutions for GE’s power generation customers harness massive volumes of data analyzed from one of the world’s largest monitored gas turbine fleet to develop solutions that allow them to make more informed operational and business decisions

McILVAINE

Ansaldo Remote Monitoring and Diagnostic Center

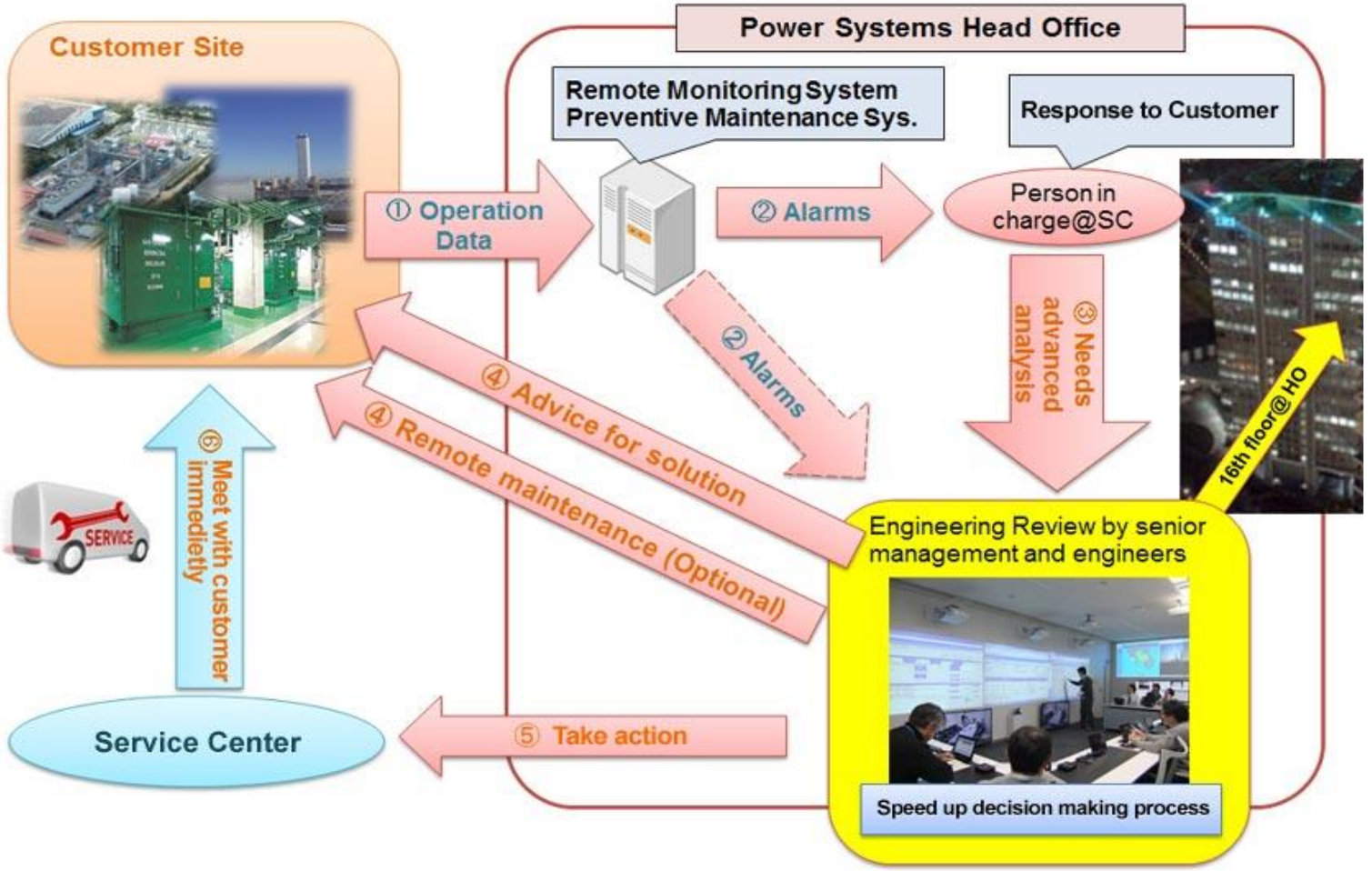
- ADA™ Advanced Diagnostic Analysis is the Ansaldo Energia suite for condition-based maintenance. Based on its modular design, ADA™ allows for advanced monitoring of main equipment parameters like steam and gas turbine performances, gas turbine combustion, machinery vibrations, generator diagnostic, electrical transient and others. Computing modules, automatic report generation, alarms notification, large data storage capabilities are some of the key features of this state of the art product in the field of remote monitoring and diagnostic.

