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The Power of Data

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The Power of Data

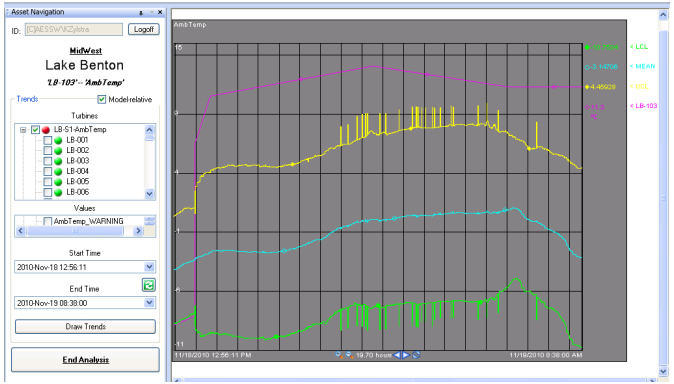
Predicting Wind Turbine Failures with the PI System and Statistical Process Controls

Presented by **John Goins – IT Manager**

Tom Hedgepeth – Database Administrator

AES
we are the energy

Predicting Wind Turbine Failures with the PI System



"Even in an environment with older technology and less than ideal communication and connectivity, Statistical Process Control has worked well. It identifies failed or failing components before an event occurs."

Kevin Zylstra
Performance Engineer

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Business Challenge

- Identify wind turbines that need maintenance before they fail.
- Calculate control limits based on varied technology at diverse locations.
- Track warning history for trending and analysis.

Solution

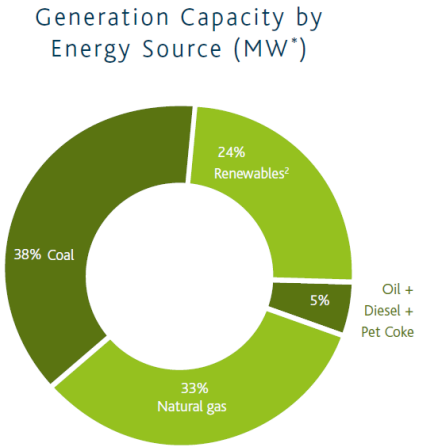
- Use PI System components to normalize the various turbine technologies and track alarms.
- Implement the PI Asset Framework to provide meta-data for our analysis
- Implement custom services to calculate control limits.

Results

- SPC is identifying abnormal or statistically different turbine attributes that would otherwise go unnoticed.
- Maintenance work can be scheduled more proactively before an event rather than after.

About AES

- **Generation**
  - Generation businesses in 20 countries on four continents
  - 37 Generation businesses
  - 29,797 MW Generation capacity in operation
  - 2,140 MW Generation capacity under construction
- **Utilities**
  - Thirteen distribution companies around the world
  - More than 12.1 million customers
  - 79,567 Gigawatt hours (GWh) of energy sold
  - Fuels: coal, diesel, hydropower, gas, oil, wind, solar and biomass
  - Generation under construction: 216 MW



Partners and Stakeholders

- Dennis Kilgore
  DLL Solutions
- Mark Brown
  Industrial Evolution
- Jeff Gibbons
  - AES Wind Technical Director
- AES Wind Performance Engineers:
  - Elaine Miller
  - Kevin Zylstra
  - Noe Encarnacion

Wind Assets in the Current Project

Condon
(83 MHI-47)

Mountain View I & II
(110 MHI-44)

Buffalo Gap I
(67 Vestas V80)

Buffalo Gap II
(155 GE1.5 Bachman)

Buffalo Gap III
(74 Siemens SWT-2.3)

Lake Benton
(141 Zond 750 48m)

