

Un-Buzz-Wording the Digital Twin: A Practical Guide and Examples for Power Plant Operators

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Co-Author and Acknowledgement

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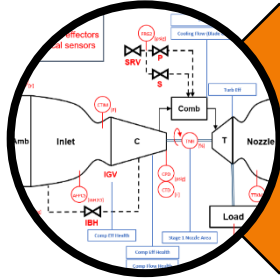
Digital Twin Concept

- The Digital Twin serves as a virtual replica of an asset in real time
 - It is an *analytical model* that represents a *physical system*
- The term digital twin has been used as a broad label for many types of analytical analysis and other representations
- A true twin contains several characteristics:
 - It must contain the physics of the physical hardware or process you are emulating
 - It must have a method for matching a generic analytical model to the condition of the hardware on a regular basis
 - It must have the capability to predict (prognosticate)

How Can a Digital Twin Help?



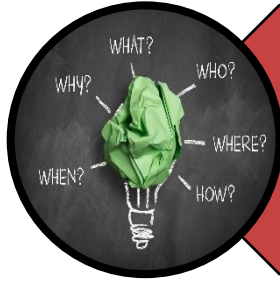
Helps determine the optimal operation under current conditions



Digital Twin fundamentally leverages existing data



Provides greater insight into unit condition and operations

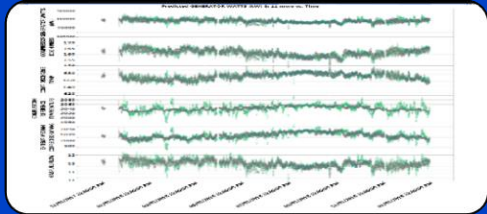


Enables reliable forecasting

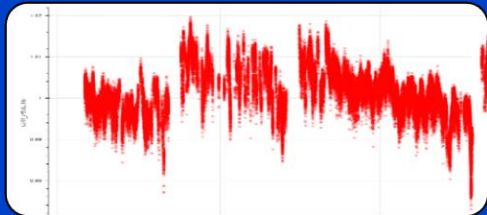
Key Characteristics of a Digital Twin



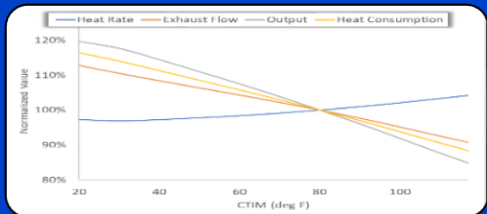
What Can You Do With It?



Future Performance Prediction



Real-Time Diagnostics



Updated Correction Curves



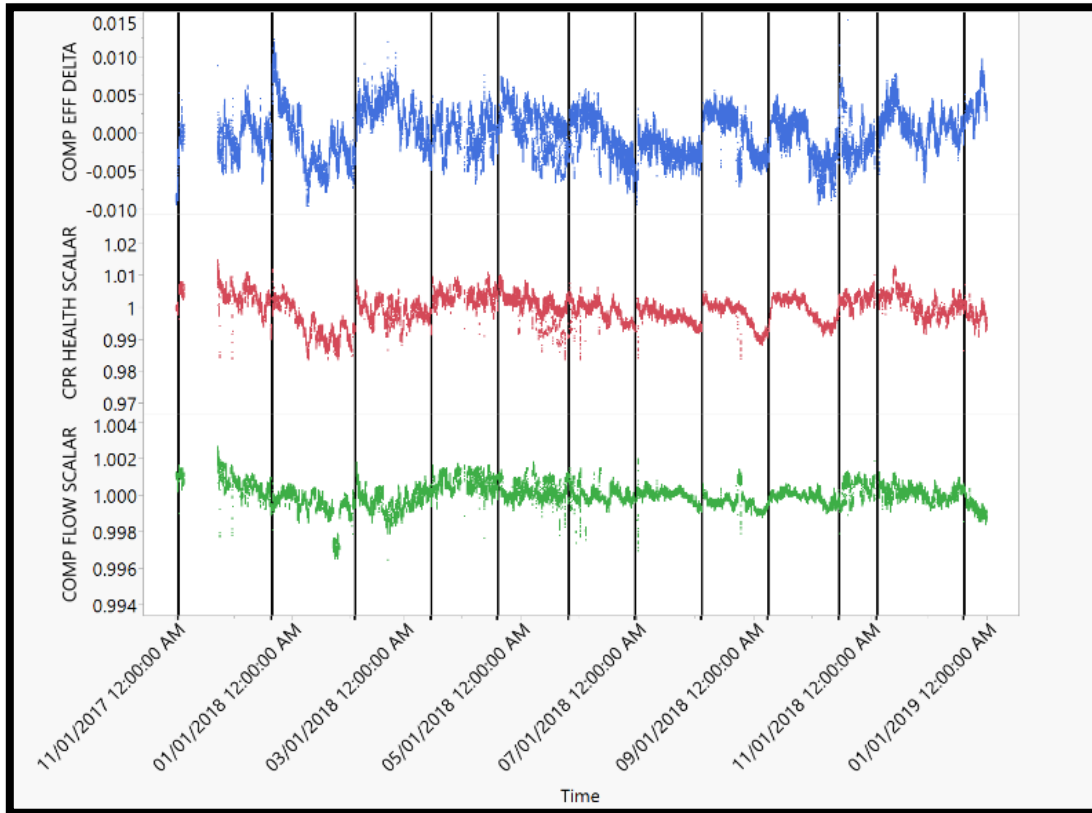
Pre/Post-Outage "What-If"



