The MOL Story

A Journey with IIOT, Advanced Analytics, & Big Data

$1B EBITDA enabled by Strategic use of the PI System and PI AF as an OT Data Model

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Contact Information

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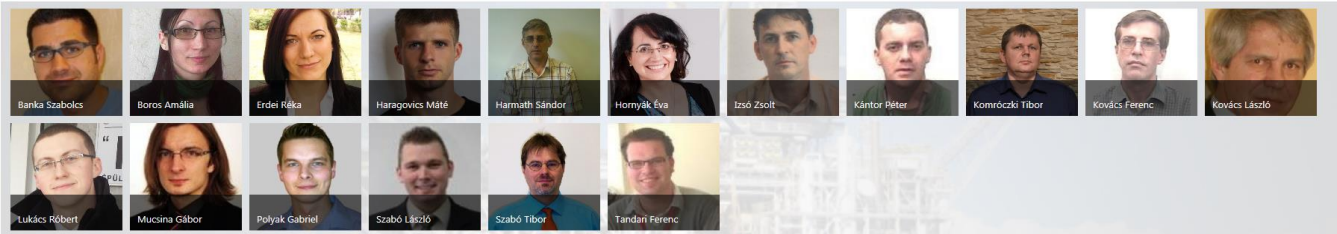
Process Information & Automation leader
MOL Plc.

Team of 16 Process Information & Automation Engineers (APC/RTO & PI Systems)

Reports to the Technology & Development Manager

Distributed in the 6 plant locations

IT in a supportive role…minimally involved – Operating Systems and SQL Servers



Outline

- MOL at a Glance
- MOL‘s Digital Transformation Journey
- Infrastructure Approach to Apps & Solutions
- Advanced PSM and CBM
- Extending Advanced Analytics with ML
- Best Practices & Perspectives

An Integrated Downstream Value Chain

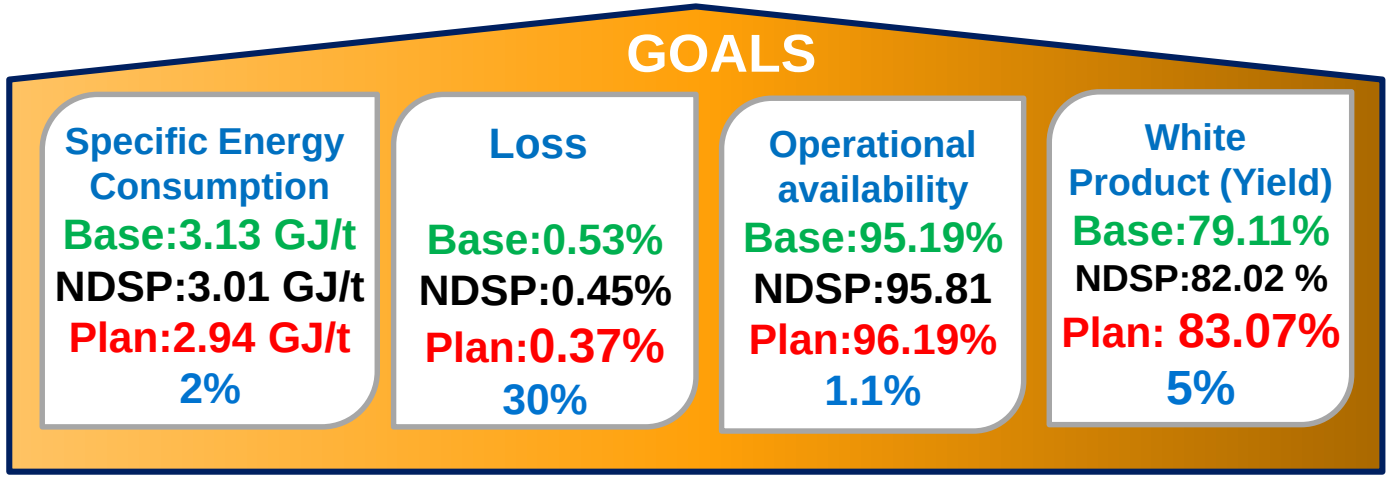
- **Integrated Fuels Value Chain:**
  - 4 refineries, 2 Petrochem plants
  - Logistics including 2,000 retail stations,

- **PI System Overview:**
  - 4 HA collectives, ~400K tags
  - Elements:
    - ~300 smart templates
    - ~21K elements & growinig
  - Notifications:
    - ~150K templates
    - ~6K notifications
  - **~61K event frames including dynamic**

- **PI Coresight is primary visualization tool**

Focus areas of New Downstream Program (NDP) and Next Downstream Program

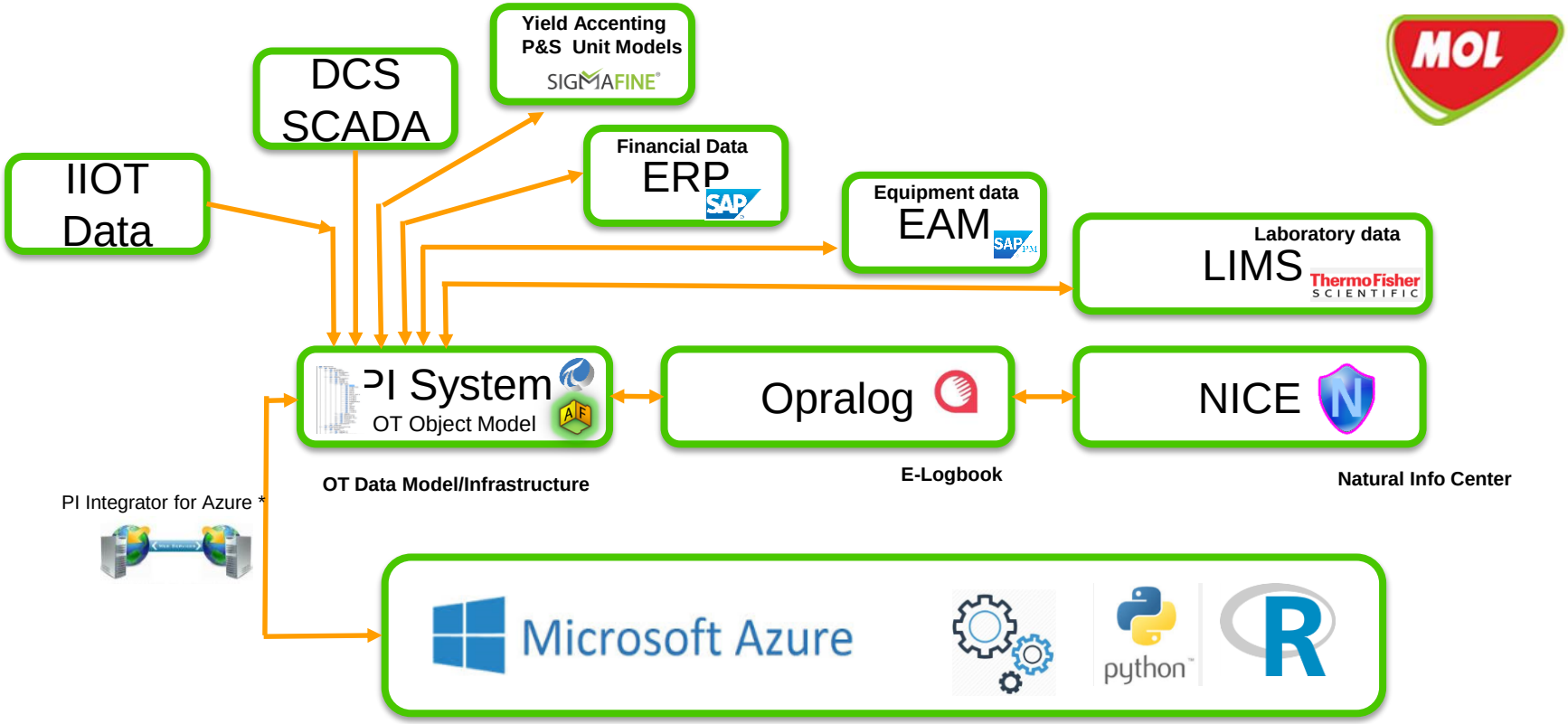
NDP Delivered $500M 2012-2014 **NxDSP Delivered +$500M 2015-2016**



