Opportunities for Predictive Analytics for Air Pollution Control

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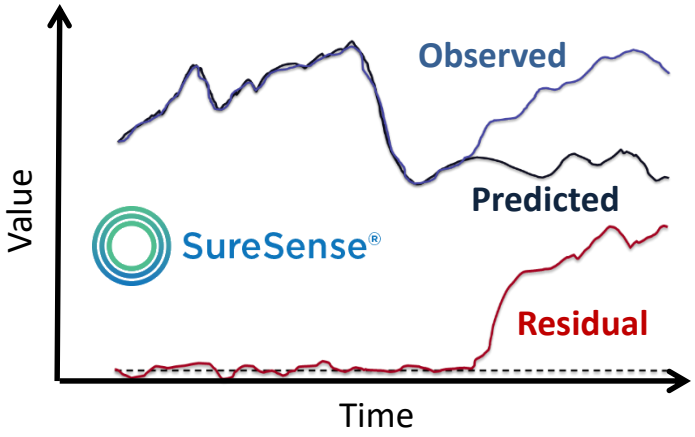
- **Consulting**
  - Business Strategy (Client's - top OEM's in Energy & Environment)
  - Disruptive Technology Introduction
  - M&A
- **Technology Liaison**
  - Licensing & Technology Transfer (Multiple licenses signed)
  - Foreign Market Introduction – India, South East Asia, Middle East & Europe
- **Data Analytics**
  - Digital Transformation Consulting
  - Advanced Pattern Recognition + Prognostics
  - Performance & Reliability Monitoring
  - Embedded OEM analytic solutions

Predictive Analytics for APC

Predictive Analytics Techniques

- Machine learning methods learn “normal” relationships between multiple parameters
- Predictions for each parameter are compared to actual values in real time (i.e. Residual)
- Residual used to accurately detect “abnormal” behavior of each parameter



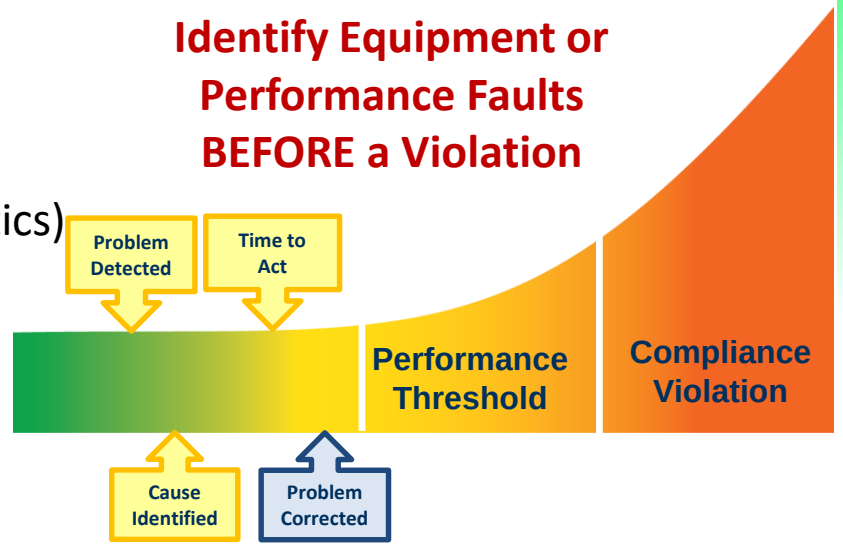
Benefits

Improve APC Equipment Reliability

- Early detection of pending equipment issues
- Higher APC availability
- Insights into issue causes (diagnostics)
- Insights into remaining time to act (prognostics)

Improved APC Process Performance

- Early detection of performance issues
- Enhance/maintain optimal emissions reductions
- Lower/optimize reagent costs



