Enabling Analytics and Operational Intelligence with the PI System

Presented by **Curt Hertler - Global Solutions Architect**
Craig Harclerode - Industry Principal – Oil & Gas

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Agenda

- Importance of the Data Model (PI AF) – The Foundation
- Context for Analytics & Operational Intelligence
- Defining Analytics – “The Analysis of Analytics”
- The Role of the PI Integrator for Higher Level Analytics
- Enabling Operational Intelligence and Excellence
- Closing Remarks

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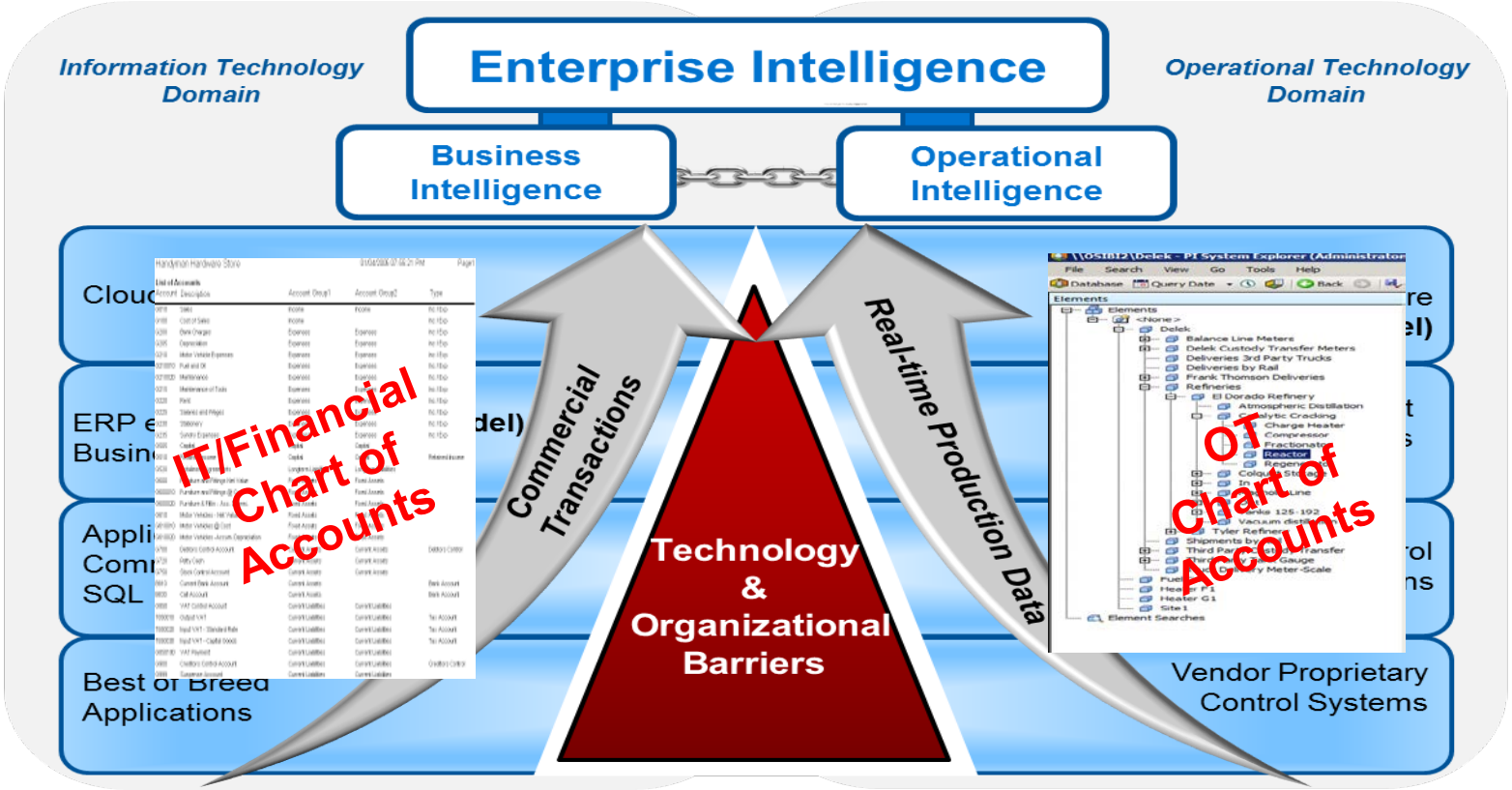
The Journey to Enterprise Intelligence – IT/OT Convergence



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The PI System - Foundational for Operational Intelligence & Excellence

Sensor Data Sources With Metadata

- Mobile
- Meter
- Car
- Equipment
- Event
- RFID
- Etc.

Intermediary Data Sources & 1st Level Calculations & Analytics

- IoT Cloud Based Hub
- IoT Head End Concentrator
- Manual Data Entry
- Local Historian (PI C/SCADA/DCS)
- Relational Data

Asset Based OT Context & Abstraction Infrastructure

Cloud Enabled, High Availability

- Aggregation
- Normalization
- Quality Check
- Security
- P-F Historization
- Metadata Integration
- Real-time Analytics
- Event Framing
- Alerts/Notification

PI System Access (PSA) (ODBC, JDBC, Web Services)

High Speed PI Integrator for Business Analytics

Cleanse
Augment
Shape
Transmit
(CASTing)

Business Imperatives

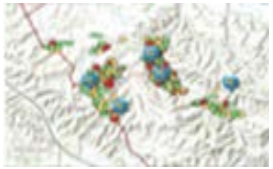
Energy Management
CBM/asset reliability
Environmental C&R

Dashboards & Operational Analytics

Mobility and Self Serve BI

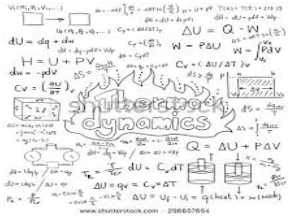
MetaData/System integration Maximo/P&S/LIMS/Etc.

Predictive, Statistical, Visual Analytics, Machine Learning



Real-time Geospatial Analytics (PI + eSRI)

Data Warehouses Data Lakes



Specialized models (Yield, P&S, Hysis, etc.)