Use the PI System to generate KPIs

Efficiency Trust Innovation Safety Proficiency

IIOT Integration with Existing OT Data Fabric & Analytics

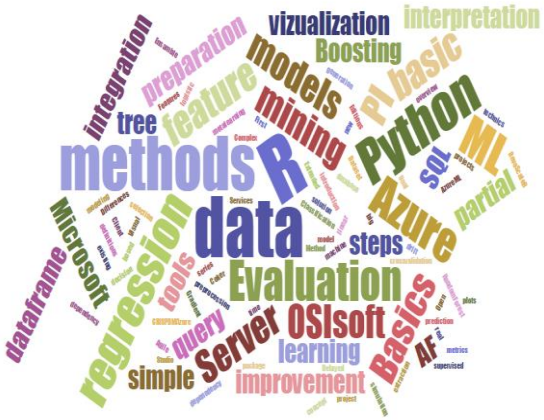


* Initially done via .csv files

Delivered $1B Business Value from Digital Transformation in last 5 years

COMPANY and GOAL

Delivered $1B in EBITDA by a business transformation enabled by a digital transformation leveraging the PI System as a strategic OT data infrastructure for advanced predictive and proactive analytics



CHALLENGE

Deliver strategic business value to respond to increasing competitive threats; **Change a diverse culture** to **"act as one"** with Operational Excellence & continuous improvement enablement.

- Increasing competitive environment in Eastern Europe
- Variable cracked spread
- Diverse culture across 8 countries
- Low use of data and analytics
- Increased use of opportunity crudes

SOLUTION

Evolved the use of the PI System as a tag based historian to an asset based infrastructure to **support cultural change** and **data based decision making and support** with advanced predictive and proactive analytics.

- Evolved from Tag to PI AF based infrastructure across the MOL fuels value chain
- Normalized tag, asset, UOM, and time using PI AF as an abstraction layer
- Used data and information to support business transformation

RESULTS

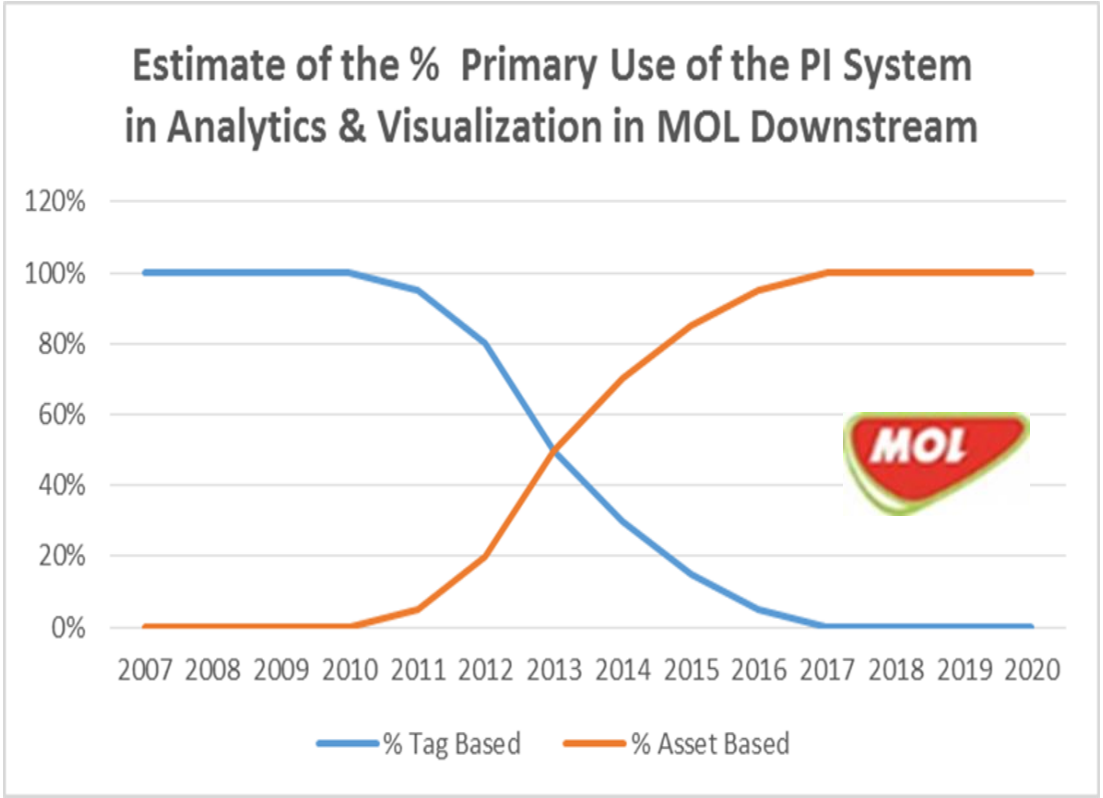
Delivered on the MOL Downstream business transformation goal of $1B and more importantly, a sustainable **cultural change based on data and information** to drive **operational excellence** going forward into he 21st century.

- *Leading Process Safety Management*
- *1st Quartile in energy, yields, loss, and utilization*
- *OT infrastructure enabling time to value and value momentum with advanced analytics including machine learning*

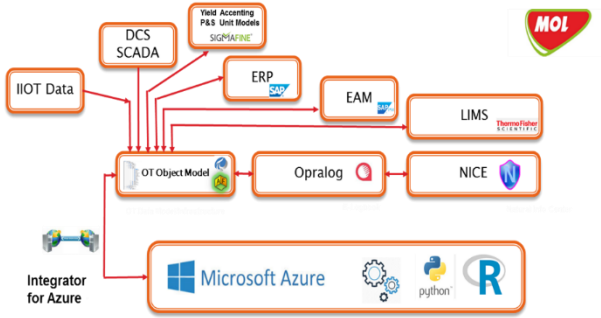
Digital Transformation Journey

Moving to PI AF is a Vision and a Journey…..”Just do It!”

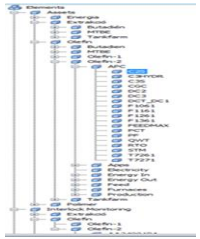
- **Start PI AF with a key business initiative** and build, capability, momentum and awareness;
- **Market PI AF vision**, capability, and value to leadership with **alignment to strategic initiatives;**
- Leverage PI AF Jumpstarts, OSIsoft consultation, PI AF templates, SIs, etc. to **lower the barriers to PI AF use**;
- **Once PI AF critical mass** is achieved, adoption will accelerate and be seen as **transformative and strategic**;
- **MOL sees PI AF as enabling** to many PI System capabilities like PI Coresight, PI Connectors, Integrators, etc.;



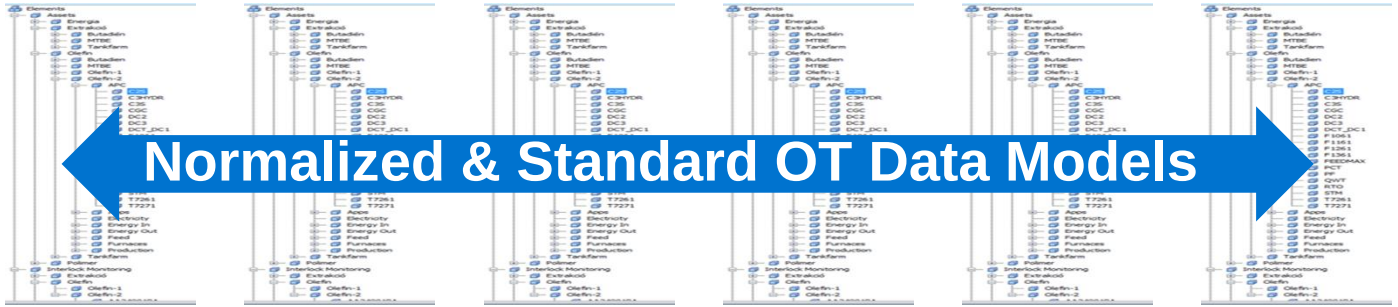
MOL Downstream Integrated OT Data Model



Value Chain



Logistics



Normalized & Standard OT Data Models

Danube Refineries | Bratislava | Rijeka | Sisak

Danube Petrochemicals | Slovnaft

Digital Transformation of New & Next Downstream Program

Safety & Asset integrity (PSM)