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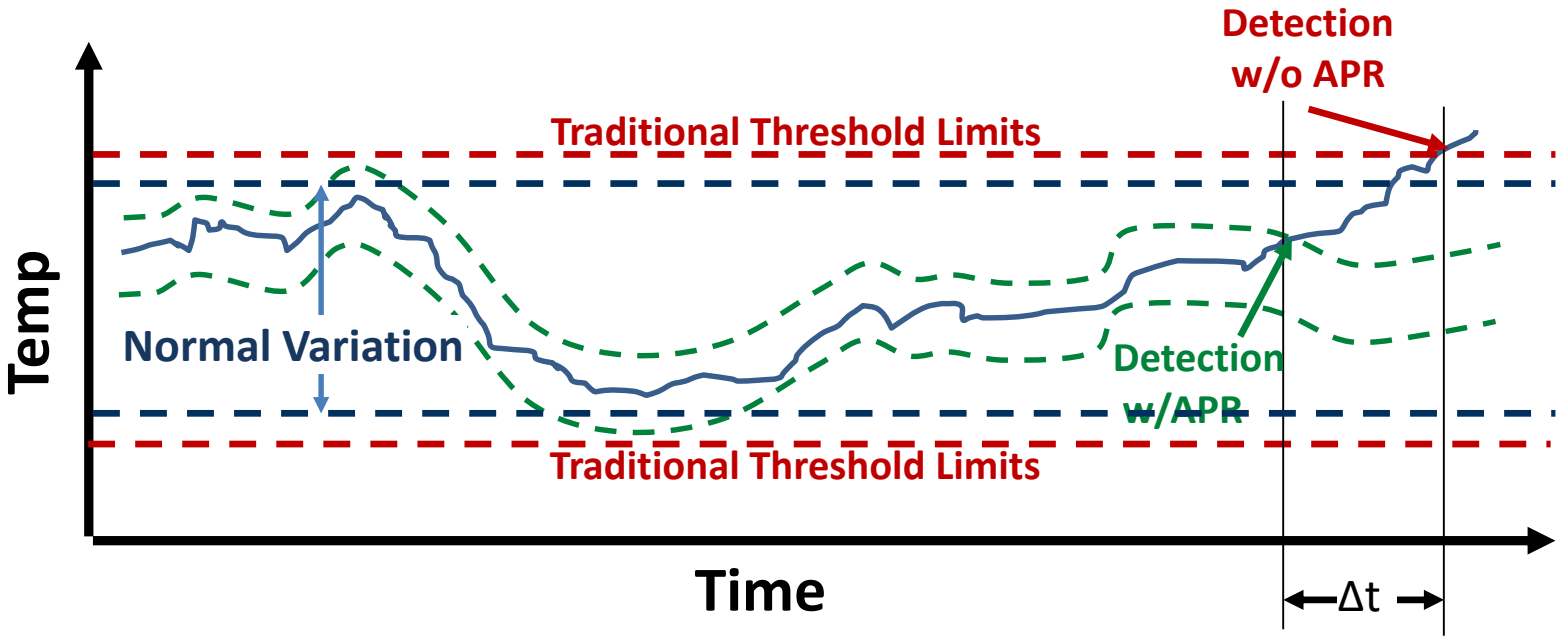
Trend Monitoring vs Predictive Analytics