"Big Data" /Hadoop Analytics/BI/EI

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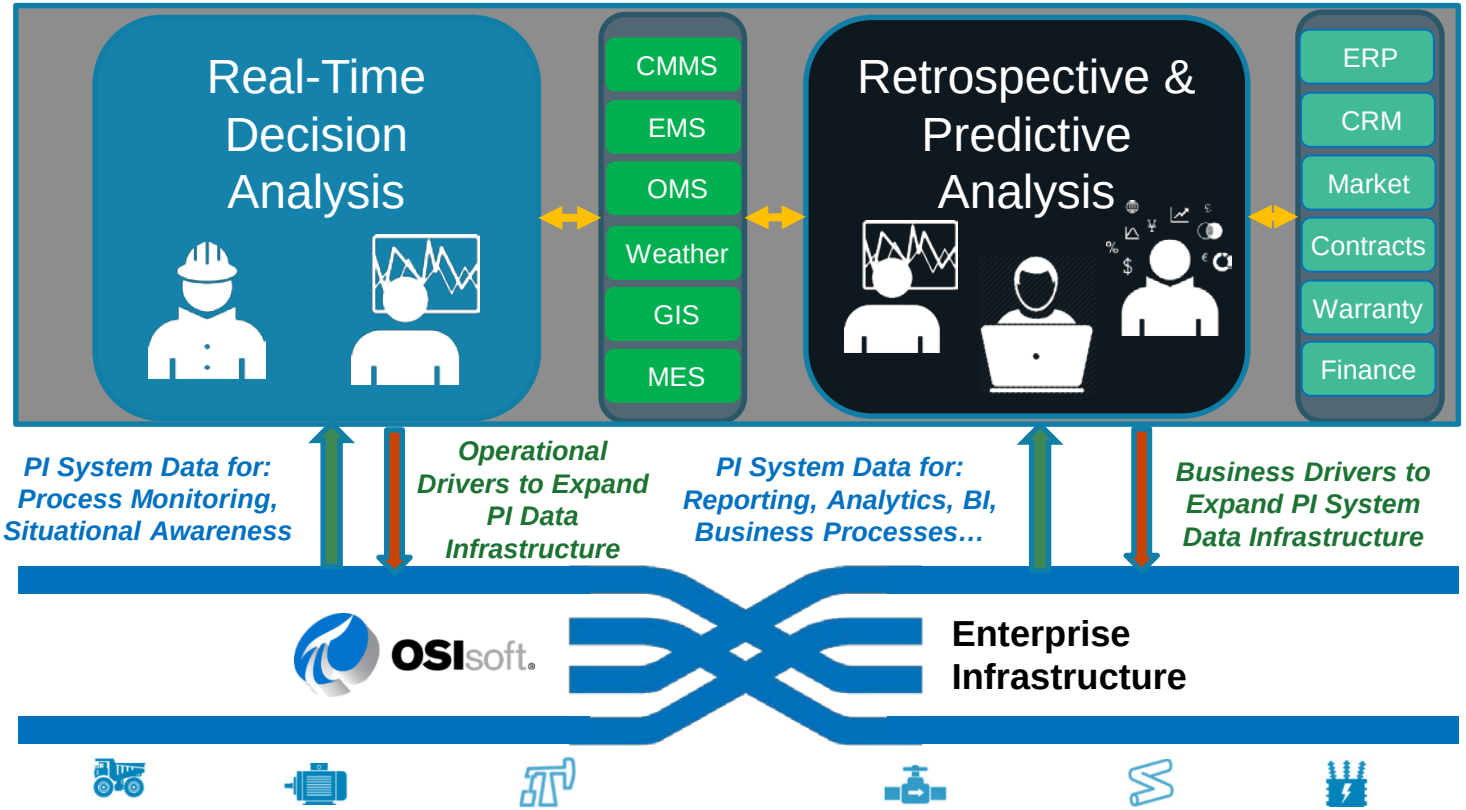
New ***Uses*** for and ***Users*** of PI System Data



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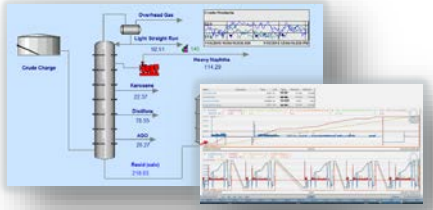
Enabling Analytics for Operational Intelligence

Real-Time Decision Analysis



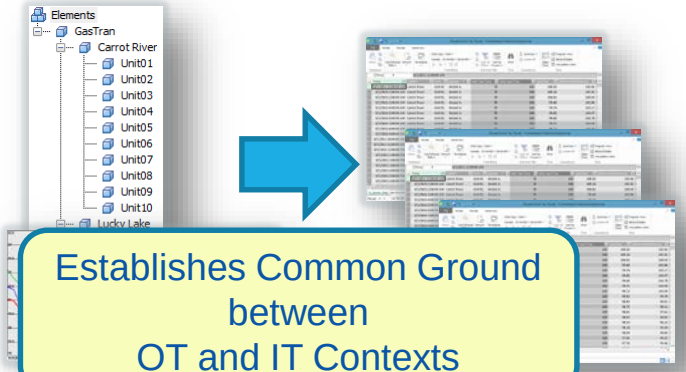
Time and Event
Trending & Awareness

Specialized Models
Simulation & Optimization

$$Q = \frac{\Delta P_{DD} * kh}{141.2 \mu B_0 \left\{ ln \frac{r_e}{r_w} - \frac{3}{4} + S \right\}}$$

First Principles
Performance
& Condition

PI Integrator for
Business Analytics



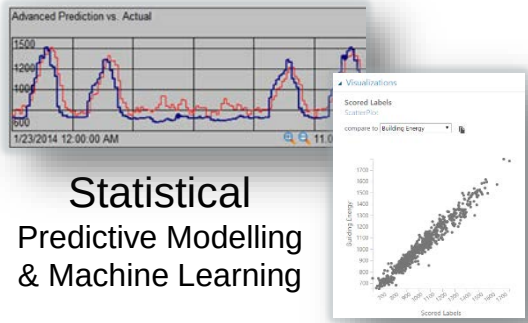
Establishes Common Ground between
OT and IT Contexts

Time, Event and Asset Context

Tabular Context

Retrospective & Predictive Analysis

Multidimensional
Business Intelligence
& Dashboards



Statistical
Predictive Modelling
& Machine Learning

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First Principles Analytics - *Performance & Condition*

- Relationships ***always*** exists between process measurements
- Requires synchronized observations for meaningful results
- Enables real-time decision making only when visible, i.e. not performed in spreadsheets

Daniel Bernoulli
(1700 – 1782)

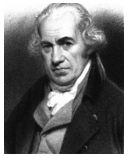
$$H = z + \frac{p}{\rho g} + \frac{v^2}{2g} = h + \frac{v^2}{2g}$$

Benoît Clapeyron
(1799 – 1864)

$$PV = nRT$$

$$Q = \frac{\Delta P_{DD} * kh}{141.2 \mu B_0 \left\{ ln \frac{r_e}{r_w} - \frac{3}{4} + S \right\}}$$

$$F = \frac{(R+1)^{1/2} \text{ x ln } ((1\text{- SR})/(1\text{- S}))}{(1-R) \text{ x ln } \left\{ \frac{2\text{- S } (R+1-(R+1)^{1/2})}{2\text{- S } (R+1+(R+1)^{1/2})} \right\}}$$



James Watt
(1736–1819)

$$P = IV = I^2R = \frac{V^2}{R}$$

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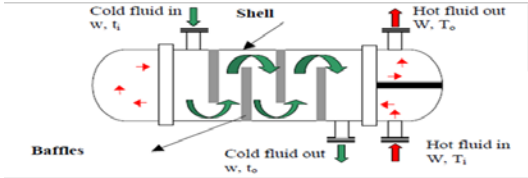
First Principles Analytics - *PI Asset Analytics*

- *Configure* calculations at scale
- Math, statistical, logical and steam table functions
- Supports simple predictive analytics
- Supports future data for forecasting
- Backfill ! Backfill ! Backfill !



Calculation Steps:

1. Heat Duty, $Q = q_s + q_t$
   $q_s = Wx\ C_{ph}\ x(T_i - T_o)/1000/3600$
   $q_s = w\ x\ C_{pc}\ x\ (t_o - t_i)/1000/3600$
2. Hot Fluid Pressure Drop, $\Delta P_h = P_i - P_o$
3. Cold fluid pressure drop, $\Delta P_c = p_i - p_o$
4. Temperature range hot fluid, $\Delta T = T_i - T_o$
5. Temperature range cold fluid, $\Delta t = t_o - t_i$
6. Capacity ratio, $R = W\ x\ C_{Ph} / w\ x\ C_{pc}$ (or) $(T_i - T_o) / (t_o - t_i)$
7. Effectiveness, $S = (t_o - t_i) / (T_i - t_i)$
8. LMTD

LMTD Counter current Flow = $((T_i - t_o) - (T_o - t_i)) / \ln((T_i - t_o)/(T_o - t_i))$
LMTD Co current Flow = $((T_i - t_i) - (T_o - t_o)) / \ln((T_i - t_i)/(T_o - t_o))$
Correction factor for LMTD to account for Cross flow

$$F = \frac{(R+1)^{1/2} \times \ln((1-SR)/(1-S))}{(1-R) \times \ln\left\{\frac{2-S(R+1-(R+1)^{1/2})}{2-S(R+1+(R+1)^{1/2})}\right\}}$$