- Interlock statuses
- Integrity Operating Windows
- Corrosion control (HTHA)
- Alarm management
- Preventing coke steam eruption

Yields

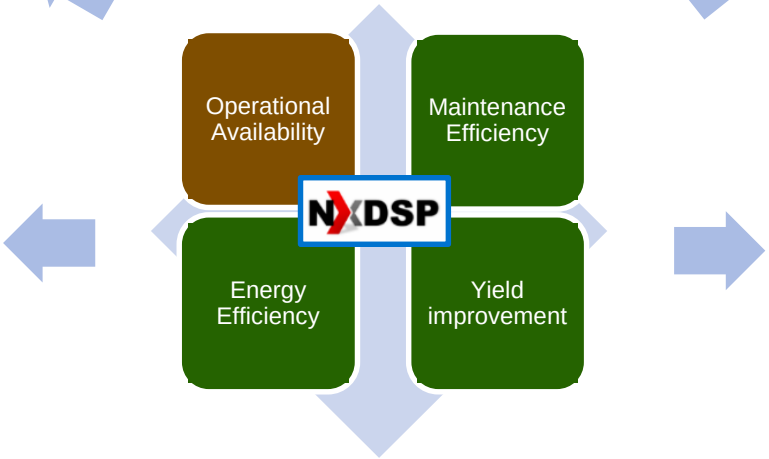
- Product quality
- Analyser reliability (Argus)
- Yield Accounting via Sigmafine (PI AF based)

Operational Optimization

- Operating envelopes
- NG (natural gas) and fuel gas demand forecasting
- Normal mode of control loops
- APC control monitoring
- Diesel sulphur optimization
- Coker yield optimization

Energy

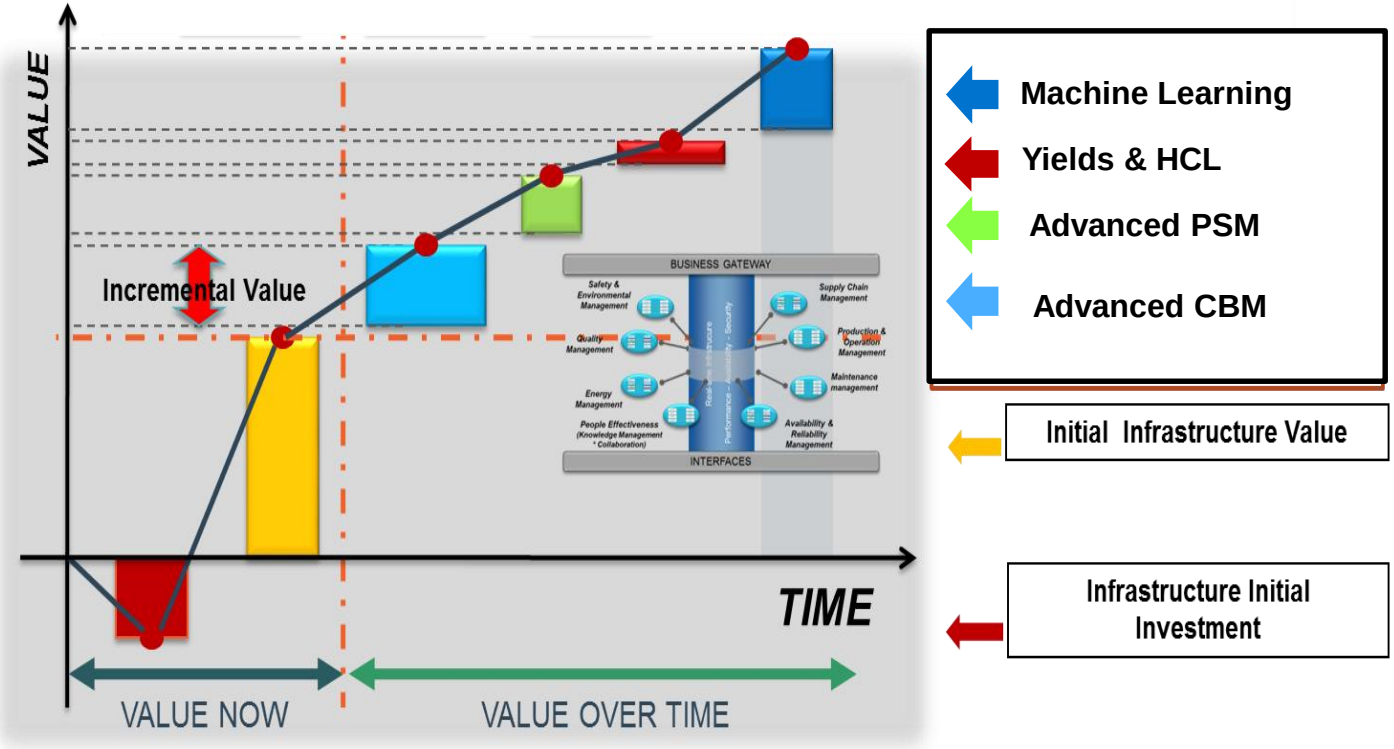
- Energy monitoring and management
- Energy KPI breakdown
- Column energy efficiency dashboard
- Hydrogen, utilities - energy balances
- Flaring



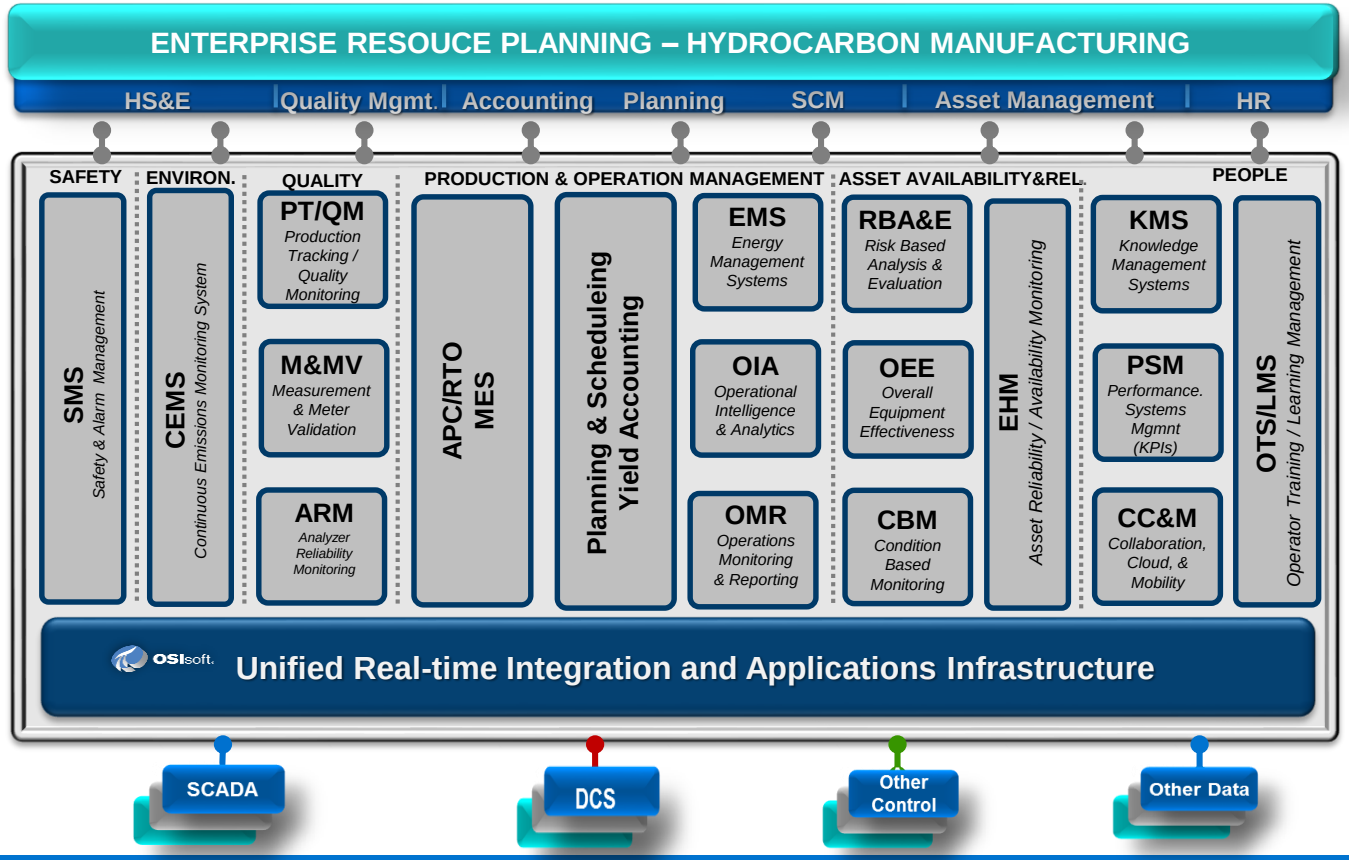
Asset Reliability from Proactive & Predictive Advanced Analytics