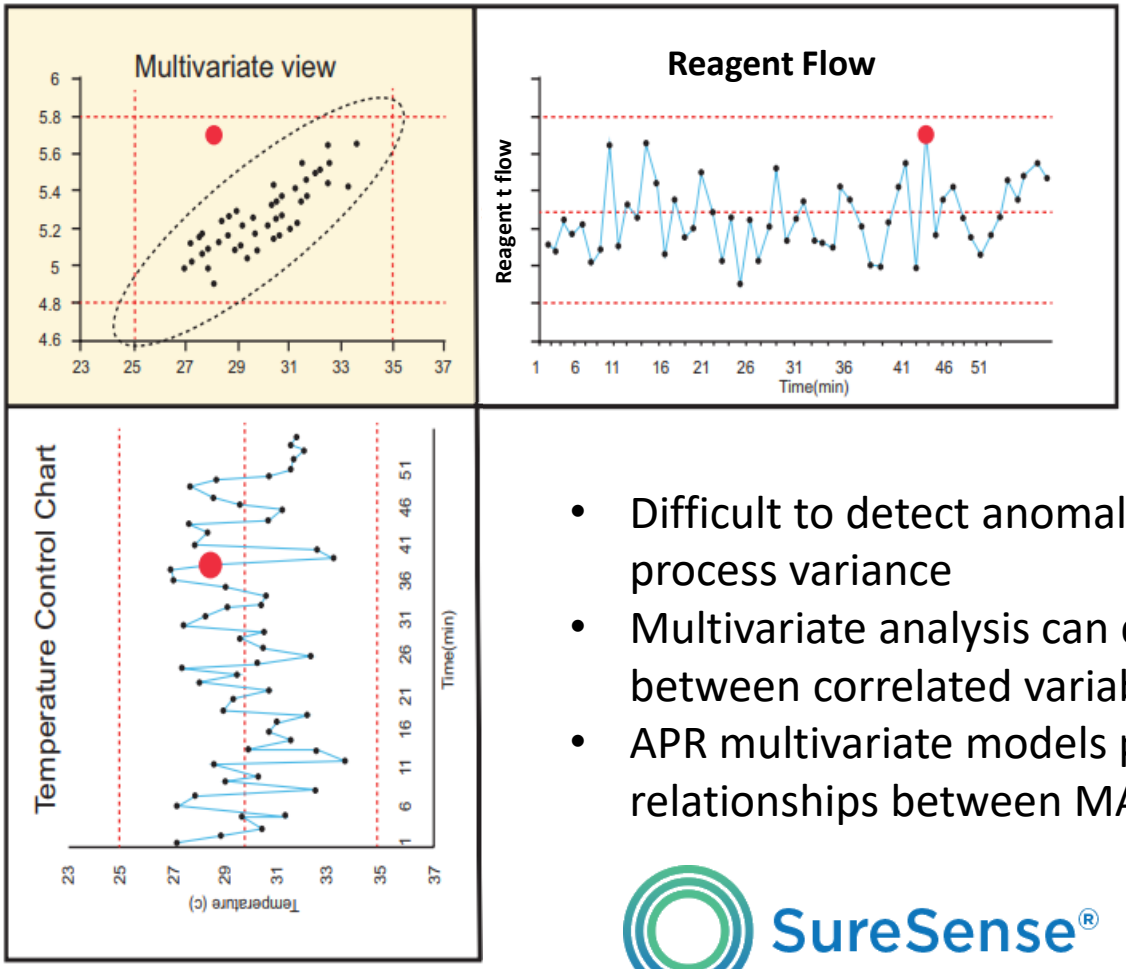
(Advanced Pattern Recognition or APR)



- Values can vary over time due to “normal” process variation
- Traditional trend limits must be wide to accommodate this variation
- Dynamic, tighter APR thresholds account for “normal” variation

APR detects anomalies EARLIER than traditional threshold limits

Univariate Variable vs Multivariate View



- Difficult to detect anomalies with wide process variance
- Multivariate analysis can detect anomalies between correlated variables
- APR multivariate models predict the relationships between MANY variables

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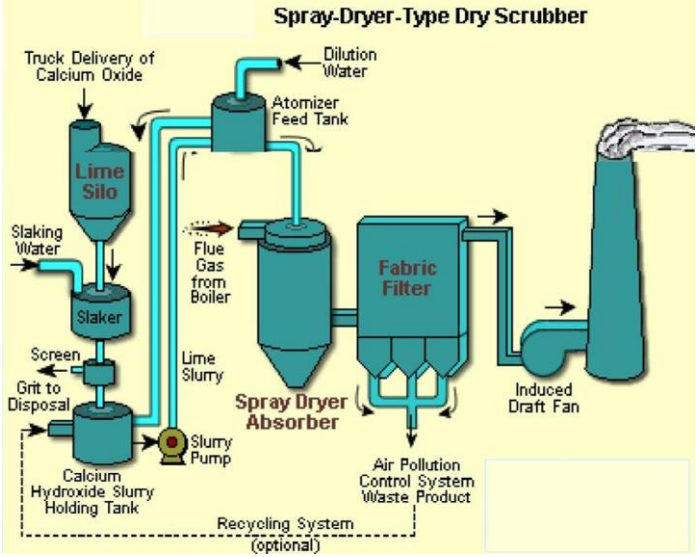
APR Application to Dry Scrubber

