



Leveraging the PI System® in the Processing of Opportunity Crudes

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Process Information Expert



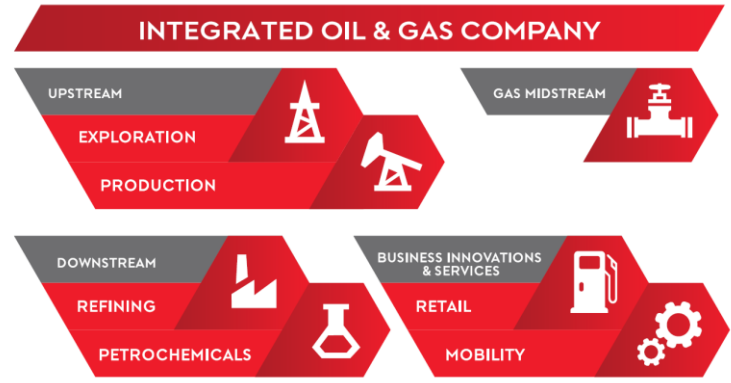
Agenda

- Introduction
- Business Opportunity & Challenge
- Solutions:
 - Keeping process in control
 - Early fault detection
- Analytics and Decision Support Strategy



MOL Group

MOL is an integrated, independent, international oil and gas company, headquartered in Budapest, Hungary with a track record of over 100 years in the industry.



An Integrated Downstream Value Chain

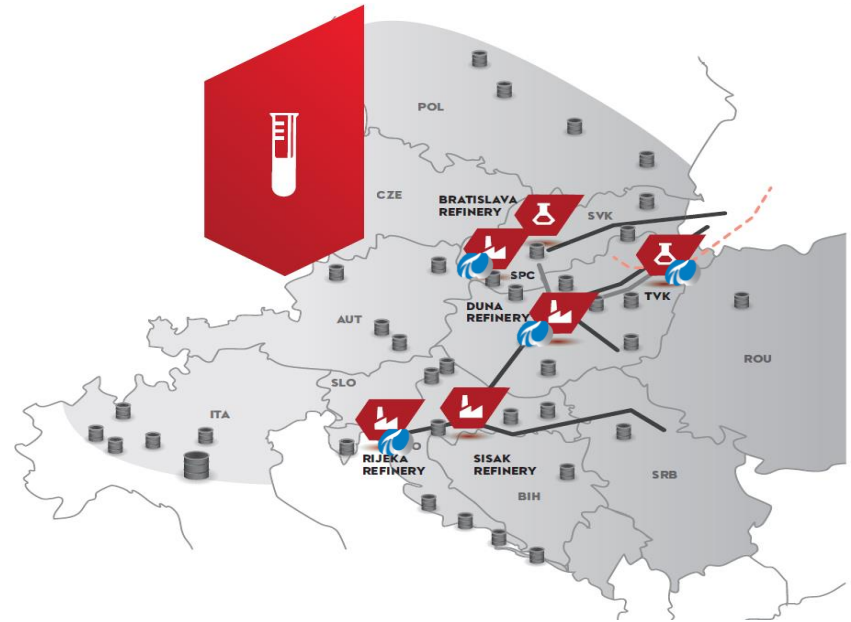


- **Integrated Fuels Value Chain:**

- 4 refineries, 2 Petrochem plants
- Logistics including 2 000 retail stations

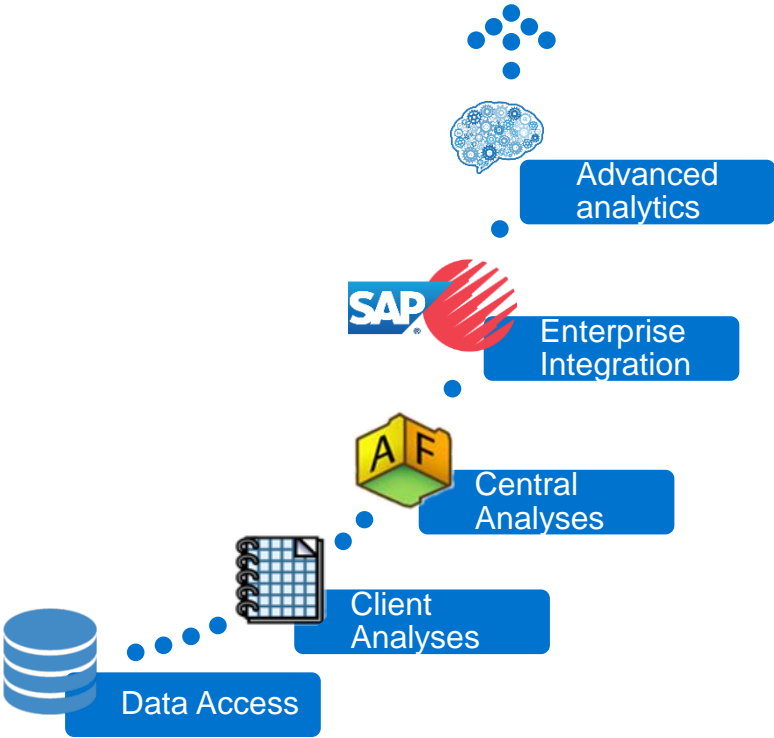
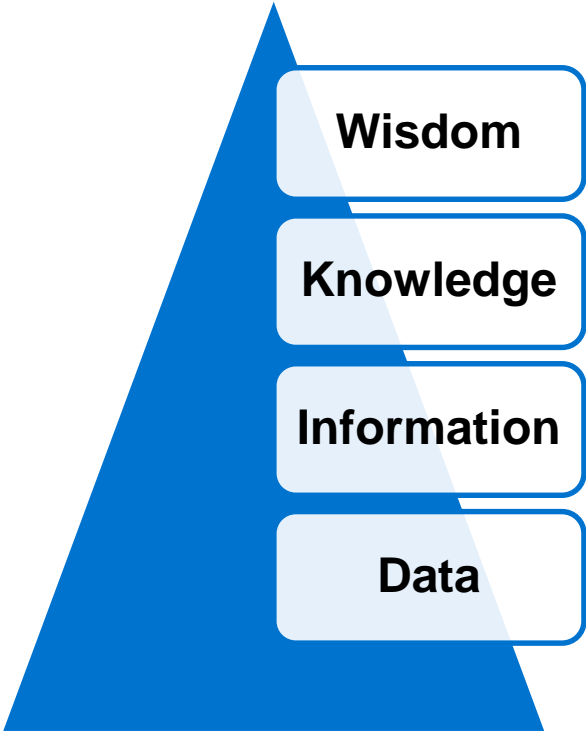
- **PI System® Overview:**