- SAP PM Integration
- Health Score in PI AF
- CBM on all rotating equipment
- PSA – Pressure Swing Adsorbers
- Chillers
- Heat Exchangers
- Electrical Infrastructure

An Infrastructure Investment Approach - “OT Data Utility”



Moving Applications to & Integrating Solutions with the Data Infrastructure – Simplification & Standardization



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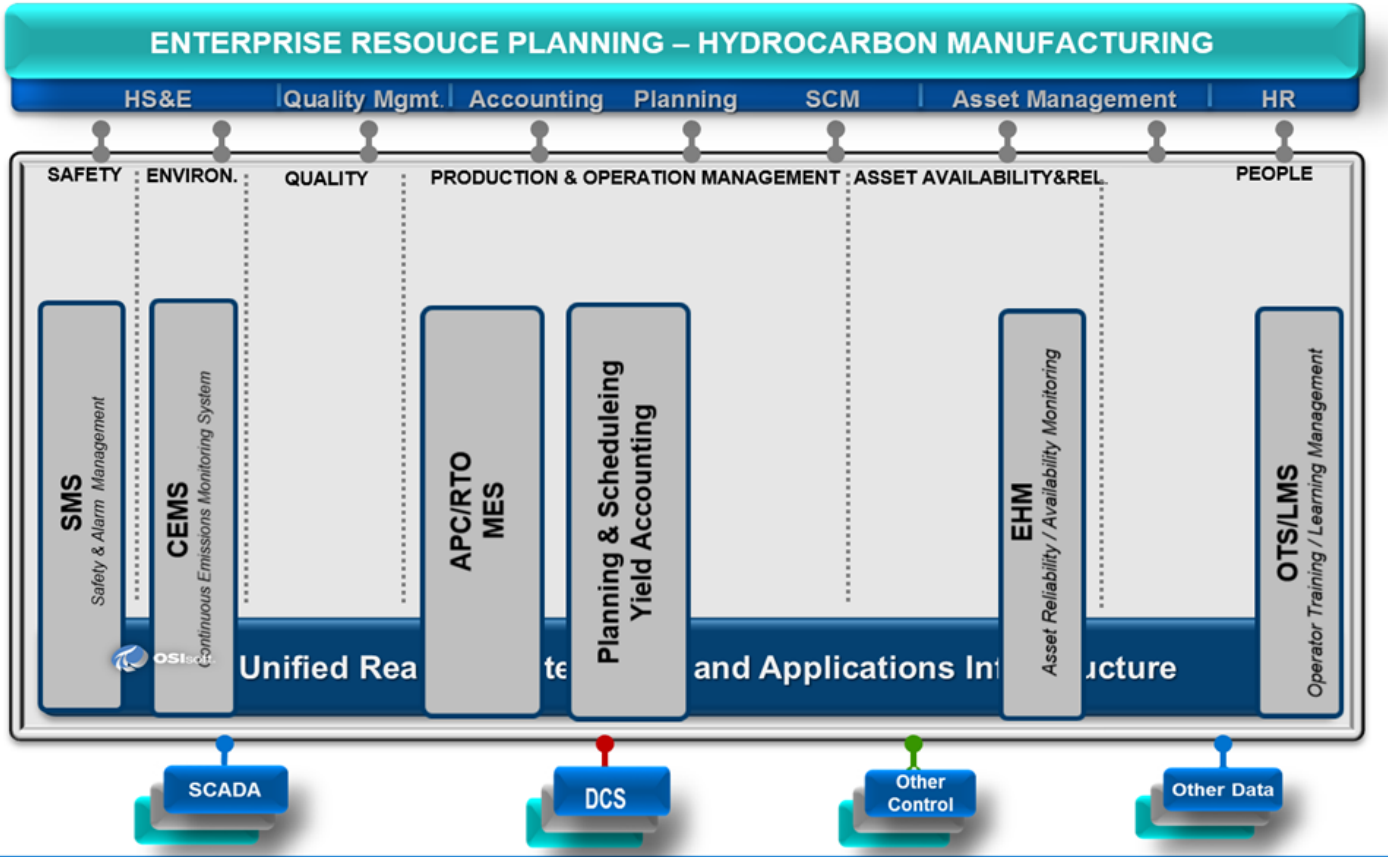
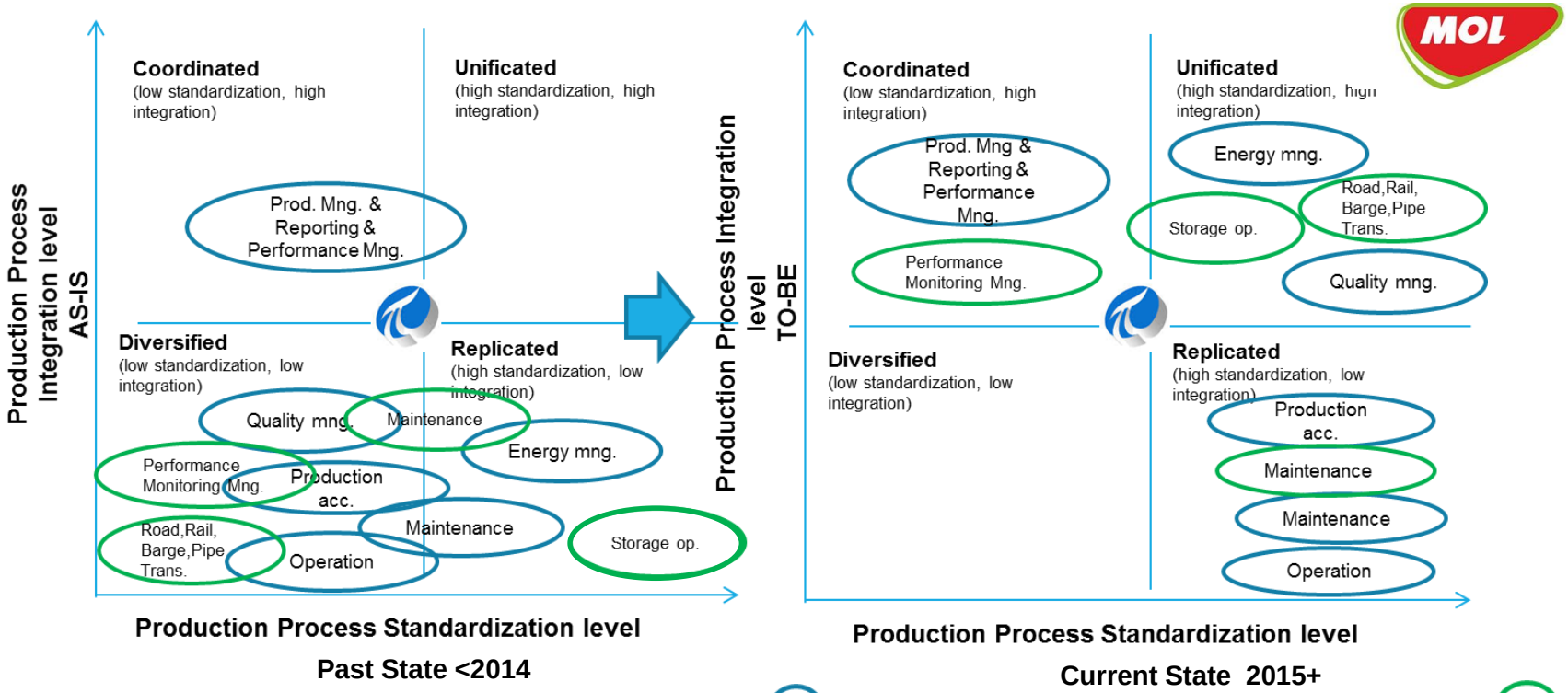