Key Variables Impacting FGD Process

- Unit Load
- Flue Gas Temps
- Ambient Conditions
- Coal Properties
- Sootblowing frequency
- Water quality/treatment

Difficult to Predict FGD Performance



Key Equipment Monitoring

- Reagent feeder system
- Water treatment
- Slaker
- Nozzles/atomizers
- BOP: Pumps, Motors, Valves
- Slurry storage & recirculation system
- Baghouse

Key Process Monitoring

- Reagent flows/use
- Reagent properties (resistivity)
- Dewpoint
- Inlet/outlet emissions
- Water quality

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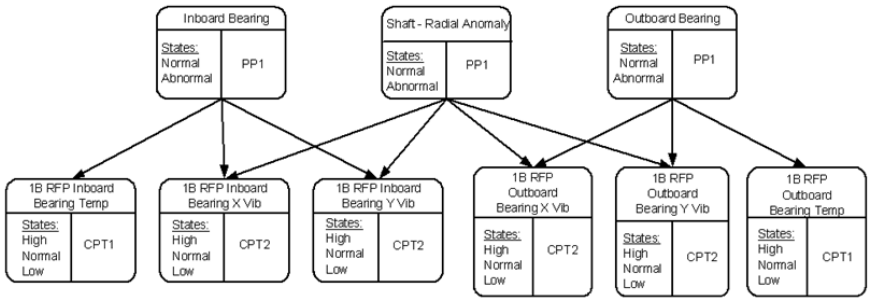
Advanced Predictive Analytics

SureSense® The Virtual SME™

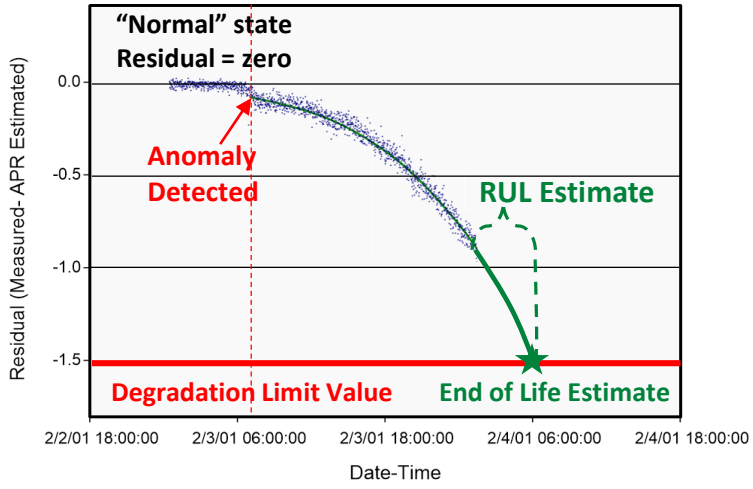
Diagnostics

- Likely cause of problem
- Based on combination of multiple symptoms
- Rules-based logic
- Model-based logic (probability based)
- Capture, leverage and automate expert knowledge



Prognostics

- Remaining time to act
- Based on degradation rate of key symptoms
- Provides risk-based info for repair timing