- 3 HA collectives, ~400K tags
- Elements:
 - ~350 element templates
 - ~23K elements & growing
- Events:
 - ~6K Notifications
 - ~10K Event Frames analyses
 - ~50K Event Frames in 2016

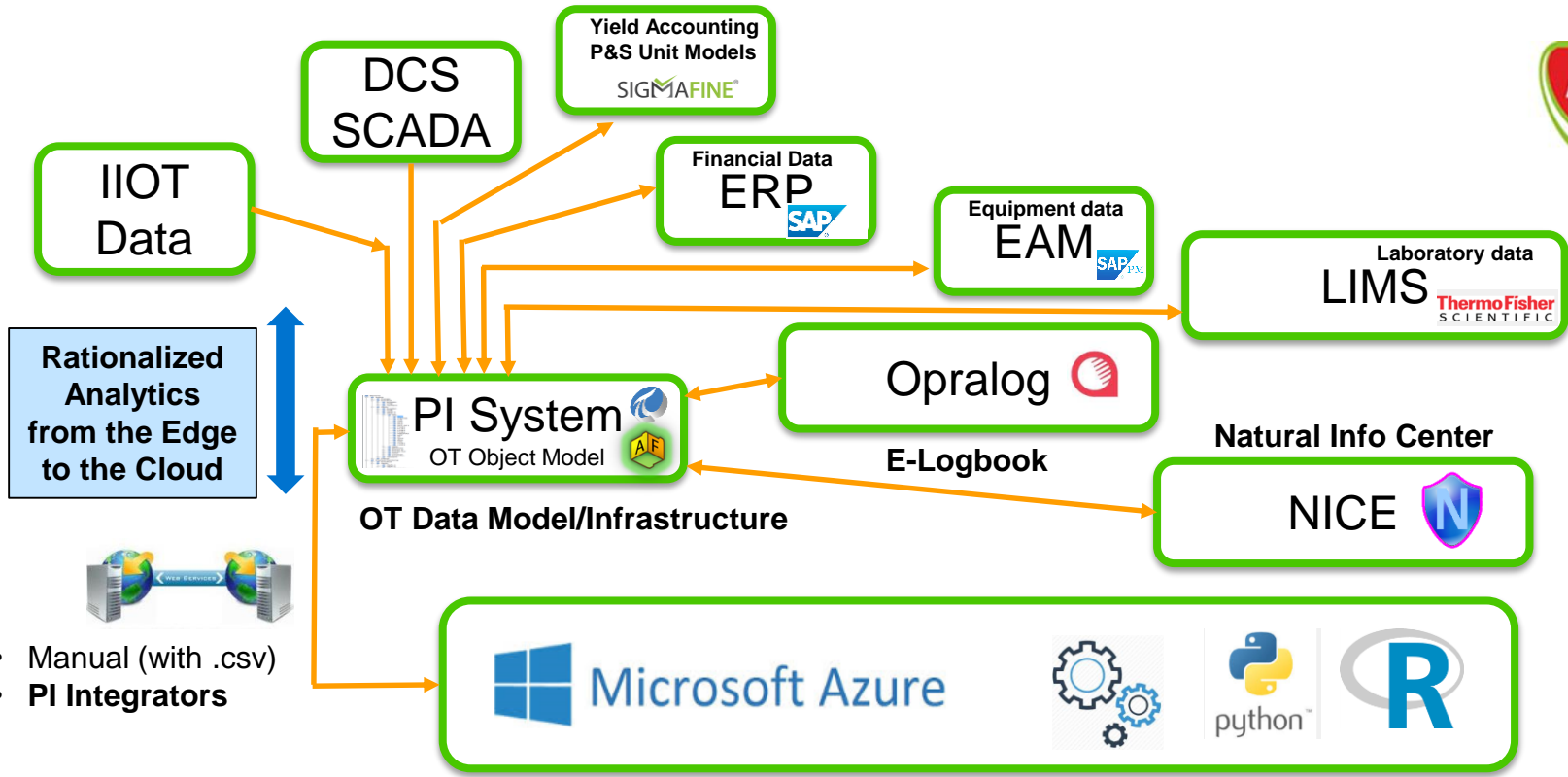


- **PI Coresight™ is the primary process visualization platform**

Digitalization Journey of MOL Group

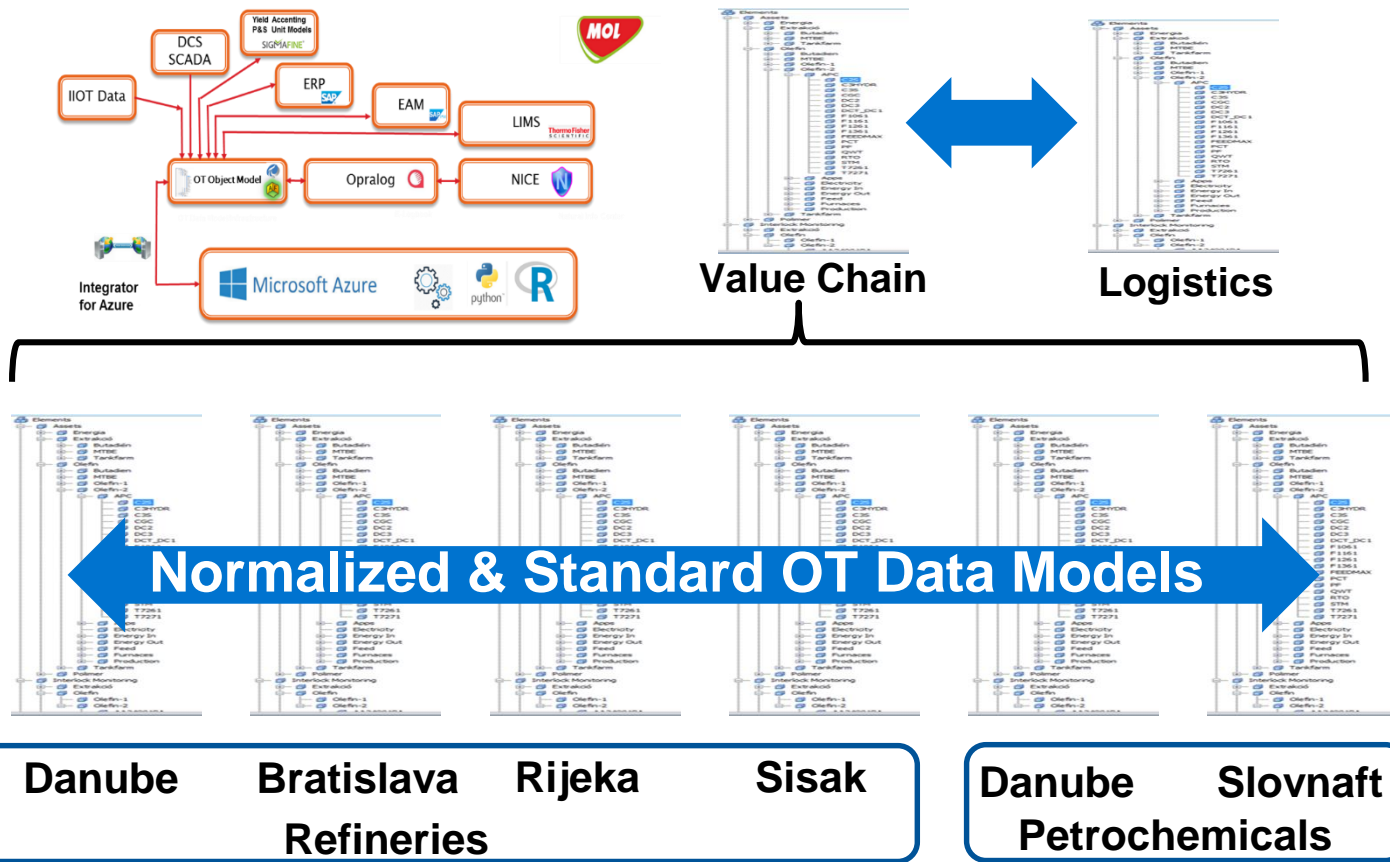


PI AF- the Foundation of MOL's Distributed Analytics



- Manual (with .csv)
- PI Integrators

Integrated Smart Fuels Value Chain Vision



Danube

Bratislava

Rijeka

Sisak

Danube

Slovnaft

Refineries

Petrochemicals

Background – Alternative supply sources

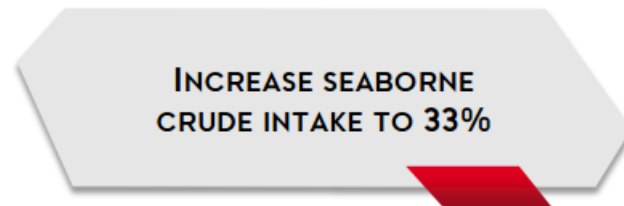