Leverage of the PI System as an Integration & Applications Infrastructure to Simplify & Standardize the Applications & Solutions Portfolio



Production (Refinery & Petchem) ○ **& Logistic standardization** ○

MOL Downstream OT Data Model Based Applications

Safety(PSM) and Asset Integrity

- Interlock governance/DCS role tracking
- Operating envelopes
- Integrity Operating Windows (IOWs)
- Advanced Alarm management

Energy

- Energy Monitoring and Management
- Energy KPI breakdown (6 tiers)
- Column Energy Efficiency Dashboards
- Hydrogen, Utilities, and Energy balances
- Flaring

CBM Asset Reliability

- All critical rotating equipment
- Hydrogen Pressure Swing Absorbers

Yields

- Crude Blending Control
- Yield Optimization/Reporting
- Product Quality
- Analyser Reliability

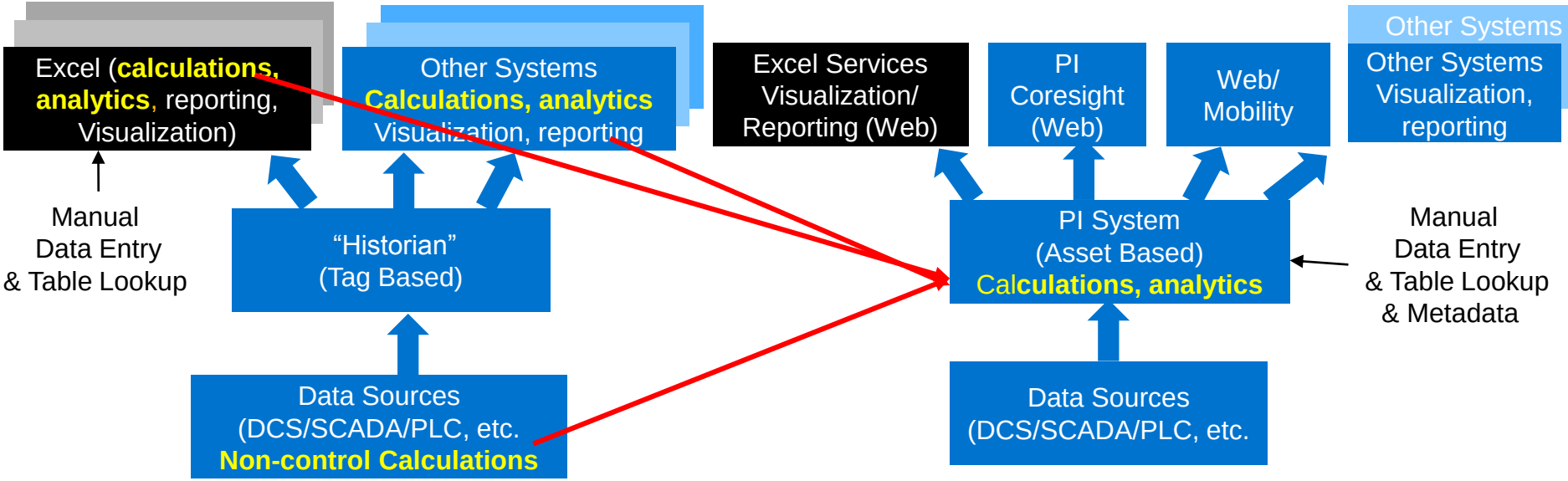
Operational Optimization

- Plan vs Actual Analytics with Future Data
- NG and Fuel Demand gas forecasting
- Peak Electrical forecasting
- Normal mode of control loops
- APC monitoring
- PI AF and Sigmafine (PI AF) used for yield accounting & Material Movement

Value Prop for Migrating from Tag/Excel to Asset/Web

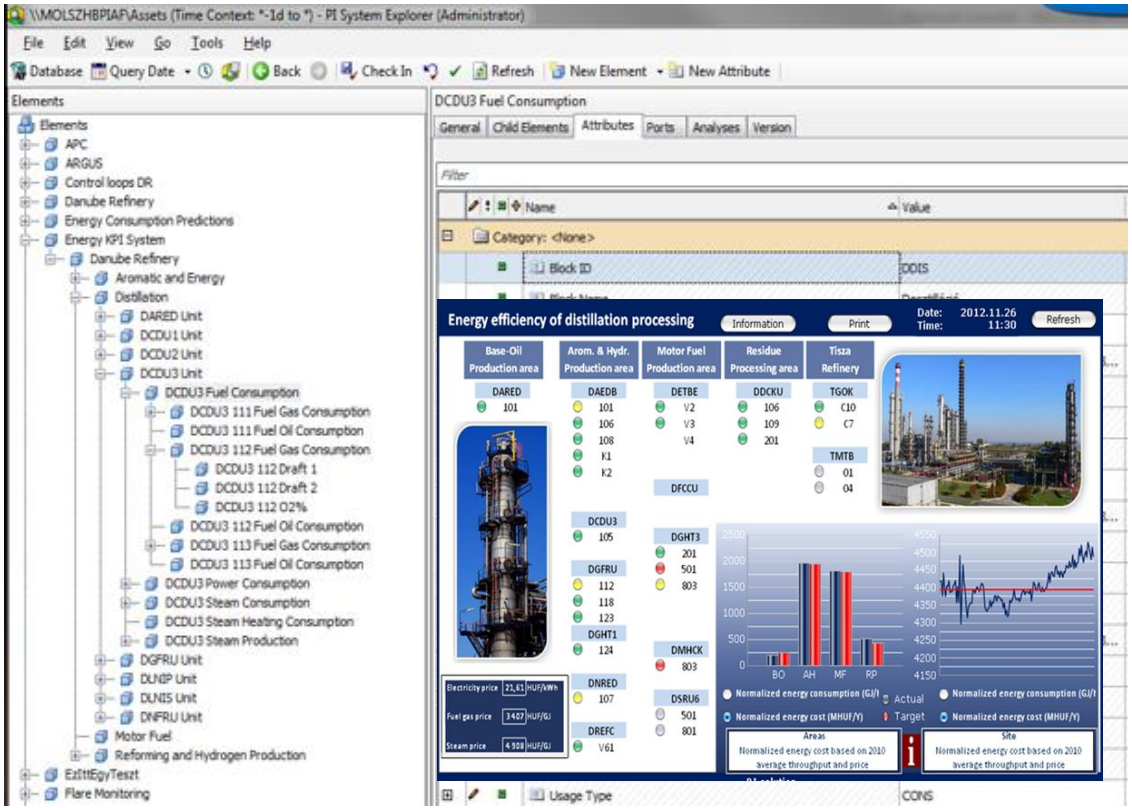
1. **Inconsistency** in analytics/calculations
2. **Tag based**
3. **Static** analytics/calculations
4. **Limited Trending & Visualization**
5. **Local**