- Through Remote Monitoring, all the relevant data are readily available to experts who, in many cases, can understand quickly the situation and give helpful indications to solve the matter. If additional on-site support is needed Ansaldo can provide at short notice skilled engineers who can assist directly and act as a link with the Operation Support Team.
- Main advantages of Remote Diagnostic and Operation Support are:
- Constant monitoring of your equipment
- Reduction of unscheduled outages
- On condition maintenance, tailored on specific requirements
- Spare parts management support
- Decision support for unexpected trips or events
- Quick response time for site engineering support
- Engineering support for troubleshooting

McILVAINE

IHI Remote Monitoring Center for Gas Turbines

Remo-moni™ is IHI's Remote Monitoring System(RMS) of Gas Turbine Driven Generator Power Plants.Remo-moni™ is an advanced monitoring system for gas turbine power plants.
IHI has the ability to observe the customer's plant from the IHI monitoring center and advise on operations and maintenance.
It is for a) Safe Operations, b) Improving High Availability and c) Save Maintenance Costs of Gas Turbines Power Plant Operation.Remo-moni™ is installed easily by connecting to internet.
since 1995 the number of Installations has grown to 77 units and 47 sites.



Turbine Services Supports Sites with Different Make Turbines

- Turbine services supports sites with different make turbines
- Monitoring and diagnostic systems supplied by independent service providers rather than turbine manufacturers can be deployed to suit the operators' requirements, rather than what might suit the manufacturer. And they can be used with different turbine makes and models, and for other types of plants. This is the argument made by **Jonathan Aylett**, of Turbine Services, a Chromalloy company
- For example, a power utility has a fleet of peaking turbines from different manufacturers and of different types, such as heavy industrial and aeroderivative. The utility company uses the same system via the internet to monitor all turbines remotely, and the system can send diagnostic messages to cell phones and email reports to company staff. It has a flexible client-server architecture which can be used in a centralized monitoring center, or decentralized to any location able to connect a client remotely to a server. It can also support remote clients running in web browsers.
- A site data server acquires and archives data from the turbine controllers. Any number of remote clients can connect to it using the company’s internal network, or remotely via internet or modem connection.
- Data update rates for the remote clients can be configured for the bandwidth of the network connection. This can be at once per second over fast LAN or internet connections, or once per hour for slow modem connections. For slow connections, remote clients can be configured to only download trend data and diagnostic messages each day, reducing data transfers.
- A typical data set of 400 analogue and 1500 digital tags is acquired each second and analyzed 24/7. It is impractical to analyze this manually, so the system analyzes the data in real time using diagnostic rules and pre-alarm checkers, generating diagnostic messages which are archived on site.

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Nuclear

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Duke Nuclear using Schneider Electric, PRISM, APR to Monitor Rotating Equipment

- Duke Energy Nuclear Generation, modeling a program successfully used by Duke's fossil fleet, began a fleetwide project in late 2014 using the Schneider Electric Process Information Signal Monitoring (PRiSM) Advanced Pattern Recognition (APR) software to "model" critical, large rotating equipment, explained Howard Nudi, fleet engineering support manager at Duke. APR software can derive predictions for multiple variables simultaneously based on empirical relationships established during normal operation. The software monitors assets 24/7, sampling real-time data every 5 minutes. If the real-time data falls outside APR software predictions, a deviation is identified and a notification is generated for the engineering group to evaluate. APR software can also tell if there is a deviation from predicted behavior and the possible reason, based on subject matter expert input programmed into the software.
- Integrating PRiSM at the first site, Harris Nuclear Plant, was completed in May 2015, Nudi said, with approximately 60 component models actively deployed. Duke quickly realized positive results as the software identified two unanticipated motor cooler fouling issues in summer 2015 on cooling tower makeup pumps, enabling site engineering and maintenance personnel to take early action to efficiently make repairs. McGuire Nuclear Station is 98% complete with more than 200 APR models deployed for Units 1 and 2. The remaining eight units in the Duke nuclear fleet will be completed by the end of 2017. The primary focus is equipment reliability and performance.