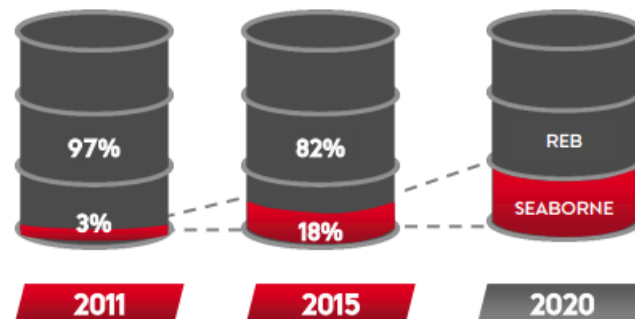
- **Opportunity crudes, Seaborne supply sources:**
 - Discounted price
 - Flexible supply
- **Strategic target:**
 - **Crude basket with 50 + grades**



▶ QUICKLY RESPOND TO MARKET CHANGES & OPPORTUNITIES WITH ALTERNATIVE/SEABORNE SUPPLY SOURCES AND A CRUDE BASKET WITH 50+ GRADES

Opportunities

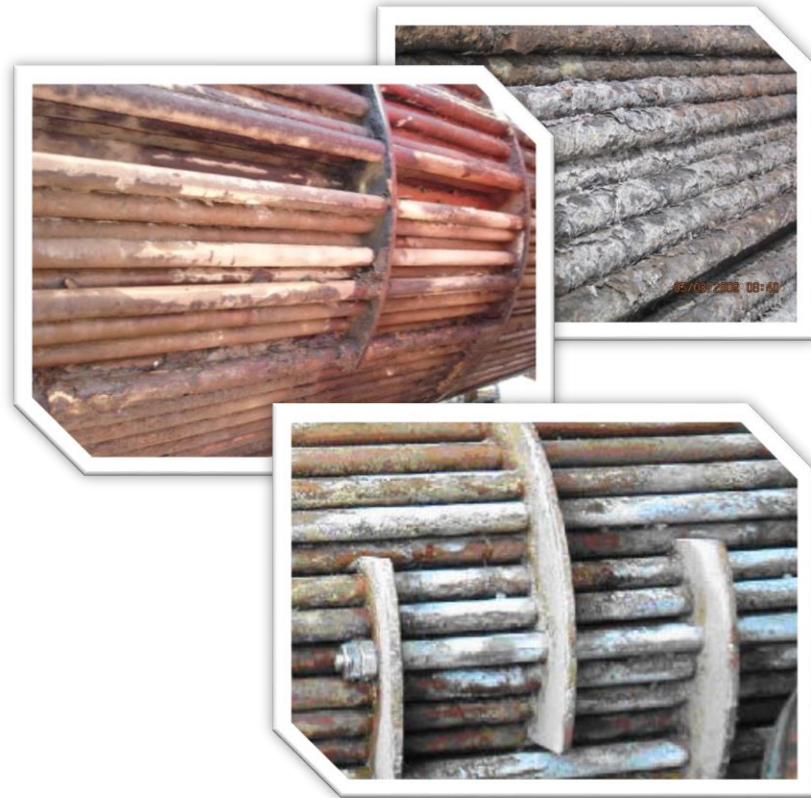
- **Discounted price**
 - **\$2 - \$4 / BBI** depending on crude type
 - Can be negative in case of higher grade crude
- **Flexibility**
 - Quickly respond to market changes with crude selection
- **Estimated benefit: \$1 - \$3 / BBI**
- **10 % alternative crude processing ~ \$10M - \$11M+ /Year/Refinery**