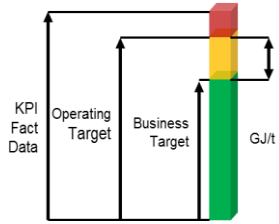
1. **Consistency** in analytics/calculations
2. **Asset based Smart objects**
3. **Dynamic, real-time** analytics/ calculations
4. **Powerful, flexible** Trending, Visualization. Events, alert
5. **Web based** access and collaboration



Examples

Energy Monitoring & Reporting

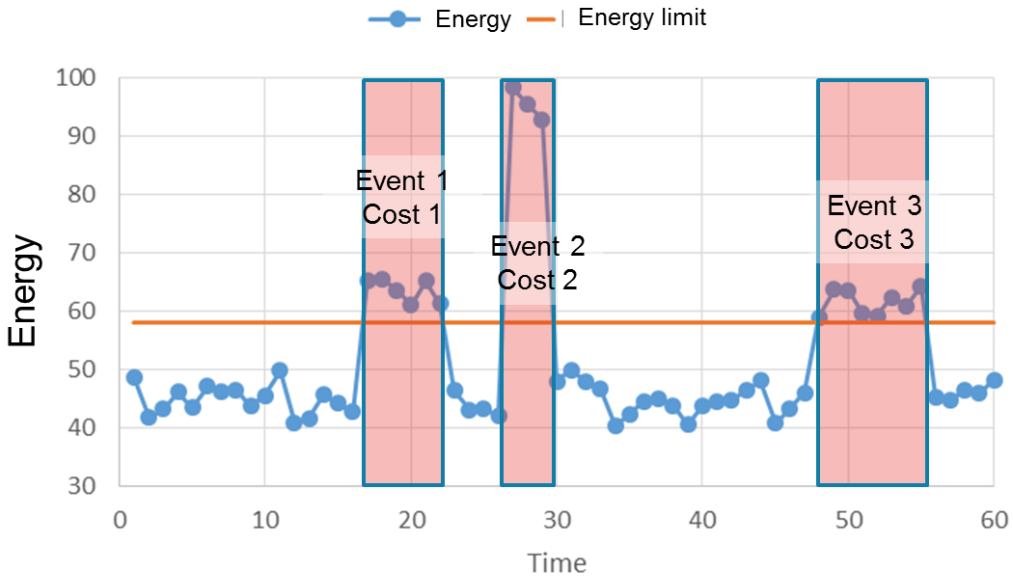


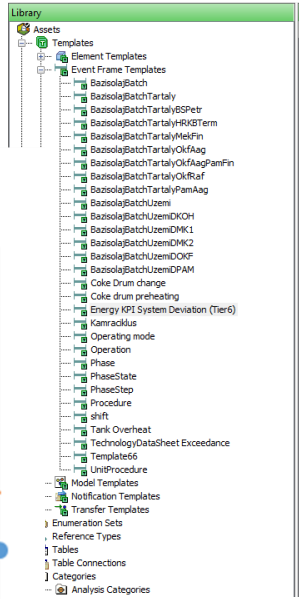


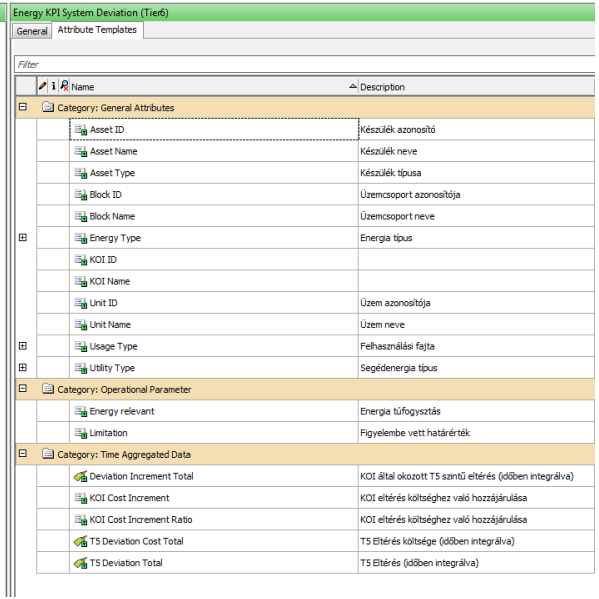
Benefits

- Continuous monitoring of the parameters
- Normalized, unified, and quality information leveraging PI AF
- Easy maintenance and Governance of the PI AF templates
- Structured format
- **Increased production** as a result of improved energy and environmental constraint visibility and forecasting

PI Event Frames – Energy Over consumption events







Natural Gas Consumption Prediction

BackGround

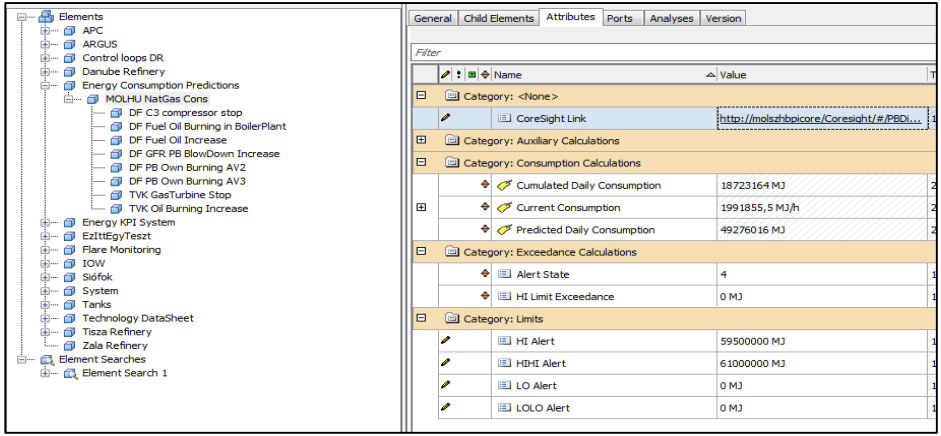
- Huge saving possibilities in the decrease of contracted natural gas daily maximum amount

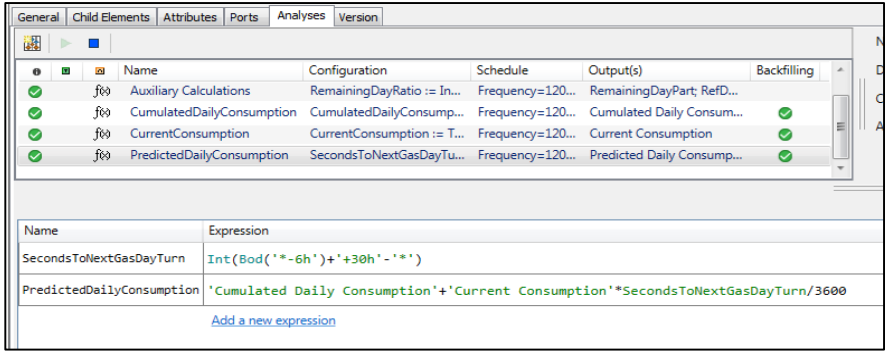
Problem

- 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





Advanced PSM & CBM

Supporting Strategic Business Initiatives – Refinery Safety Excellence – Enabled by the PI AF Data Object Model

- On-line analyzers
- Interlock monitoring & governance
- Flare
- Iintegrity Operating Windows (IOW)
- Operation Envelopes(OW)
- Advanced Corrosion Analytics