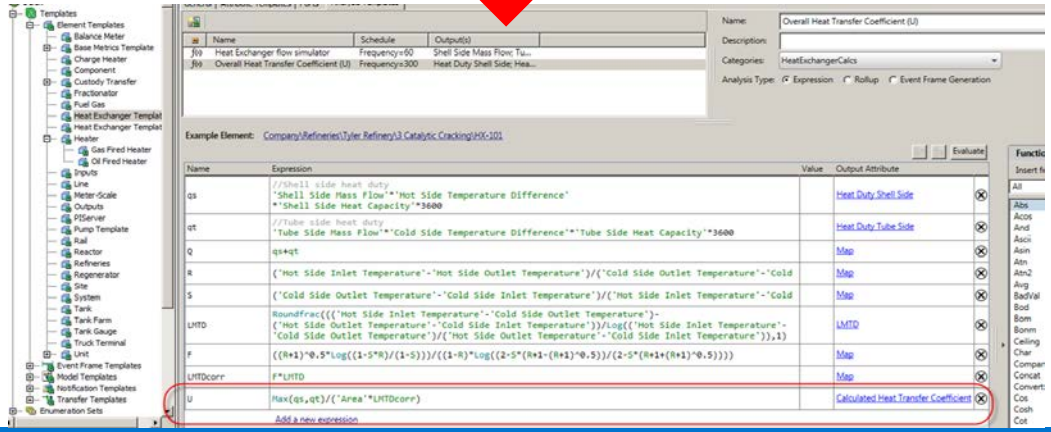
9. Corrected LMTD = F x LMTD

Heat Exchanger Key Performance Indicator:

Overall heat transfer coefficient

$$U = \frac{Q}{A \times \text{Corrected LMTD}}$$

RULE: *IF the heat transfer coefficient is decreasing, THEN the* ***Heat Exchanger FOULING*** *!!! Cleaning is required!*



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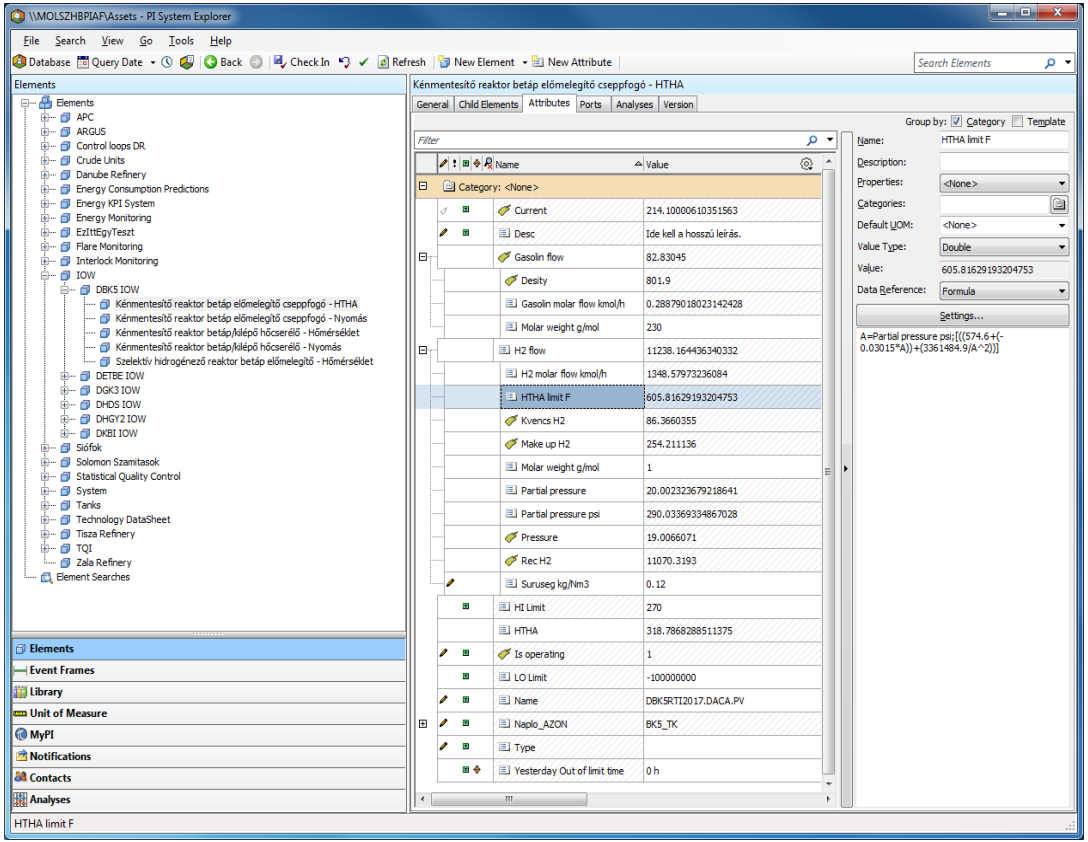
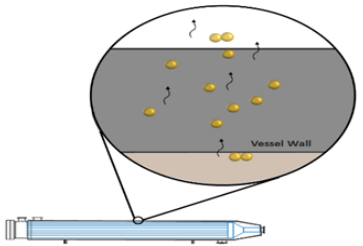
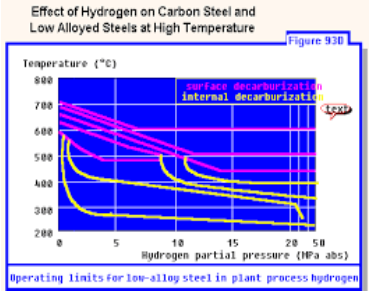
Advanced Corrosion Analytics - *PI Asset Analytics*



- High Temperature Hydrogen Attack (HTHA)
- f^x (metallurgy, temperature, hydrogen partial pressure(PP), length of exposure)
- Developed PI AF template that:
  - Determine partial pressure H2
  - Attribute of pipe class
  - Temperature and length of exposure limits
  - **Total time above Temp and PP**
  - Alerts/notification/event frame
- Tested and rolled out in 6 units < 1 week
- Expanding to all plants in 2015.





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Natural Gas Consumption Predictive Analytics

BackGround

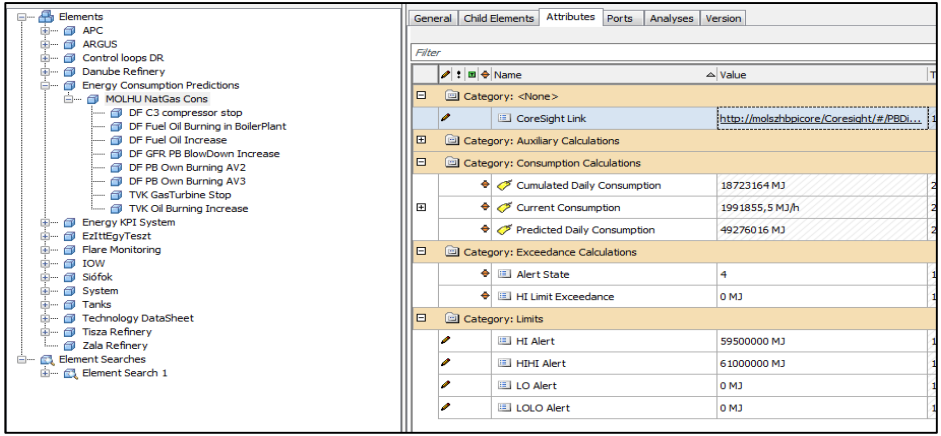
- Huge saving possibilities in the decrease of contracted natural gas daily maximum amount

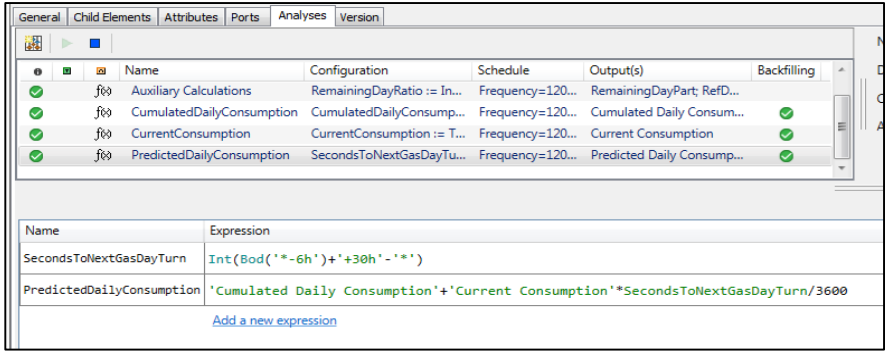
Problem

- High penalty on daily amount exceedance
- Alerting system was needed

Solution

- Consumption prediction calculations in PI Analysis
- Detailed information on PI Coresight display (about consumption, prediction, contacts of decision makers)
- E-mail alerting system in Notifications