Strategic goal:
Increase seaborne crude processing to 33% by 2030

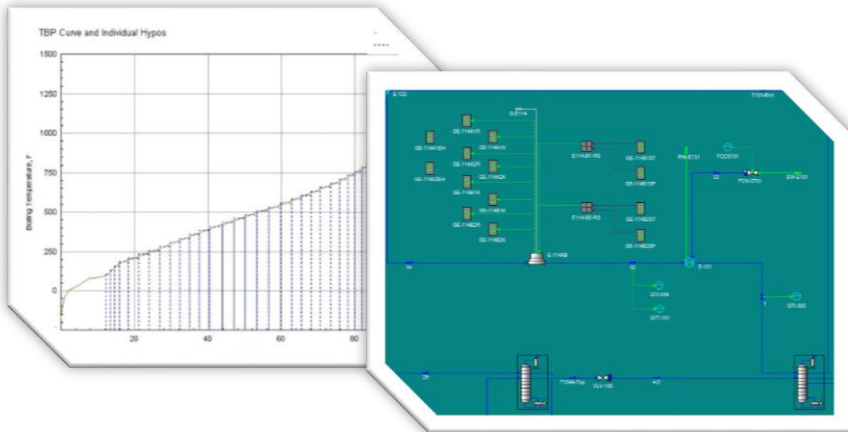
Challenge – Alternative supply sources

- Refinery was designed for a given type of crude
- No crude mixing – fluctuation in process
- Operations challenges:
 - Crude Desalter Performance
 - Corrosion
 - Fluctuation in process
 - Unpredictable issues
 - Equipment Performance & Reliability
 - Fouling



Solution – Crude analysis, Asset upgrade

- Crude Assays
- Process Simulations
- Refinery Modeling
- Crude Blender
- Improvements of desalters and other assets



Solution – Increase Real-Time Situational Awareness

Issues

- Fluctuation in crude quality
- Changes in quality of semi-finished products
- Disturbances in process



- **Increased number of events to react**

Solution

- Faster, proactive and predictive decision support
- Advanced analytics
- Equipment performance/CBM
- Failure detection, notification



- **Support Operational Awareness**

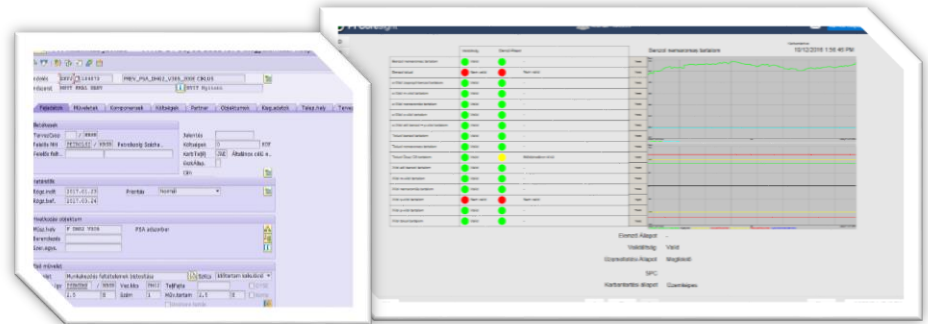
Examples – Keeping process in control

Operation - Avoid harmful process conditions

- Integrity operating window (IOWs)
- Corrosion control & monitoring
- Feed composition tracking

Maintenance - Early failure detection

- Preventive & condition based maintenance
- Online statistical validation of controllers, sensors



Integrity Operating Window – Objective

- **Objective:** Keep process safety parameters in control
- **Solution:**
 - Structure in PI Asset Framework (PI AF)
 - Calculation, limit evaluation
 - Advanced PI Analytics and PI Event Frames

The screenshot displays the PI Asset Framework (PI AF) software interface. It is divided into several sections:

- Category: Configuration Parameters:** A table listing various parameters such as Deviation Action Timeframe, Functional Location, HI Limit Pressure FDX, HI Limit Temperature FDX, Hydrogen Content Limit, Hydrogen Content Limit Table, Hydrogen Content Measurement, Material Type, Pressure Measurement, and Unit Operating.
- Category: General Attributes:** A table listing attributes like Block ID, Desc, Name, and Unit ID.
- Category: Limit:** A section with tabs for General, Child Elements, and Attributes. It shows a table with columns for Name and Backfilling, containing entries for HI Limit and IOW HTHA Exceedance State Calculation.
- Category: Process Data:** A section showing data points for Current, Hydrogen, and Pressure.
- Category: Results:** A section showing results for Exceedance, H2 Pressure, and Temperature.
- Category: Time Cumulation:** A section showing results for Exceedance.

Two callouts highlight specific features:

- An orange box labeled "HI limit calculation" points to the "HI Limit" entry in the Limit table.
- A larger orange box labeled "IOW HTHA Exceedance state calculation" points to the "IOW HTHA Exceedance State Calculation" entry in the Limit table.

Below the Limit table, a detailed view shows the following table:

Name	Expression
x	'H2 Partial Pressure'
NelsonTempLimit	'TA' + 'TB'*x + 'TC'*Log(x+'TD') + 'TE'/(x+'TF')
y	'Current'
NelsonPressureLimit	'PA' + 'PB'*y + 'PG'*Exp('PC'*y+'PD') + 'PE'/(y+'PF')

Integrity Operating Window – User Experience

- **Visualization:** PI Coresight™
- **Work initiation:** PI Notifications (e-mail with suggested actions)
- **Results:**
 - Increased process safety
 - Faster reaction
 - Longer asset lifecycle

The screenshot displays the PI Coresight interface. On the left, a table lists process parameters with their current and limit values. A trend chart shows the historical data for one of these parameters. On the right, an email notification window is open, detailing the current status and suggested actions for a specific parameter.