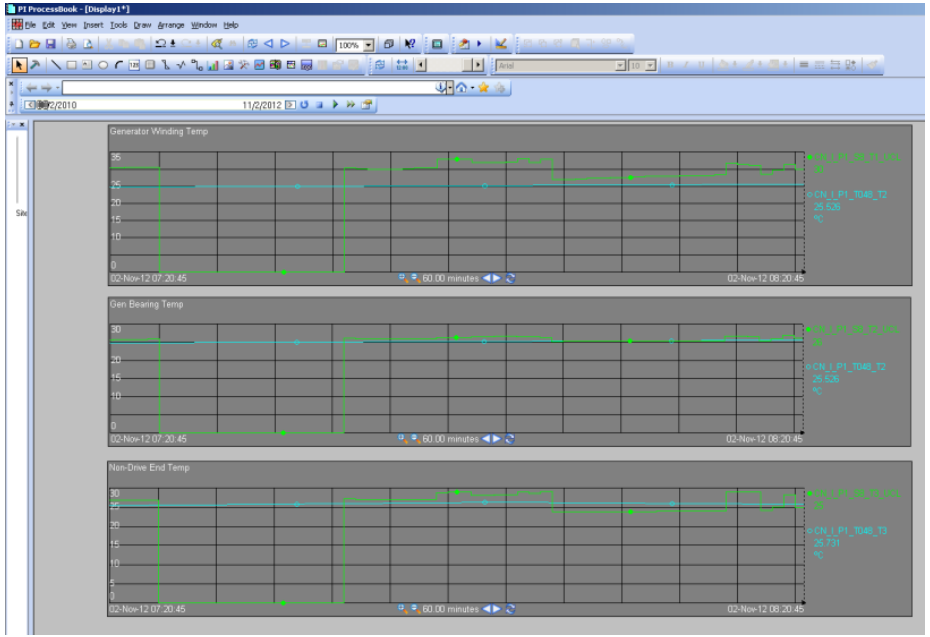
Armenia Mountain
(67 GE 1.5 MW SLE)

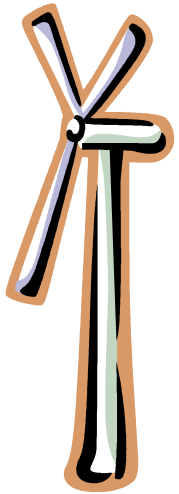
Laurel Mountain
(41 GE 1.6XLE)

Storm Lake
(104 Zond 750 50m)

Business Challenge

When you have a small number of assets it is easy to monitor their health, perform trends, and watch real time data.





Business Challenge

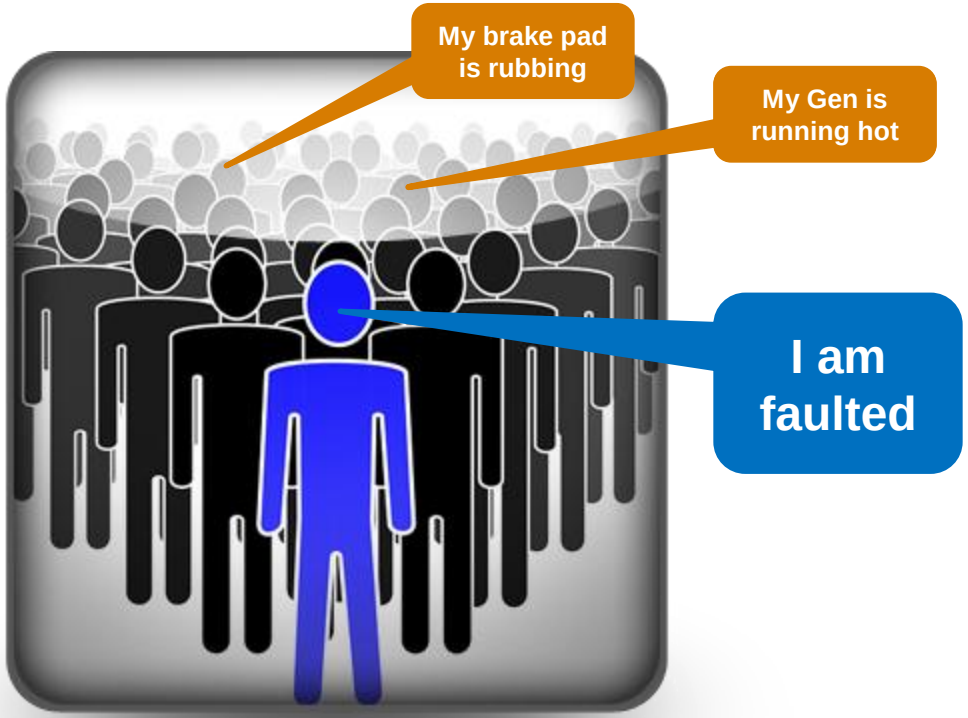
Wind projects typically have numerous assets to monitor.