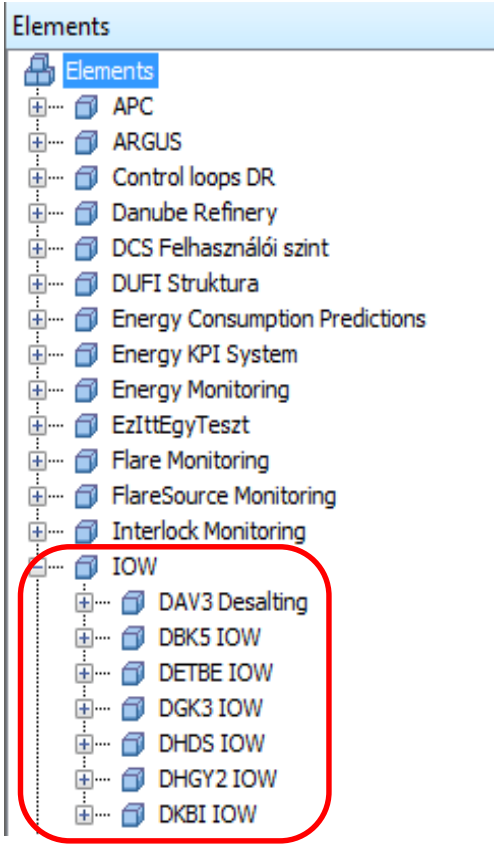
- Proactive/Predictive analytics with PI AF
- Reports – PI DataLink
- Displays PI Coresight
- Notifications Notifications

- Safe operation
- Reduced shut-downs
- Availability/Utilization
- Integrity
- Loss of containment

Integrity Operating Window- Using PI AF

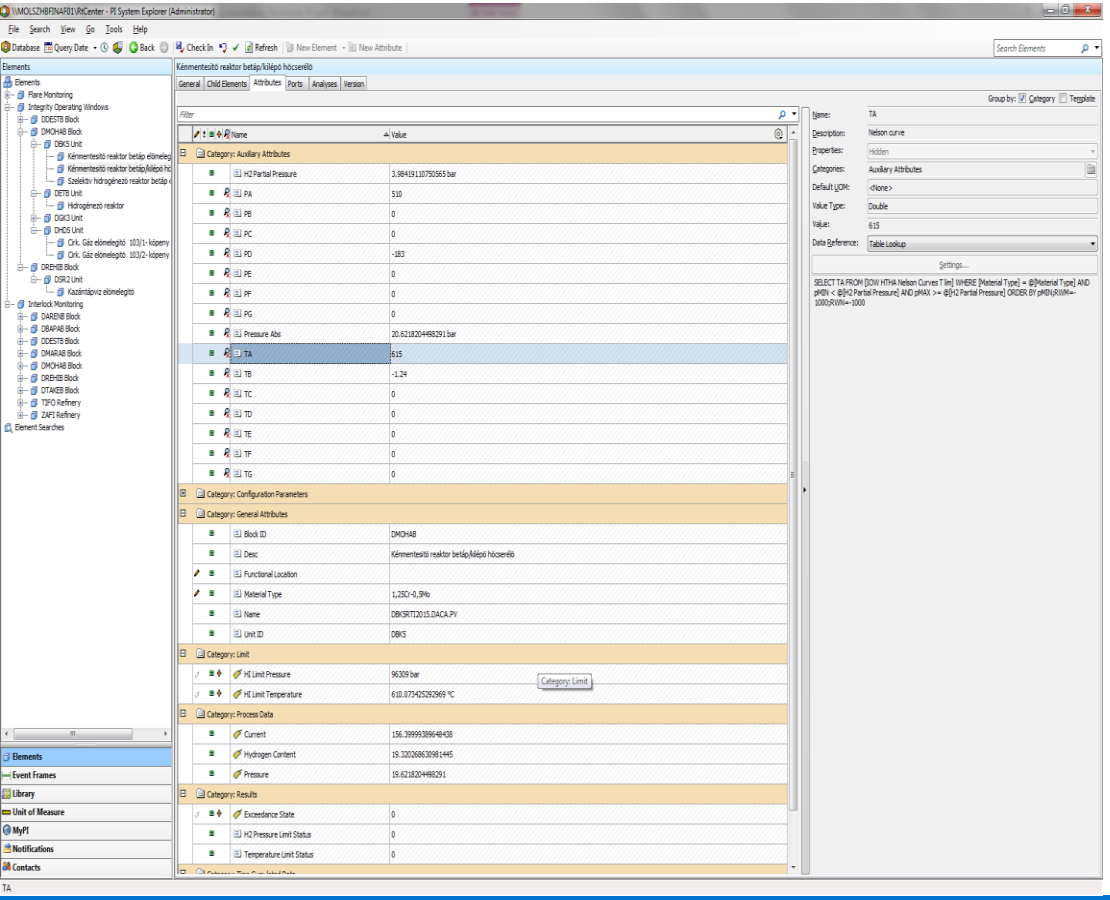
IOW - Established limits for process variables (parameters) that can affect the integrity of the equipment if the process operation deviates from the established limits for a predetermined length of time – All in PI AF

Requires attention within specified timeframe	Requires drastic and/or immediate action
Standard	**Critical**
Heater Tube Skin Temperature	Boiler Feed Water Level
Crude Fractionator Dew Point Temperature	Hydro-process Reactor Temperature
pH of Crude Tower Overhead	Heater Tube Skin Temperature
Desalter Outlet Salt Content	Sulfuric Acid Strength in Alkylation



Advanced PSM – High Temperature Hydrogen Attack (HTHA) – Hydrogen Embrittlement

Improving Asset Integrity with Advanced Corrosion Analytics

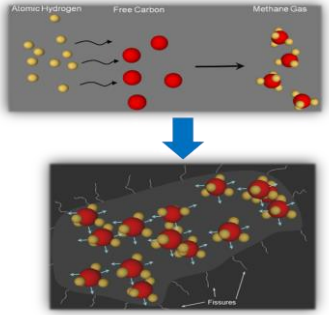


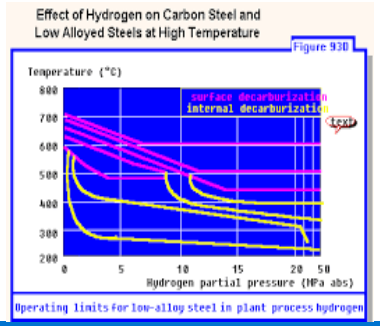
- **High Temperature Hydrogen Attack (HTHA)**
- **f^x (metallurgy, temperature, hydrogen partial pressure(PP), length of exposure**

Developed PI AF template that:

- Determine partial pressure
- 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**
- **All plants in 2015 < 2 months – 50+ nodes**





Results of Action – Attitude & Culture

- Ability to optimize alloy selection based on empirical data
- Determine if equipment needs to be replaced or inspected in turnaround
- Maintenance team has a continuous monitoring tool to make better decisions
- Better teamwork & communication between operations & maintenance

Challenge – Critical Availability Problems

- Hydrogen Production Plants (HPP) are critical units in the refinery
- Pressure Swing Adsorbers (PSA) are critical equipments in unit operation
- Cyclic operation – Heavy load on valves (9-10 open-close hourly)
- **$1.2M loss in three years due to PSA valve failures**
- UPTIME program: **97 % Operational availability**

Architecture – Roles of components

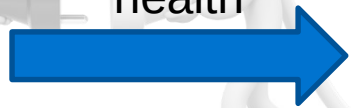
PI Server

- Process database
- Online analysis of process information
- Calculation of asset health
  - Asset condition
  - Running hours
  - Performance
- User Interface
  - PI Coresight
  - PI DataLink

Connection

(WebLogic)