Functional location	HTHA Parameter Description PI Tag	Current T [°C]	HI Limit T [°C]	Trend T
F DKBI 101	Izomerizáló reaktor DKBIITH094.PVA	264.31	282.22	
F DKBI 176	Reaktor termék léghűtő DKBIIT097.PVA	84.37	282.22	
F DBK5 460V4	Kénmentesítő reaktor betáp előmelegítő cseppfogyó - köpeny DBK5RT12017.DACA.PV	240.80	291.36	
		125.70	290.98	
		160.30	282.47	
		96.30	280.13	
		150.65	254.82	
		184.33	258.52	
		146.02	247.41	
		217.44	251.05	
		236.30	251.05	

Actions:

- Actions1: Value
- Actions2: Value
- Actions3: Value
- Actions4: Value

Notification Content:

Subject: IOW Exceedance Notification

Body:

IOW paraméter túllépés történt!

Üzemi:
Unit ID: Value
IOW paraméter leírása:
Desc: Value
IOW paraméter PI Tag:
Names: Value
IOW paraméter Coresight:
CS Display: Value
Az IOW paraméter jelenlegi értéke:
Current: Value **Current:** Units
 Így túllépte a minimum **LO Limit T:** Value vagy maximum **HI Limit T:** Value határértéket.
A szükséges intézkedéseket az alábbi időkeren belül tegye meg:
Deviation Action Timeframe: Value

Corrosion Control & Monitoring

- **Objective:** Support corrosion monitoring and water treatment
- **Solution:**
 - Comprehensive and logical structures in Asset Framework (AF)
 - Visualization in PI Coresight, alerts in Notifications
- **Results:**
 - Reduced corrosion → Cost savings

Laboratory results (water treatment efficiency)

Name	Live ID	HH Limit	HI Limit	LO Limit	LO Limit T
...	...	100000000	50	-100000000	NKLimit
...	...	7,9999999996325684			
...	...	0			

Corrosion coupon results

Üzemény	CM Parameter Leírása	Aktuális	LO Limit	HI Limit	Tülsúly	Trend
DAV3	Korróziós kupón viz. szulfidtartalom	0.03	No Data	0.23		
DAV3	Elteljesítő refluksztály viz. ammónium	18.00	No Data	50.00		
DAV3	Elteljesítő refluksztály viz. szulfidtartalom	1.10	No Data	20.00		
DAV3	Elteljesítő refluksztály viz. pH	6.90	5.50	6.50		
DAV3	Elteljesítő refluksztály viz. szulfidtartalom	33.00	No Data	50.00		
DAV3	Elteljesítő refluksztály viz. vas tartalom	0.21	No Data	1.00		
DAV3	Korróziós a fűtőgáz kondenzátor klapjában	0.50	No Data	0.23		
DAV3	Korróziós a fűtőgáz refluksztály efflovo vízben	0.03	No Data	0.23		
DAV3	Korróziós a fűtőgáz refluksztály vízvesztésben	0.09	No Data	0.23		
DAV3	Fűtőgáz refluksztály viz. ammónium	7.60	No Data	50.00		
DAV3	Fűtőgáz refluksztály viz. szulfidtartalom	28.40	No Data	20.00		
DAV3	Fűtőgáz refluksztály viz. pH	6.80	5.50	6.50		
DAV3	Fűtőgáz refluksztály viz. pH analízator	9.38	5.50	6.50		
DAV3	Fűtőgáz refluksztály viz. szulfidtartalom					

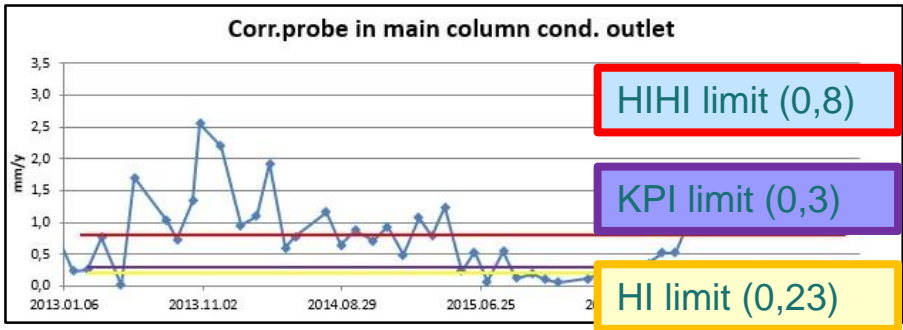
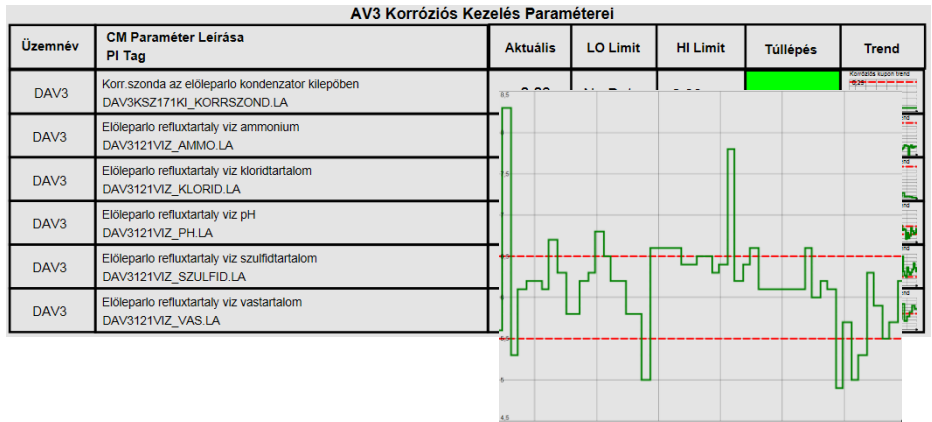
Corrosion Control & Monitoring–Chemical Treatment

Monitoring


- Online Coresight Display
- Monthly Corrosion Report

Actions

- Chemical Treatment program
 - Process Treatment
 - Water Treatment
 - Amine System Treatment
- Increased sampling frequency in case of alternative crude