Additionally, each turbine will have multiple temperature and other sensors that need to be monitored.

Business Challenge

We are really good at knowing which turbine is not operational.

How do we aggregate all of the data into something that will help us identify problems before the turbine shuts down.



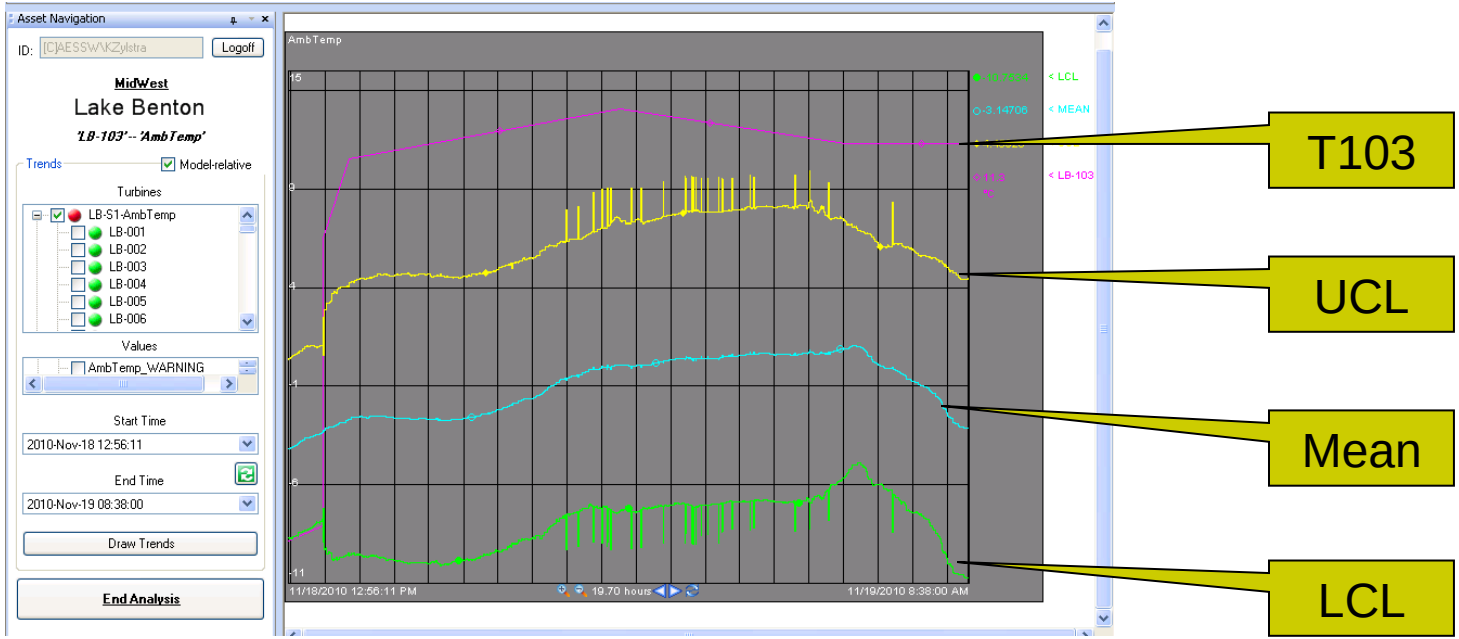
Solution

- Use Statistical Process Control concepts to drive our analysis.
- Use Control Charts with Upper and Lower Control Limits around a population mean.
- Use PI Performance Equations to control whether a turbine is included in the mean.
- Turbines running outside the UCL and LCL trigger alarms that drive our analysis.