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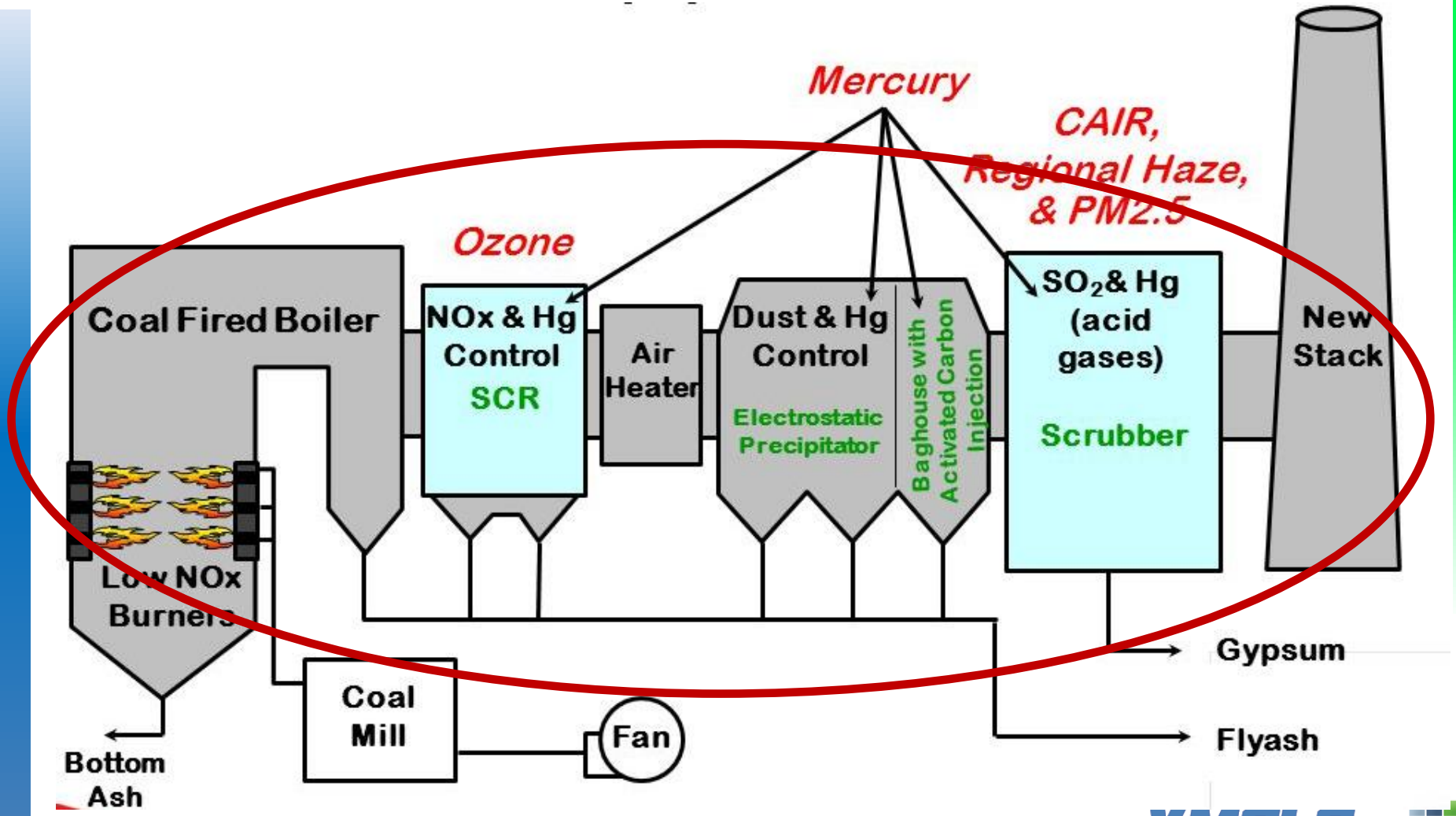
A Holistic Approach

Reliability & Performance of the APC System



Conclusions

- Predictive analytics accurately detects anomalies in APC performance and reliability BEFORE they impact compliance
- The Virtual SME can automatically diagnose the likely cause of the problems based on multiple symptoms
- Remaining time to act can allow better maintenance planning and lower maintenance costs
- Predictive analytics can increase APC-related availability and lower overall operating costs

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Thank You.

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