Feed Composition Tracking – Background

- **Delayed Coker Unit (DCU):**
 - Semi-continuous, thermal cracking process
 - Produces white components & coke
 - **Wide variety of feedstock:**
 - Residuals from different crudes
 - Heaviest oil from other conversion processes, other refineries
 - **Issue:**
 - Increased number of steam eruptions during coke cutting
 - Increased drum vibration during coking and cutting
- 
- **Safety risk**

Feed Composition Tracking – Investigation

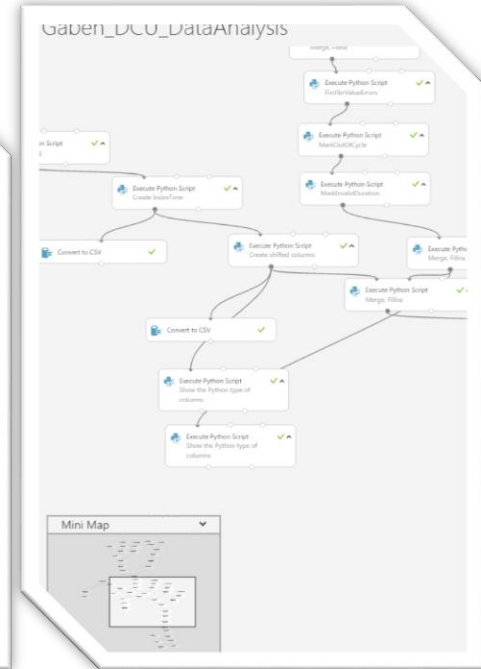
- **Datasources:**
 - Process data – Event Frames
 - Movement data – Oracle database
 - Laboratory data – Oracle database
 - Manual data – Excel files



Complex data preparation and cleaning was needed

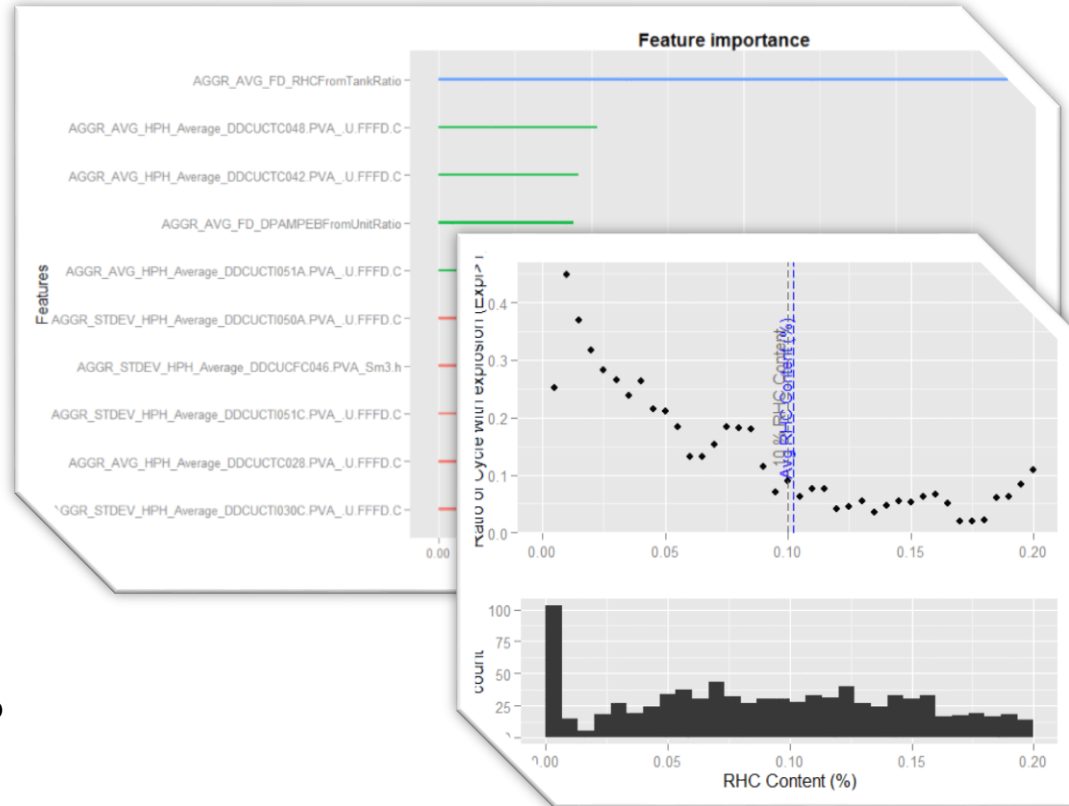
Azure Machine Learning with Python scripts

```
1 # imports up here can be used to
2 import pandas as pd
3 from datetime import datetime
4 import numpy as np
5
6 # The entry point function can contain up to 2
7 # Param<dataframe1>: a pandas.DataFrame
8 # Param<dataframe2>: a pandas.DataFrame
9
10 def azureml_main(dataframe1 = None, dataframe2
11
12     df=dataframe1
13
14
15     avgCols = [col for col in df.columns if co
16     avgCols = avgCols + [col for col in df.col
17     avgCols = avgCols + [col for col in df.col
18     avgCols = avgCols + [col for col in df.col
19     avgCols = avgCols + [col for col in df.col
20     avgCols = avgCols + [col for col in df.col
21     avgCols = avgCols + [col for col in df.col
22     avgCols = avgCols + [col for col in df.col
23     stdevCols = [col for col in df.columns if
24     stdevCols = stdevCols + [col for col in df
25     stdevCols = stdevCols + [col for col in df
26     maxCols = [col for col in df.columns if co
27     inCols = [col for col in df.columns if co
```