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Energy Demand Forecasting with Future data

Improve energy trading by

- Collect real-time data
- Train energy consumption models
- Predict energy consumption based on production plan
- Monitor and update models

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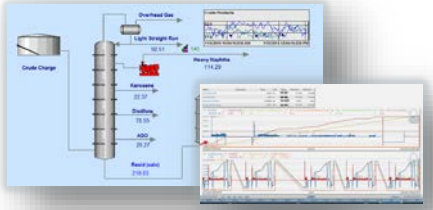
Enabling Analytics for Operational Intelligence

Real-Time Decision Analysis



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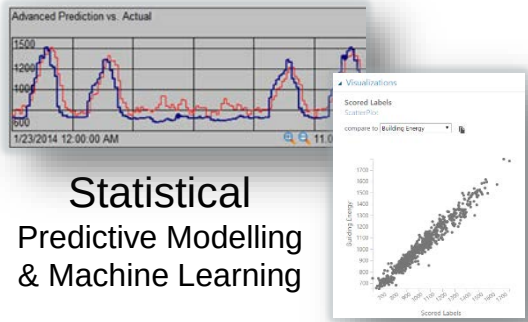

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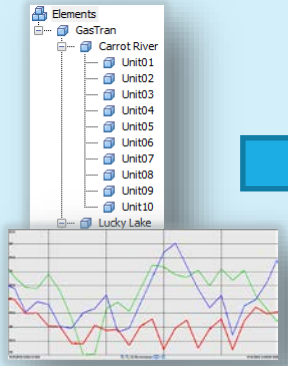
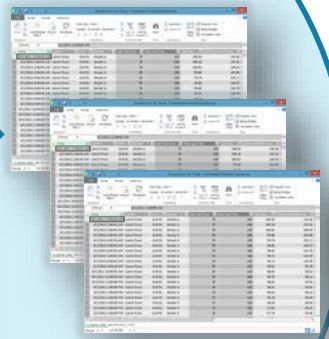
PI Integrator for Business Analytics



Time, Event and Asset Context



Tabular Context

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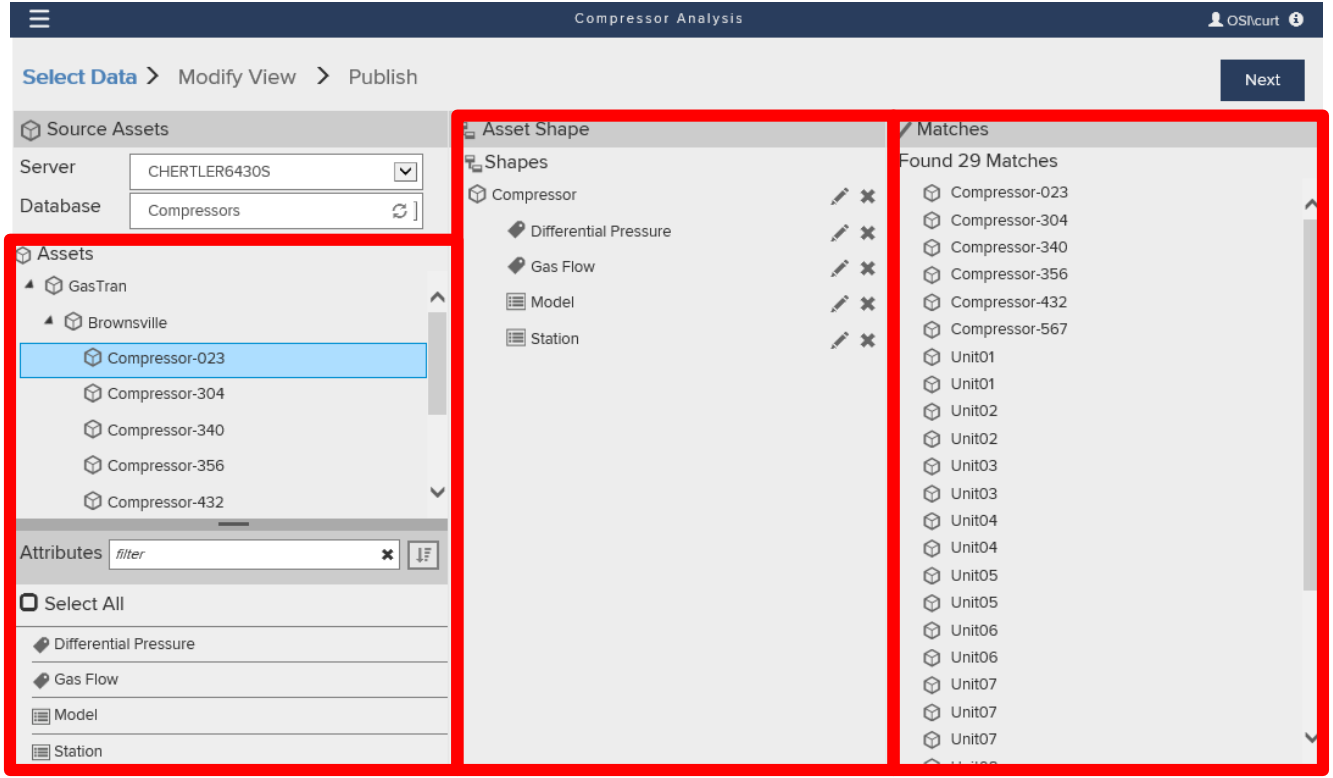
PI Integrator for Business Analytics - “*Select Data*”

- Now available
- Create “PI Views” from AF Hierarchy
- Select AF Elements and Attributes
- Scale up leveraging name, hierarchy, or category



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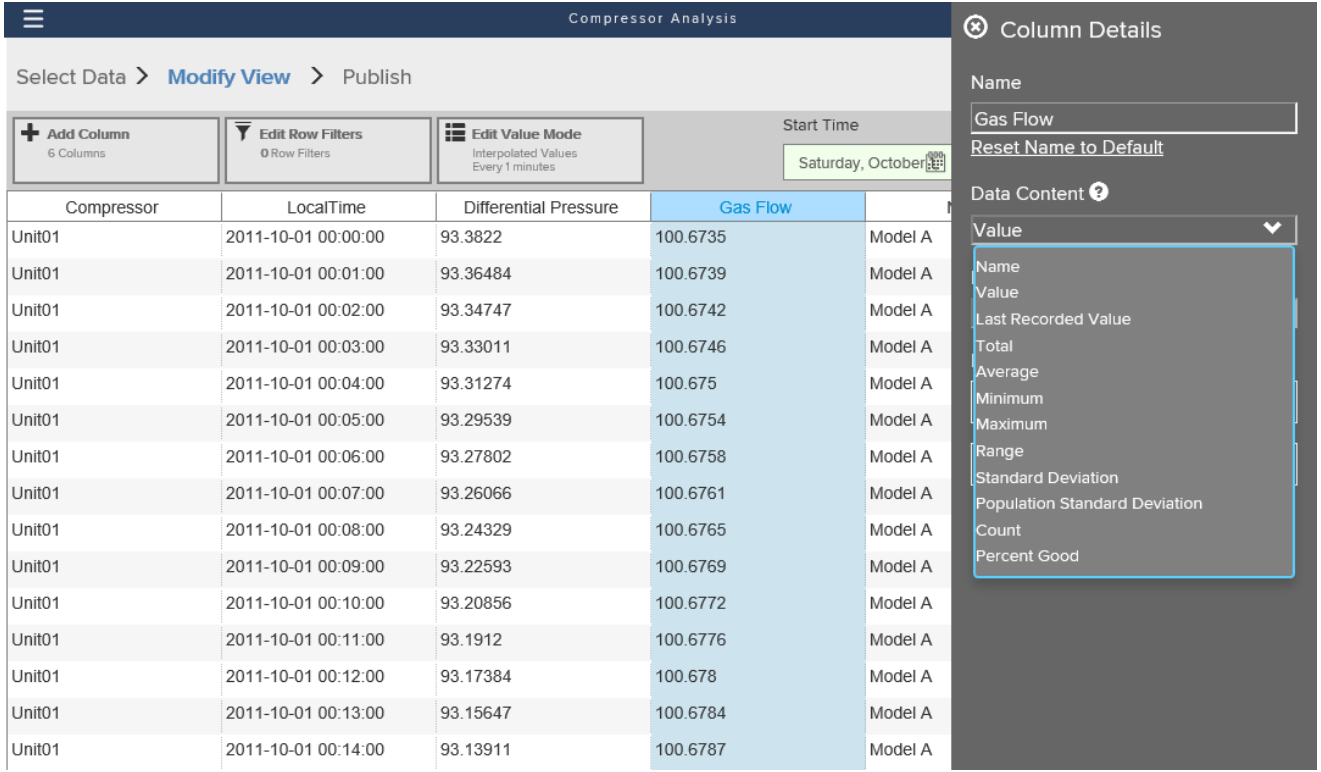
PI Integrator for Business Analytics - “Modify View”