Solution

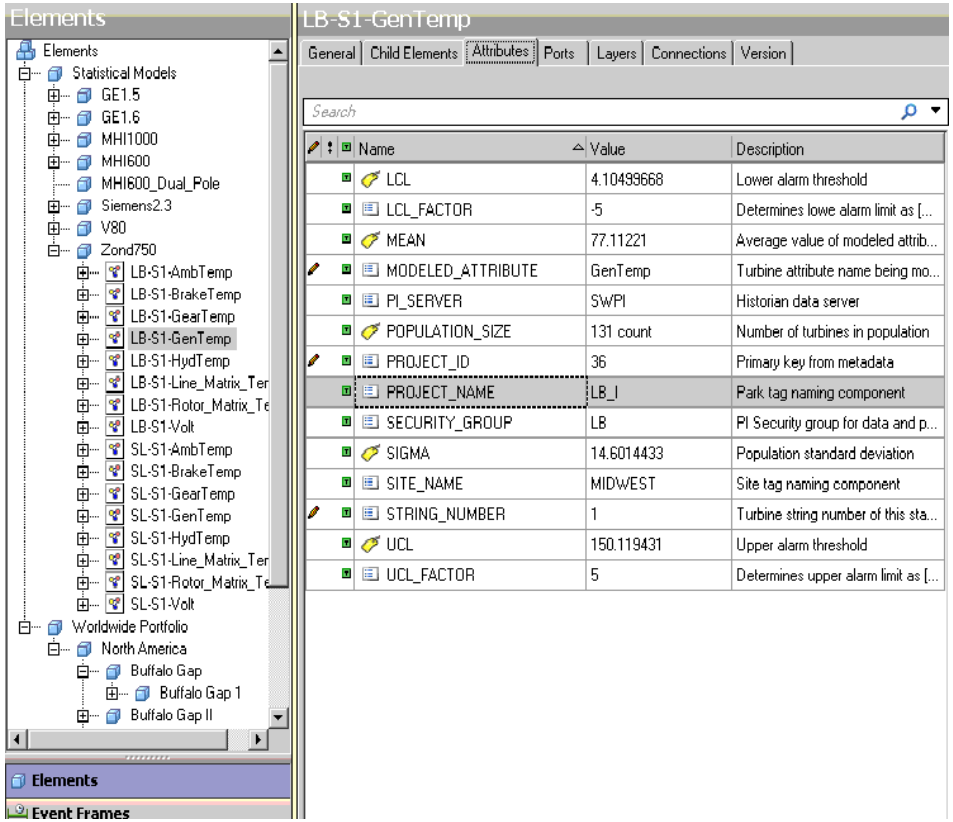
- Use our existing PI System to gather the necessary data from the various SCADA systems.
- Use PI Asset Framework to model our data in a consistent format.
- Use custom calculation engines to watch the data and calculate upper and lower control limits for sensors we wished to monitor.
- Use PI Alarms to automatically trigger warnings when an individual sensor deviated from normal.

Control Chart using ProcessBook



PI Asset Framework

- Implemented reusable template for all turbines.
- Extended template into templates for each turbine technology.
- Included additional meta-data from SQL for tracking.
- Included additional meta-data for “string” analysis.