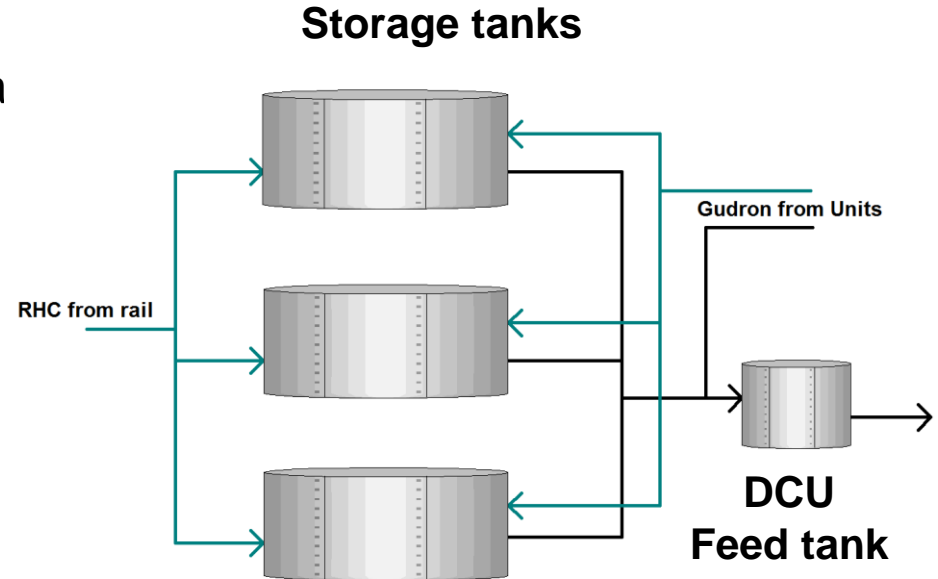
Feed Composition Tracking – Investigation

- Model building, analysis in Rstudio:
 - Gradient boosting model
 - Feature importance and visual analysis
- Most important factor:
 - RHC content of feed (RHC: heaviest product of Residual Hydrocracker)
 - It has to be kept above 10 %
 - Difficult to calculate online



Feed Composition Tracking – Online Calculation

- **RHC content of storage tank:**
 - Data: movement information in a Oracle database
 - Frequency: daily
- **RHC content of feed tank:**
 - Data:
 - Valve positions
 - Tank volume change
 - Storage tank RHC Content
 - Frequency: online



Feed Composition Tracking – Online Calculation

- **First step: Storage tanks:**
 - Base data: material movement into storage tanks
 - Data import with PI RDBMS Interface
 - Daily calculation
 - Calculate the RHC content of storage tanks with a simple mixture calculation
- **Result:** RHC content of storage tanks (daily resolution)

The screenshot displays a software interface for feed composition tracking. On the left, a tree view shows the hierarchy of elements, including 'Tank Composition Calculation' and 'DFOTT20015 RHC Content'. On the right, a detailed view for 'DFOTT20015 RHC Content - Movement Based' is shown. This view includes a table of auxiliary attributes, identity, and NICE data, and a table of calculations with expressions.

Category	Name	Value
Auxiliary Attributes	Daily All Input Mass PI Tag	DFOTT20015_DAILYMOVMASS_ALLINPUT.MOV
Auxiliary Attributes	Daily RHC Input Mass PI Tag	DFOTT20015_DAILYMOVMASS_RHCINPUT.MOV
Auxiliary Attributes	Online Mass PI Tag	DFOTT20015.PV
Identity	Tank ID	20015
Identity	Tank Name	DFOTT20015
Identity	Tank Unit ID	DFOT
NICE Data	Daily All Input Mass	0 t
NICE Data	Daily RHC Input Mass	0 t
NICE Data	Online Mass	16827.25390625 t
Results Auxiliary	Daily First Tank Level Change	-1

Name	Expression	Value
startWithLvlDecrease	IF TagVal('Daily First Tank Level Change', 't-5m') = -1 THEN 1 ELSE 0	
initTankMass	IF startWithLvlDecrease = 1 THEN TagVal('Online Mass Validated', 'y', 't') ELSE TagVal('C	
initRhcMas	initTankMass * TagVal('Tank RHC Content', 'y') / 100	
newTankMass	TagVal('Daily All Input Mass', 'y')	
newRhcMass	TagVal('Daily RHC Input Mass', 'y')	
Ratio	(initRhcMas + newRhcMass)/(initTankMass + newTankMass) * 100	

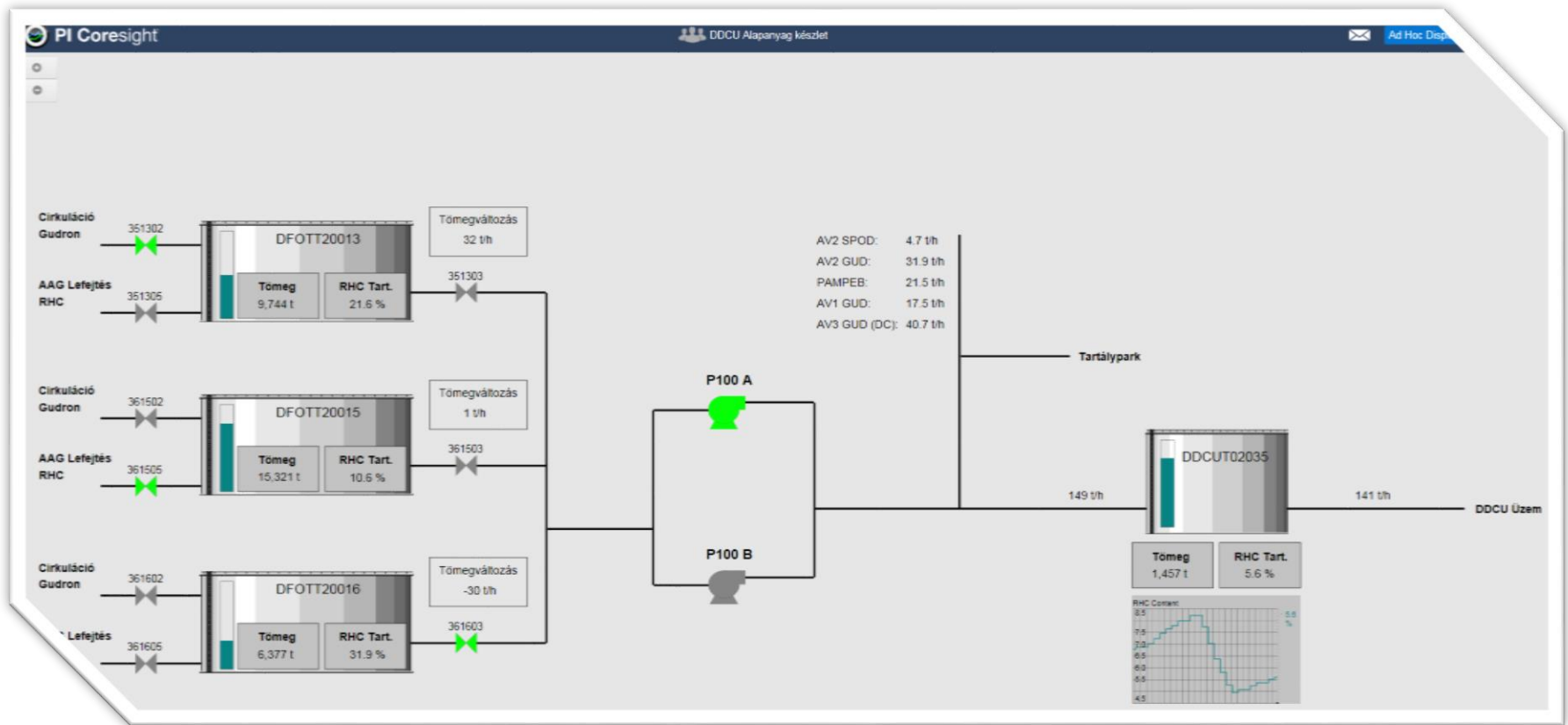
Feed Composition Tracking – Online Calculation