- Select any time range and interval
- Add columns for proper aggregating PI System data
- Add columns for common time and date functions



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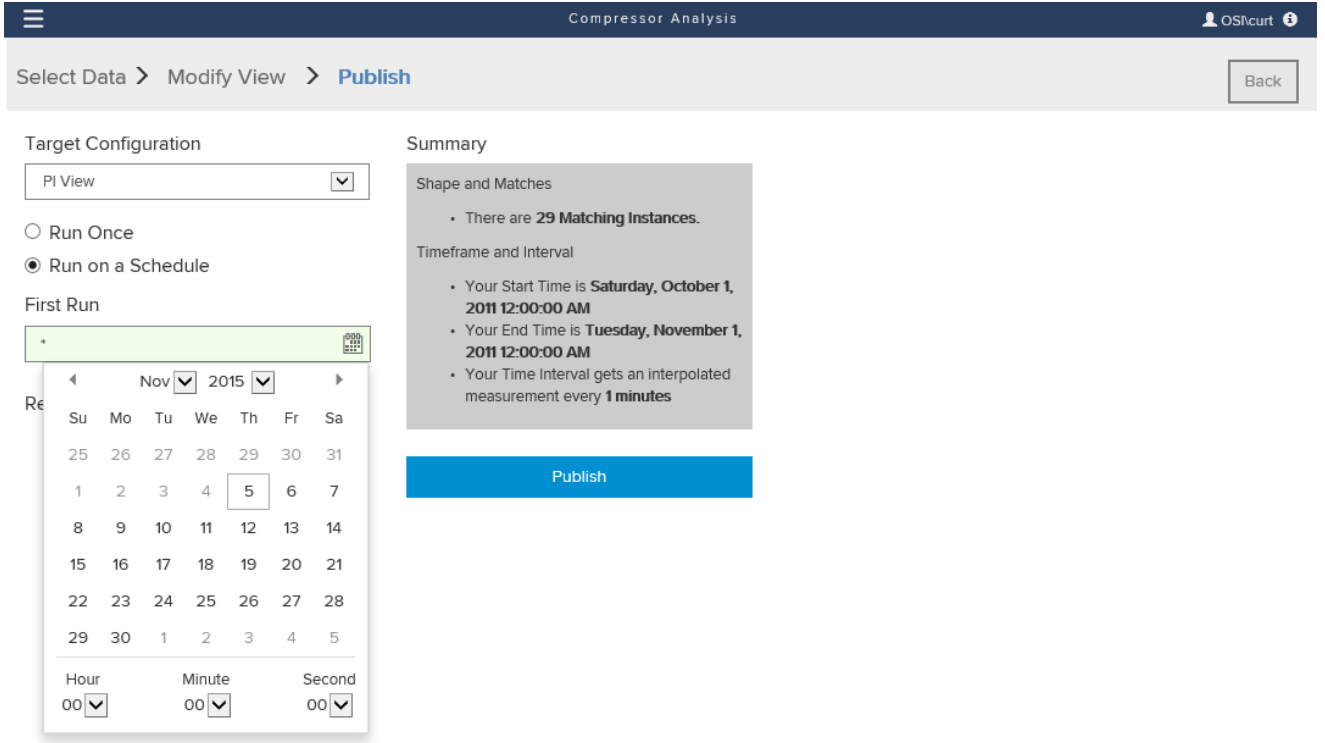
PI Integrator for Business Analytics - *"Publish"*

- Select targeted endpoint "PI View", MS SQL, File, more to come….
- Publish once or on a scheduled bases



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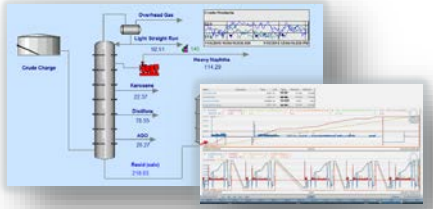
Enabling Analytics for Operational Intelligence

Real-Time Decision Analysis



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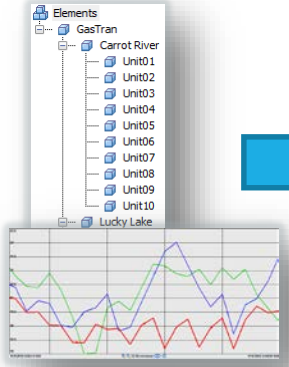
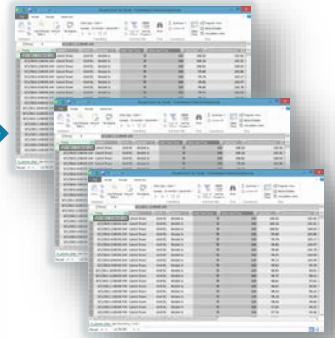
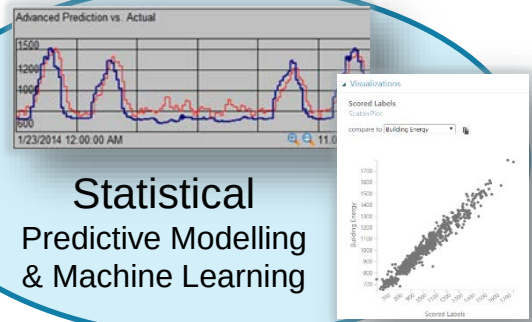


Time, Event
and Asset
Context



Tabular
Context

Multidimensional
Business Intelligence
& Dashboards



Statistical
Predictive Modelling
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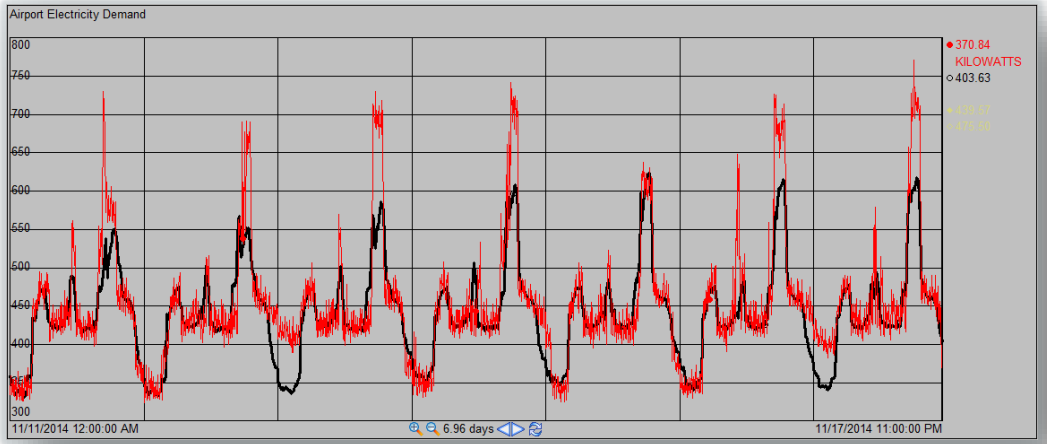
Statistical Analytics - *Example: Power Forecast*