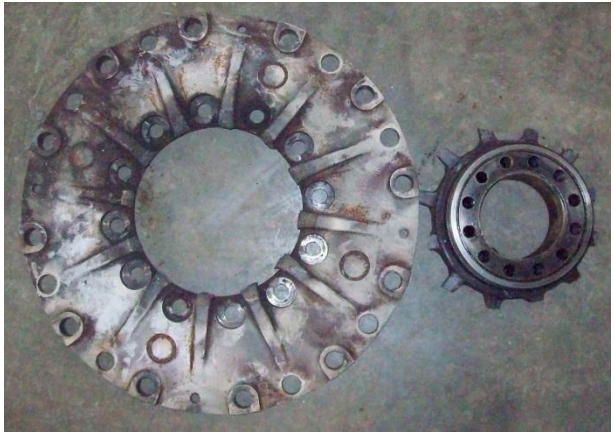


PI System Alarms

- For each sensor that we wish to monitor PI Alarm tags are configured.
- We compare the real-time value against the statistical UCL, LCL, and hard-limits.
- Different Alarm levels are triggered based on the limit.
- Alarms are automatically saved to a SQL database for historical look-backs and other analysis.

Results

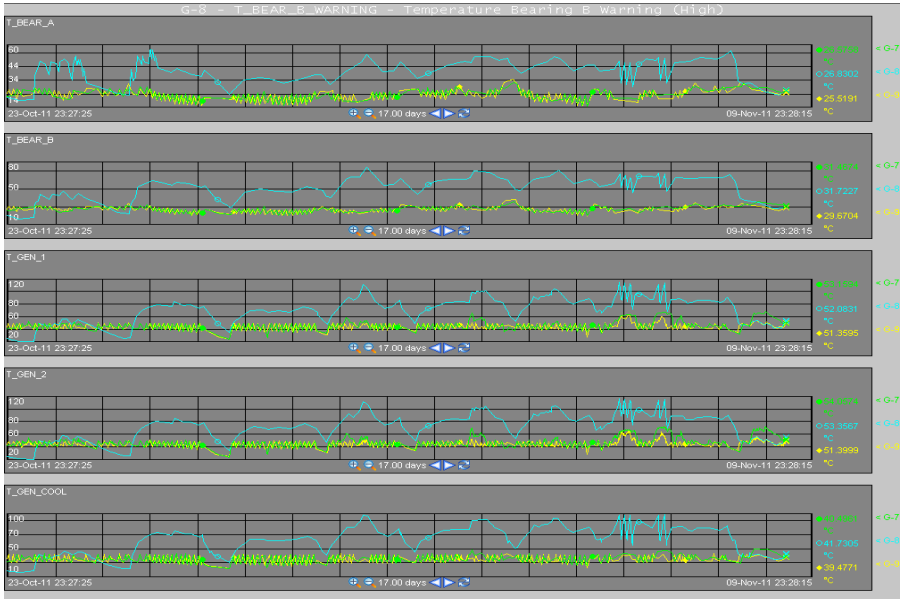
- SPC indicated high ambient and brake temperatures.
- The failed part caused the brake disks to rub and run warmer.
- Turbine was repaired with ¼ of the normal down time, using fewer parts, and on our schedule.



“The continual rubbing of the brake pads causes premature failure and creates dust in the nacelle. The dust accumulates in the generator and diminishes the cooling capacity.”

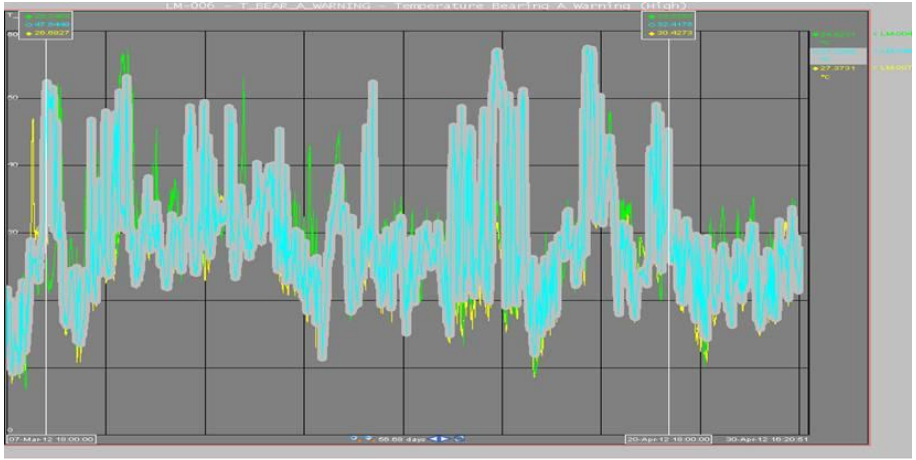
Results

- SPC indicated high bearing and gearbox temperatures on a GE 1.5.
- During a repair the generator cooler fan was not wired to a spare breaker correctly, which caused the cooling system to not respond correctly.
- “Thanks to the SPC program it did not require the turbine to fault for high temperatures in order to discover and correct the problem.”