McILVAINE

Renewable Energy

McILVAINE

Schneider Electric using Microsoft for Solar Azure Cloud Platform

- Schneider Electric will expand its existing work with Microsoft as a Global Independent Software Vendor (ISV) to include Azure IoT technologies that enable innovations in solar monitoring solutions. By utilizing the more secure, remote connectivity of the Microsoft Azure cloud platform, Schneider Electric's ConextTM Advisor accesses solar power plant performance data and provides high-level analysis via the cloud. Delivering detailed KPIs, Conext Advisor improves visibility into plant performance and enables faster, better-informed decision-making.

  Conext Advisor allows plant owners, managers and investors to supervise their solar systems' operations in real time. Its analytics can be used to monitor performance metrics to identify site factors such as shading, soiling or signs of aging components, and proactively identify maintenance, servicing and refurbishing needs. Conext Advisor is part of Schneider Electric's comprehensive suite of control supervision, performance analytics, and forecasting modules that help optimize performance, minimize operating expenses and enhance solar energy generation.

  Said Arnaud Cantin, VP of the Power Plants line of business for Schneider Electric Solar and Energy Storage. "The key to Conext Advisor is that it is an advisor: it does not stop at data acquisition, display and reporting; through the power of analytics in the cloud, it interprets data and provides recommendations that enable customers to take action and significantly improve the performance of their assets."

  Schneider Electric will continue to accelerate solar innovations with Microsoft and the power of the Internet of Things. To learn more about Schneider Electric's solar products and solutions, visit **http://solar.schneider-electric.com**

McILVAINE

SKF supplies Remote Monitoring for Marine and Offshore Wind Facilities

Phil Spry, Team Manager for Reliability Services at SKF explains to Evolution Magazine in October 2016:“We have been an established provider of remote monitoring services to the marine and offshore wind sectors for some years now. With our move into the industrial sector, any company with Internet access can implement a world-class predictive maintenance programme simply and cost-effectively. By outsourcing the process, customers can move the cost of condition monitoring from the CAPEX to the OPEX budget; perhaps more importantly, they are able to make significant improvements to the quality and reliability of monitoring and diagnostics without the need to invest in on-site teams, giving them far greater operational flexibility.”

Typically, a remote monitoring service such as that offered by SKF begins with an on-site visit by engineers to determine the criticality of assets, agree the frequency of data capture and map data collection routes. Data can be gathered by onsite employees, the service provider’s technician or automatically using specialist equipment, before being securely transferred using the service provider’s proprietary software to a remote monitoring center. Data is reviewed by condition monitoring analysts, who provide detailed asset condition reports via a secure Internet connection. Urgent issues that require immediate attention are relayed directly to onsite engineers or plant managers. Phil Spry summarizes:

“A key advantage of our Remote Monitoring Service is that it allows customers to delegate the responsibility for an extremely specialized but nonetheless vital service to our team of experts. This frees up in-house staff and resources and enables customers to concentrate on their core business.”

McILVAINE

Generators

JS Power uses Netbiter for Cloud Control of Backup Power Generators

- JS Power is a British company selling, installing and maintaining backup power generators. The generators run on diesel or biodiesel and provide business-critical backup power for data centers, hospitals and commercial buildings — operations which need power at all times. The problem Although JS Power uses sturdy and reliable power generators based on engines from Scania and Sisu, the innate remoteness of backup power generators makes it hard to constantly keep track of critical operation parameters such as fuel levels, battery voltage, oil pressure etc. With installations all over Europe, it is a great challenge to be sure that each generator always is ready to start.
- "One of the inherent problems of our industry is generator maintenance," says Jonathan Searby, Director at JS Power. "We are constantly working to reduce client maintenance costs, while always making sure that the generators are ready to start 24/7. This is where a remote management solution is a big help."
- A Netbiter communication gateway is installed in each power generator connected to the control panel via the internal Modbus network. The Netbiter monitors around 50 different parameters from the generator and sends these via a LAN/Ethernet connection to a secure server called Netbiter Argos. JS Power can log into Netbiter Argos over the web and access parameters such as operation status, operating hours, fuel levels, oil pressure etc. It is also possible to remotely start and stop the power generators, which is critical to make sure the engine will be ready to start when needed. This is done once a week to make sure that each unit is operational. A surveillance IP camera ensures that JS Power sees the power generator starting up and that nobody is working on the generator at the moment.

McILVAINE