Predicted Power = 0.2324 * Average(**Actual Power**, 1 day ago, +/- 5 min) +
0.1421 * Average(**Actual Power**, 2 days ago, +/- 5 min) +
…….(terms for 3-13 days ago)……
0.0435 * Average(**Actual Power**, 14 days ago, +/- 5 min)

- Statistically derived equation with coefficients and time relative averages
- Configurable in PI AF with backfill to assess
- Schedule in PI AF to provide forecast - PI Sever future data



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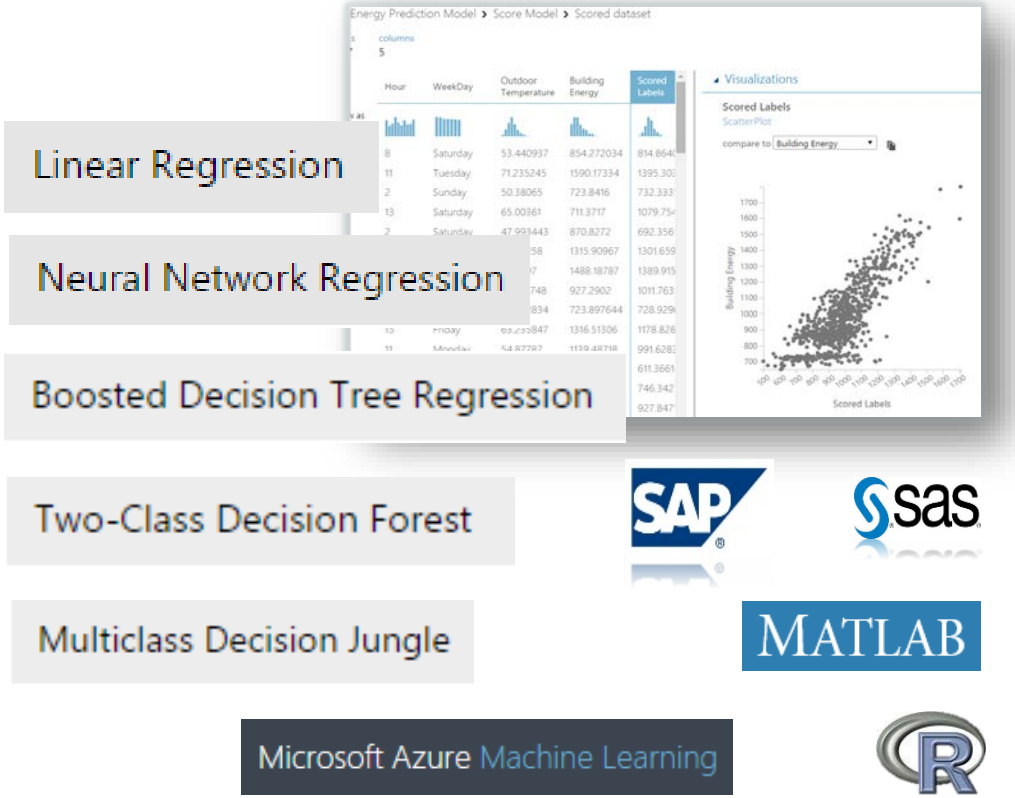
Statistical Analytics - Predictive Modelling & Machine Learning

- Complex systems where first principles equations interact or don't exist
- Empirical or "fitted" models generated from time, event and asset data in tabular context
- Predicts outcome, e.g. equipment failure, unmeasured or forecasted quantities
- Model continuously improves or "learns" with additional data



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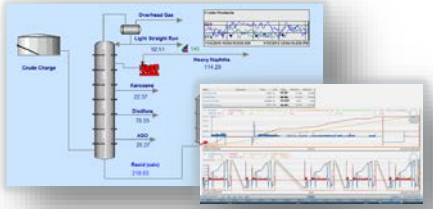

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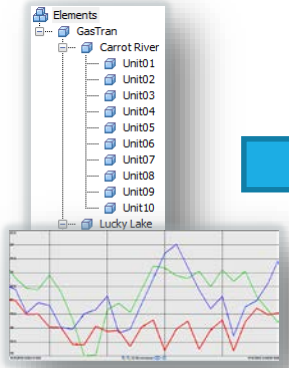

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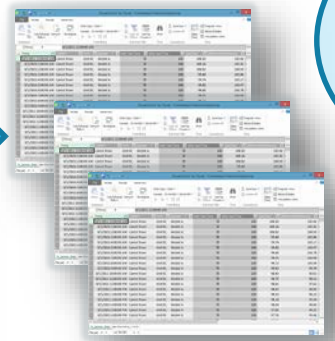

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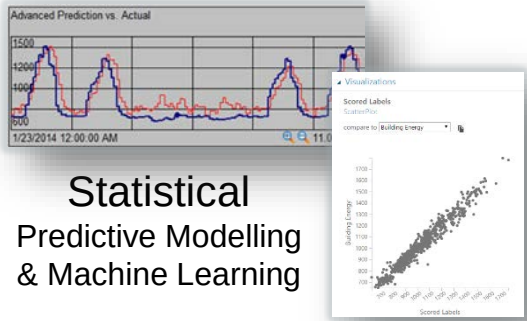

Statistical
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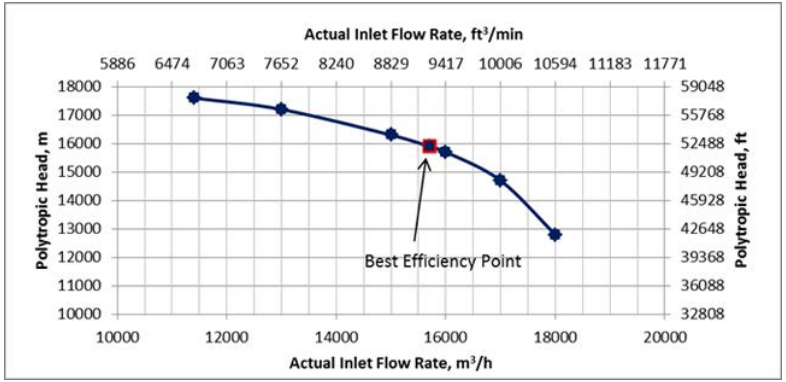
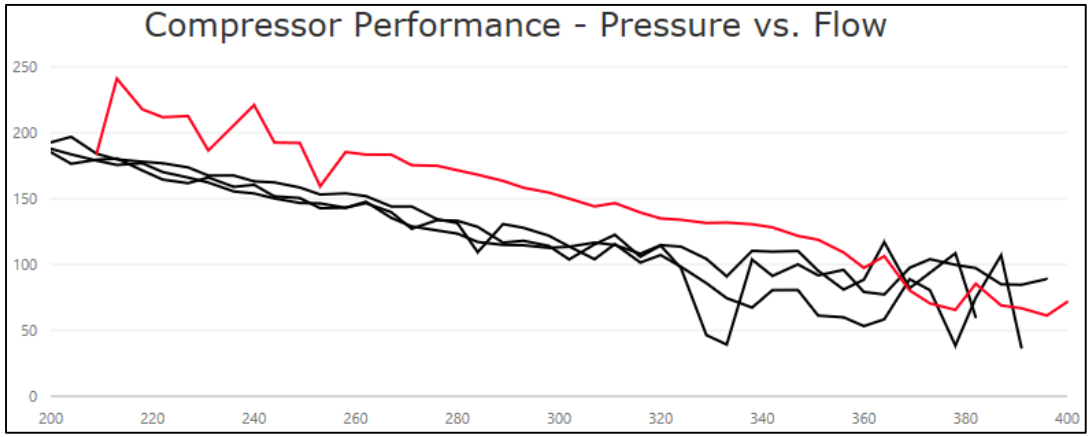
Multidimensional Analytics – Business Intelligence

- Ad hoc, visual analysis of a table or related tables of data
- Columns aggregated for selected rows, presenting results in a variety of ways
- Excellent tools for personal analysis and enterprise reporting and dashboards