Results

- SPC showed high drive end generator bearing temperature warnings on a GE 1.5.
- Technicians troubleshot the electrical and mechanical systems and found that there was a problem with the generator alignment.
- The alignment was corrected and temperatures were returned to normal.
- Misalignments on the generator cause increased temperatures and excess wear on the drive end bearings.

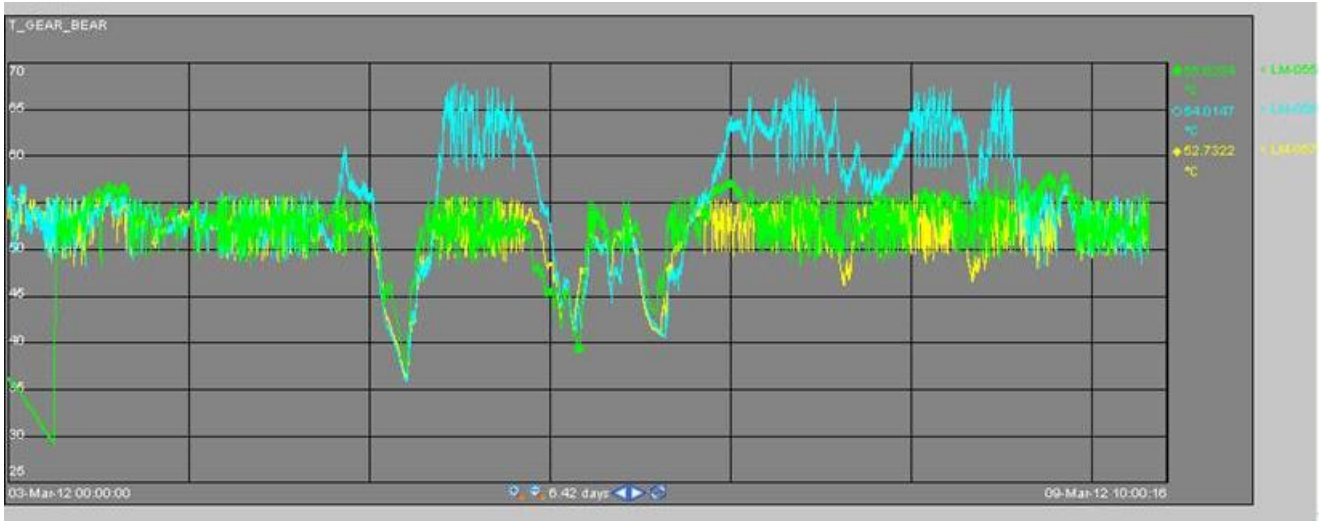


“This is the first mechanical problem discovered by SPC in the East and continues to build confidence in the value of this program.”

Elaine Miller
Performance Engineer

Results

- SPC indicated elevated gearbox oil temperatures on a GE 1.5 turbine.
- Technicians at the turbine found a tripped circuit breaker for the low speed fan. The breaker was reset and temperatures returned to normal.
- The early identification allowed us to fix a small problem rather than waiting for the turbine to fault for high temperatures.



Results

- Additional examples of problems identified using SPC, Control Charts, and the PI System:
  - Failed contactors on the low speed gearbox cooling system
  - Failed temperature sensors
  - Clogged oil filtration systems

John Goins & Tom Hedgepeth

John.Goins@aes.com

Tom.Hedgepeth@aes.com

THANK YOU

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