Calculated asset health



Maintenance related information

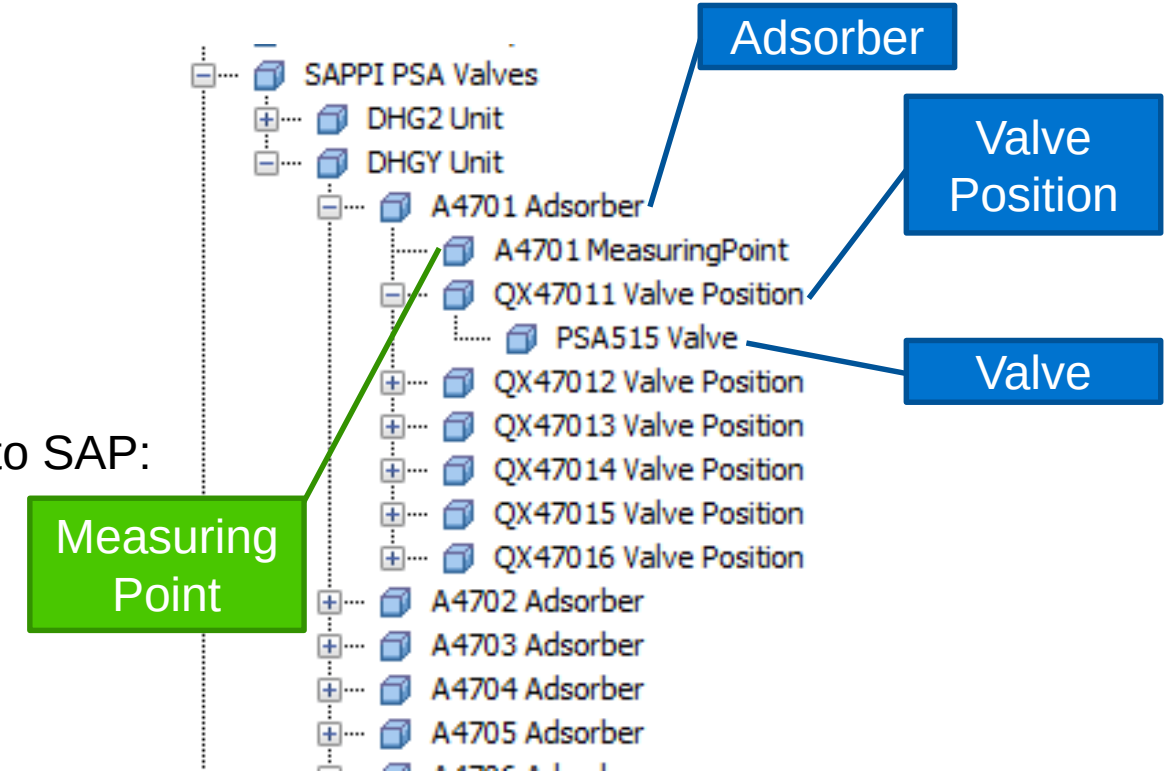
SAP PM

- Technical database
- Management of maintenance processes
- Creation of work orders or notifications
- Trigger maintenance strategies based on asset health

PI AF Structure

- Structure for calculation:
  - Adsorber
  - Valve positions
  - Valves

- Structure for moving data into SAP:
  - Adsorber
  - Measuring Points

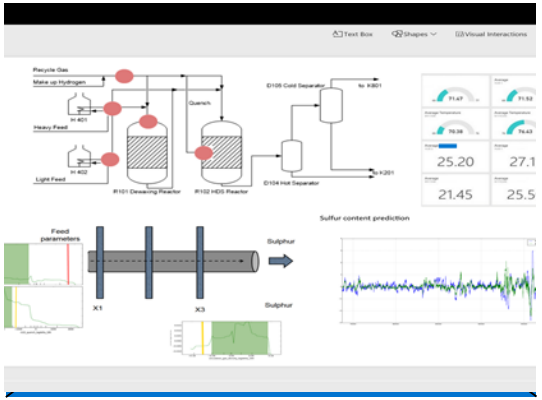


Extending Advanced Analytics with ML

Improving Sulfur in Diesel Prediction from Azure Machine Learning

COMPANY and GOAL

Replace RTO and offline modeling with Azure based Machine Learning to improve the prediction and optimization of sulfur in diesel in a diesel hydrotreating unit



CHALLENGE

Off line and rigorous on line RTO models were **slow**, difficult to maintain, and produced inconsistent results in predicting the sulfur in the diesel **resulting in lost benefits in excess of $600K/yr & growing.**

- RTO systems were expensive and difficult to maintain
- Off line models were to slow
- Lost benefits of ~$600K/yr in 4 units
- Growing potential loss from decreased specifications of sulfur in diesel

SOLUTION

Leverage **existing OT data infrastructure** to enable Azure machine learning to predict sulfur in diesel by:

- Analysis of data to determine the control variables which has the highest effect on sulfur content
- Determine the desired intervals for each variable to control the output sulfur content
- Advanced model to (time window based) to predict the changes of the sulfur based on the changes in the control variables

RESULTS

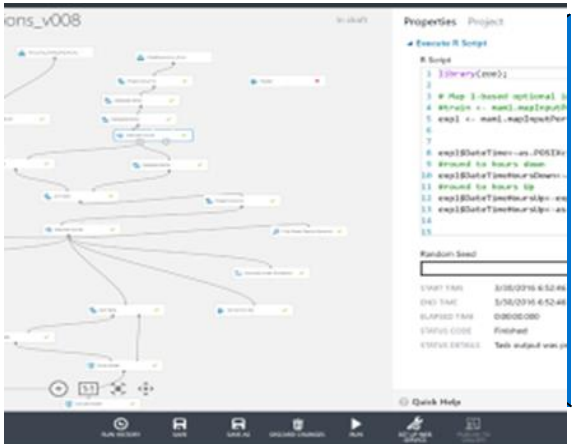
Ability to identify and control (open loop) the key variables in **predicting sulfur in diesel**. Expanding to other hydro treating units. **Initial savings ~600K and growing**.

- Enhanced the maintenance of existing empirical inferential calculations (Other Hydrotreater Sulfur content, Cloud point, Pensky Martens FP, Gasoline EBP)
- Enabled the determination of new empirical inferential calculations (E.g. NHT, Amine systems….)

Improving DCU Yield and Safety with Azure Machine Learning

COMPANY and GOAL

Improve Delayed Coking Unit yield and Reduce the risk of coke hot spot steam explosions from feed and operational variability by using Azure machine learning.



CHALLENGE

Opportunity crudes provided incentive to raise DCU yields but resulted in an increase likelihood hot spots **resulting in steam eruption events while decoking.**

- Economic incentive to run opportunity crudes $6M for each 1% increase in DCU yield
- Increase feed variability to the DCU
- Increased risk of hot spots and steam explosion events during decoking – 4X increase in Q1 2016

SOLUTION

Leverage **existing OT data infrastructure** to enable the use of **advanced analytics and machine learning** to **improve yields and reduce the risk of steam eruption**.

- PI AF infrastructure in place from prior digital transformation from tags to assets
- Use Microsoft Azure Machine Learning to do massive high fidelity data correlation of DCU feed properties to yields and explosions

RESULTS

Reduced DCU steam explosion events while improving DCU yields from the processing of more opportunity crudes

- *Enabled the sustainability of increased DCU yields of over 2% by processing opportunity crudes*
- *Reduced steam explosions by 75%*
- *Calculated savings for 1 DCU unit = $6M/yr for each 1% yield = $12M/yr*
- ***Rapid rollout** to other DCUs*

Best Practices & Perspectives

Key Takeaways…..

1. **Focus on rapid extension of the PI System across the enterprise**

2. **Migrate to the use of PI AF quickly by support of key business initiatives and leadership…it is a journey of continuous improvement**

3. **Link to support of strategic business transformation strategy and vision if possible, gain executive awareness and support**

4. **Develop PI AF core competency and organizational awareness**

5. **Once in place, the OT infrastructure can and will enable rapid and scalable applications to business issues & opportunist**

Thank You

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