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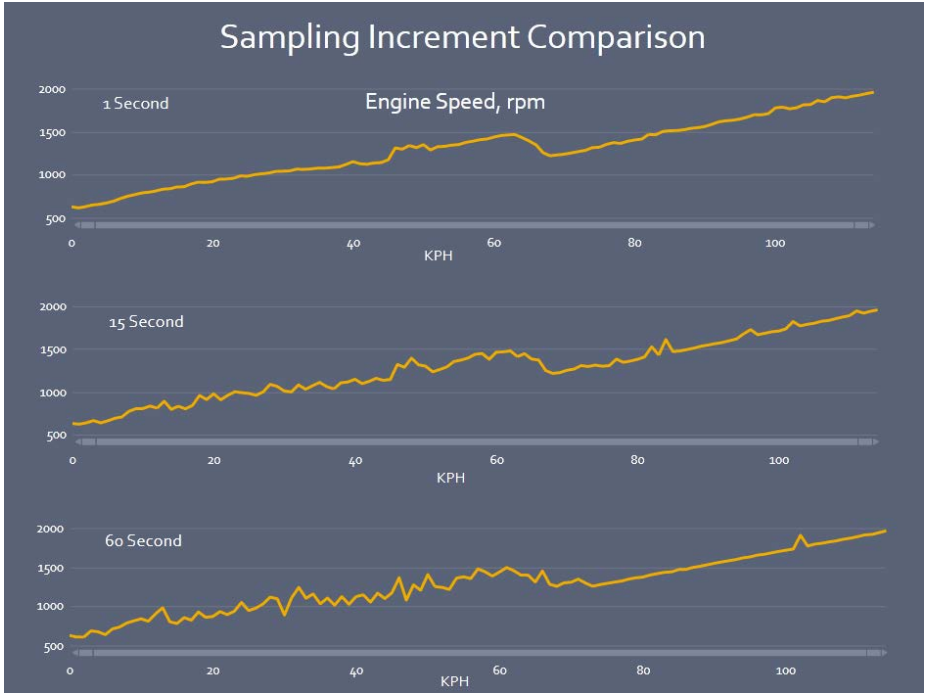
Multidimensional Analytics – Time Contextualization

Flexible, repeatable access to high fidelity operational data

- Time relative aggregations and statistics at any interval
- Juxtaposition of values - published rows can contain previous row's value.
- Backfill First Principle facts as best practice



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The Most Advanced Refinery in the World by 2020

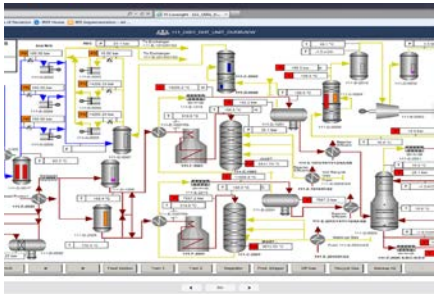
YASREF (Yanbu Aramco Sinopec refinery JV)

"Selecting the **PI System and EA early** *supported a smooth refinery start up and set the foundation for an integrated, collaborative data based decision making culture that* **supports YASREFs vision of being the most advanced refinery in the world by 2020."**

Mahmoud M. Madani, IRIS Lead Project Engineer

Yasref

UC2015



CHALLENGES

23 separate applications from a variety of vendors including DCS; aggressive grassroots schedule

- Lack of collaborative, data based decision making using standard DCS supplier approach
- Weak data and analytical foundation to enable OpEx and continuous improvement

SOLUTION

YASREF strategically chose the PI System as an integration and applications infrastructure applications

- Migrated standalone applications to the infrastructure with PI AF
- Used Microsoft platform to provide advanced web based reporting and decision support

RESULTS

The market responds to quick ramps of energy production and maintains grid reliability

- Eliminated over 50% of the standalone applications
- Enabled a very smooth refinery startup
- Provided KPIs and performance reporting foundation for OpEx

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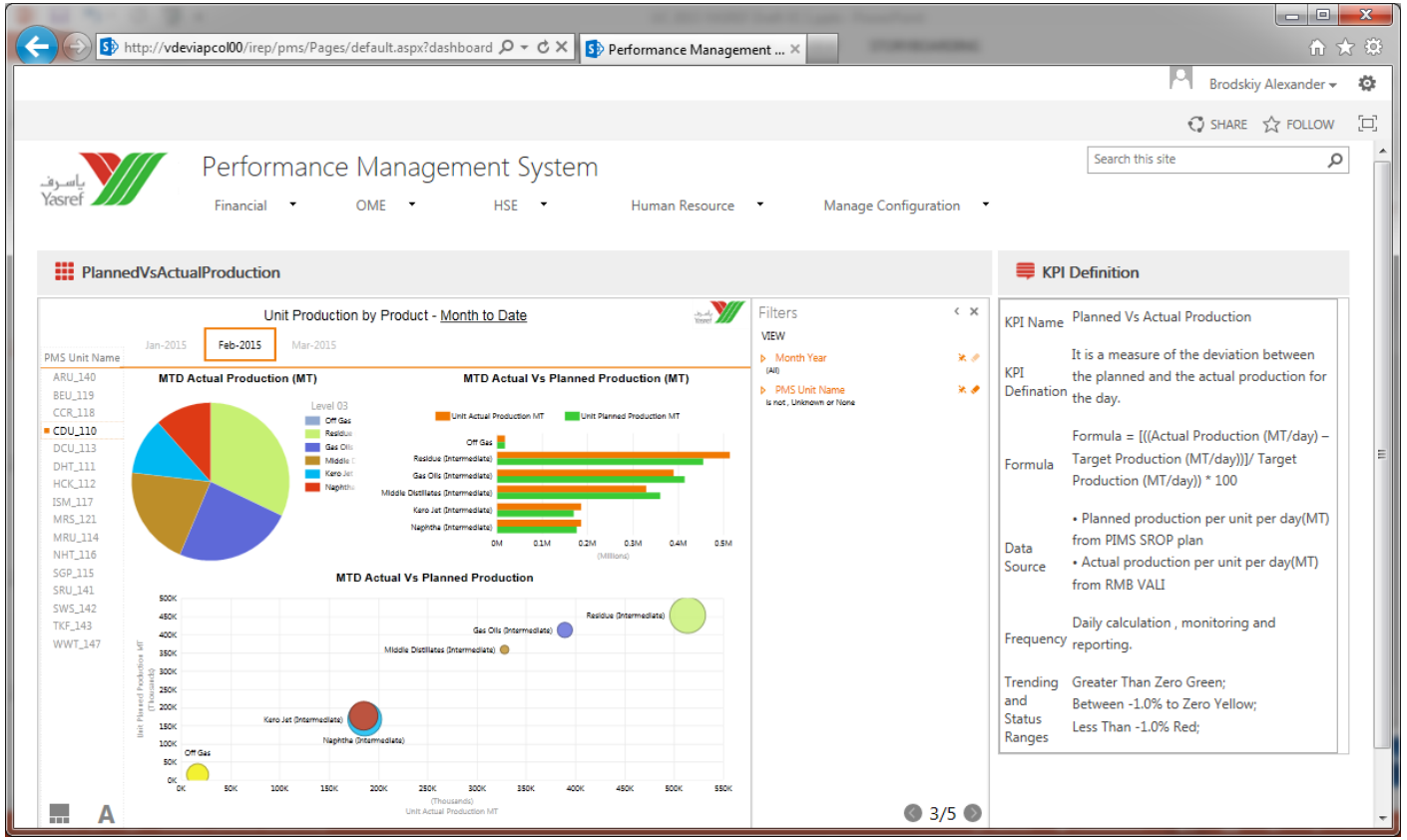
Performance Management System