Case Studies

- **Fault Diagnostics**
- **Future Performance Prediction**

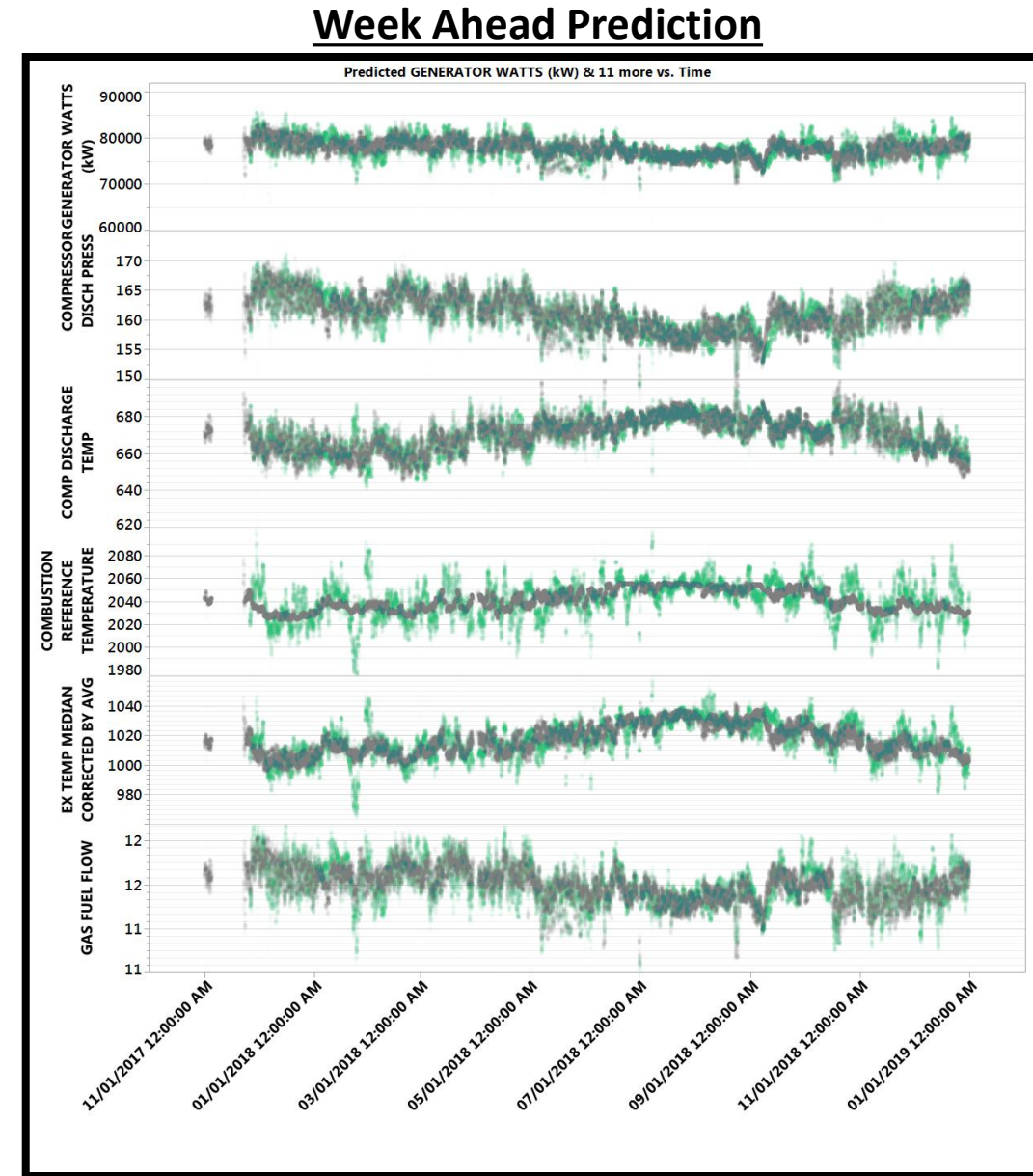
Water Wash Impacts



- Plot shows one year+ of compressor health parameters
 - Vertical lines show offline water washes
- Can clearly see sawtooth pattern from offline washes
- Used Digital Twin to Predict potential power recovery from wash

Performance Forecasting

- Constant recalculation of health parameters enables accurate forecasting
 - At right, light green is DT prediction
 - Dark colored points are site data
- Can predict performance one week or more in advance



Prediction Accuracy

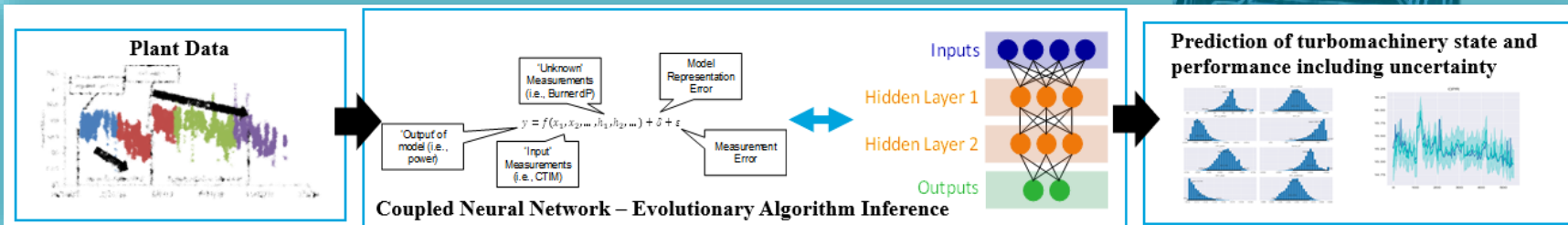
| Prediction | One Day Ahead | One Week Ahead |
|-----------------------------|--------------------------|------------------------|
| Generator Watts (kW) | +/- 1,758 | +/- 2,556 |
| CDP (psig) [bar] | +/- 1.78 [+/- 1.12] | +/- 2.5 [+/- 1.17] |
| CDT (deg F) [deg C] | +/- 4.7 [+/- 2.6] | +/- 6.77 [+/- 3.39] |
| TTRF (deg F) [deg C] | +/- 15.94 [+/- 8.86] | +/- 23.5 [+/- 13.1] |
| EGT (deg F) [deg C] | +/- 9.4 [+/- 5.2] | +/- 14 [+/- 7.8] |
| Fuel Flow (lbm/s) [kg/s] | +/- 0.158 [+/- 0.072] | +/-0.23 [+/- 0.104] |

Errors shown for F-Class Turbine

Summary on Digital Twin for Gas Turbines

- Using an embedded *Neural Network system to auto-calibrate* and assist with fault generation for performance characteristics of the gas turbine
- Direction to expand capabilities including mechanical and emission diagnosis
- Creates improved **diagnostic** and **prognostic** capabilities
- Complements and Enhances existing **health** and **performance monitoring** [e.g., APR]
- The Future: Fully integrating with AI/ML technologies to enhance monitoring leading to the possibility of synthetic faults **not previously observed**

- Digital Twin – virtual representation of a **specific** piece of equipment or system created through a combination of:
 - Data
 - Knowledge
 - Analytics
 - Physics Based Models



A blue-tinted photograph of four people, two men and two women, standing in a row. They are dressed in professional attire, including lab coats and a hard hat. The text 'Together...Shaping the Future of Energy™' is overlaid in white on the image.

Together...Shaping the Future of Energy™