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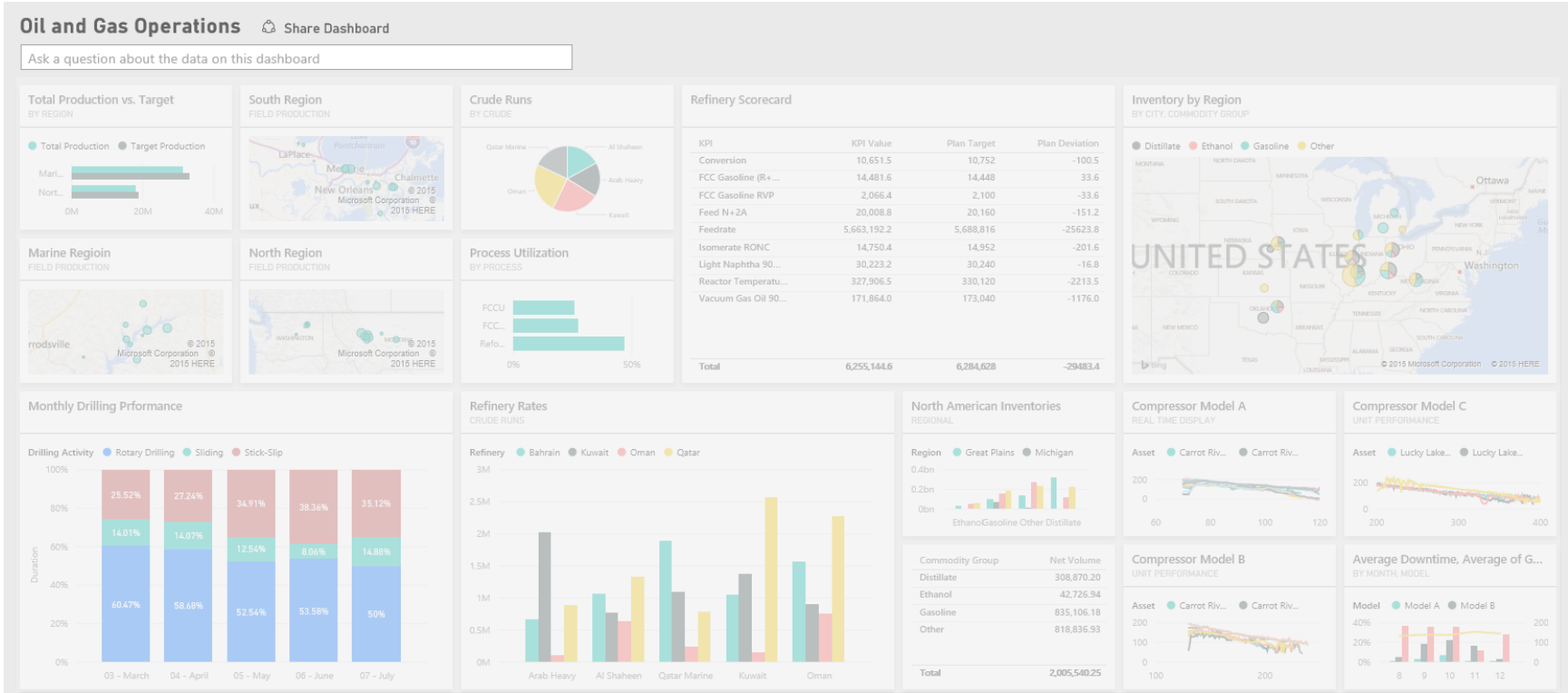
Enterprise Performance Summary



Exploration & Production | Refining | Distribution

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Driving Continuous Improvement

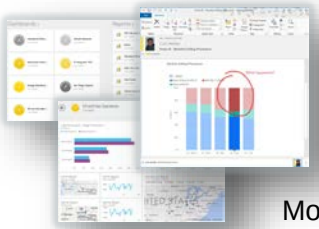
Organizational Insight

Content

Access

Personal Analytics & Assessment

Collaborative Intelligence



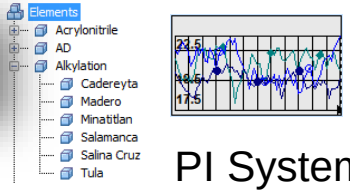
Mobility & Socialization

Data with Context

Action

Operational Awareness

PI Integrator for BA



PI System

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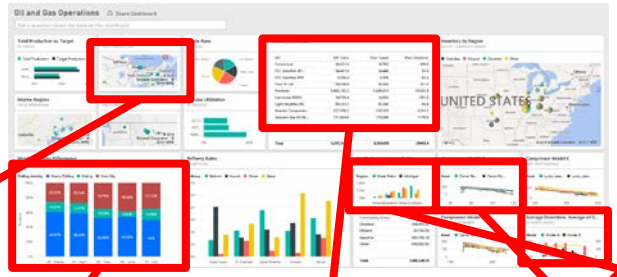
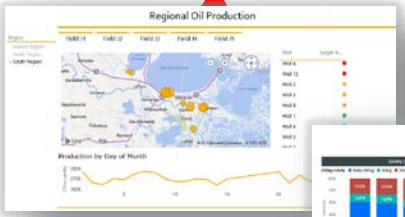
Detailed Reporting and Analytics

Dashboard drilldown to detailed reports

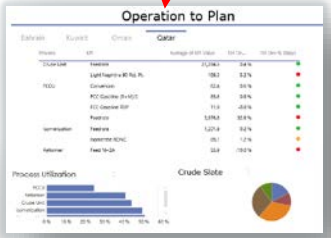


PI Coresight



Production Summary

Drilling Activity



Refinery KPI Scorecard

Asset Performance

Regional Product Inventories

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Summary and Wrap Up

- The PI System enables all types of operational analytics by providing time-related data supported by the essential foundation provided by PI Asset Framework.

- Look holistically when selecting an analytical method or methods. PI Analytics is very capable of performing equation-base analytics for performance and conditions assessment, as well as, certain types of predictive analytics.

- The PI Integrator for BA establishes “Common Ground” between OT and IT contextualization's enabling Operational Intelligence.

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Contact Information

Curt Hertler
curt@osisoft.com
Global Solutions Architect
OSIsoft, LLC

Craig Harclerode
charclerode@osisoft.com
Industry Principal – Oil & Gas
OSIsoft, LLC

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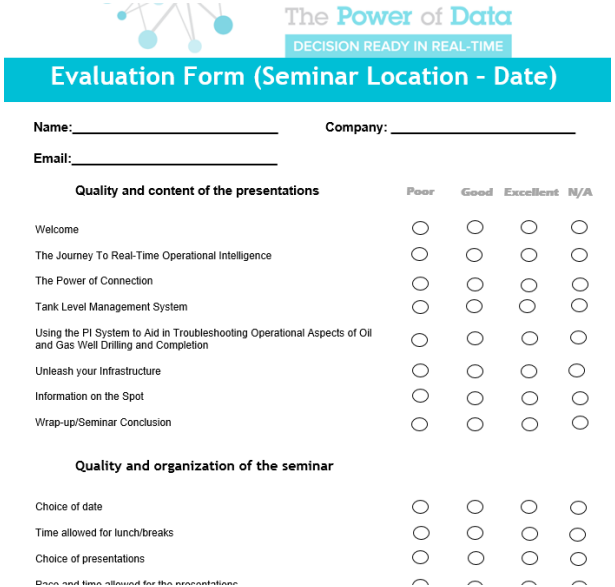
Questions

Please wait for the **microphone** before asking your questions

State your **name & company**

Please don't forget to…

Complete the Survey for this session



The Power of Data

DECISION READY IN REAL-TIME

Evaluation Form (Seminar Location - Date)

Name:_____ Company: _____

Email:_____

Quality and content of the presentations	Poor	Good	Excellent	N/A
Welcome	○	○	○	○
The Journey To Real-Time Operational Intelligence	○	○	○	○
The Power of Connection	○	○	○	○
Tank Level Management System	○	○	○	○
Using the PI System to Aid in Troubleshooting Operational Aspects of Oil and Gas Well Drilling and Completion	○	○	○	○
Unleash your Infrastructure	○	○	○	○
Information on the Spot	○	○	○	○
Wrap-up/Seminar Conclusion	○	○	○	○

Quality and organization of the seminar				
Choice of date	○	○	○	○
Time allowed for lunch/breaks	○	○	○	○
Choice of presentations	○	○	○	○
Pace and time allowed for the presentations	○	○	○	○

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감사합니다

谢谢

Danke

Gracias

Merci

Thank You

ありがとう

Спасибо

Obrigado

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