- **Second step:** Feed tanks:
 - Base data: RHC content of storage tank, valve positions, online tank mass
 - Online data from DCS system
 - Hourly mixture calculation
- **Result:** RHC content of feed tank (hourly resolution)

The screenshot displays the OSIsoft software interface for configuring an analysis. The main window is titled 'TCC_RHC Hourly' and shows a list of child elements: 'TCC_RHC Hourly RHC Mass Aggregation', 'TCC_RHC Mass Validation', and 'TCC_RHC Tank RHC Calculation'. The 'Rollup attributes from' section is set to 'Child elements of DDCU02035'. The 'Attribute Name' is 'Hourly RHC Mass to DDCU'. The 'Attribute Level' is 'Root Level'. The 'Element Template' is 'RHC Level2 - DFOT RHC Tank Template'. The 'Sample Child Element' is 'DFOTT20013'. The 'Parent Element' list includes 'Hourly RHC Mass to DDCU', 'Hourly Mass Change', and 'Level'. The 'Filter' section shows a list of attributes for 'DDCU02035', including 'Online Mass PI Tag', 'Total Input Flow PI Tag', 'Tank ID', 'Tank Name', 'Tank Unit ID', 'Online Mass', 'Total Input Flow', 'Hourly RHC Input Mass', 'Online Mass Validated', and 'Tank RHC Content'.

Category	Attribute Name	Value
Auxiliary Attributes	Online Mass PI Tag	DDCU02035.PV
Configuration Parameters	Total Input Flow PI Tag	DDCU0225A.PVA
Identity	Tank ID	02035
Identity	Tank Name	DDCU02035
Identity	Tank Unit ID	DDCU
NICE Data	Online Mass	1121.35205078125 t
Process Data	Total Input Flow	134.120515625 t/h
Results Auxiliary	Hourly RHC Input Mass	5.875156 t/h
Results Auxiliary	Online Mass Validated	1121.166015625 t
Results Final	Tank RHC Content	5.233515 %

Feed Composition Tracking – User Interface



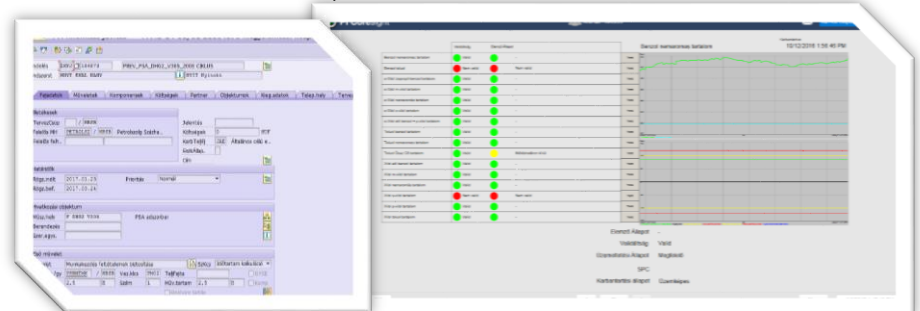
Examples – Keeping process in control

Operation - Avoid harmful process conditions

- Integrity operating window
- Corrosion control & monitoring
- Feed composition tracking

Maintenance - Early failure detection

- Preventive and condition based maintenance
- Online statistical validation of controllers, sensors



Preventive and Condition Based Maintenance

- **Objective:** a robust OT/IT system to support preventive maintenance strategies
- **Criteria:**
 - **Flexibility and scalability** (further strategies expected)
 - **Integrated solution** (utilization of existing softwares)
- **Tools:**
 - PI System® → Main process database + Real time analysis
 - SAP PM → Equipment database + Maintenance management tool
- **Solution:** Connection between systems

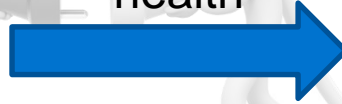
Preventive and Condition Based Maintenance

PI System®

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

Connection (WebLogic)

Calculated asset
health



Maintenance
related information



SAP PM

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

Preventive and Condition Based Maintenance

- Flexible calculations in PI Asset Framework (PI AF)
- Interface with PI Web API
- Work Order creation in SAP PM
- Estimated benefit: **\$230,000/year**
- First working solution:
 - Preventive maintenance of pressure swing adsorber valves in Hydrogen Production Plants

The screenshot displays the PI Coresight interface for 'Hidrogéngyár 2. üzem - PSA adszorber áttekintő'. It shows a table of maintenance data for four valves (V301, V302, V303, V304) with columns for 'Norm áll', 'Preventív számítás aktív', 'Hátralévő ciklusok (db)', 'Hátralévő üzemóra (óra)', and 'Számítási Hiba'. The data is as follows:

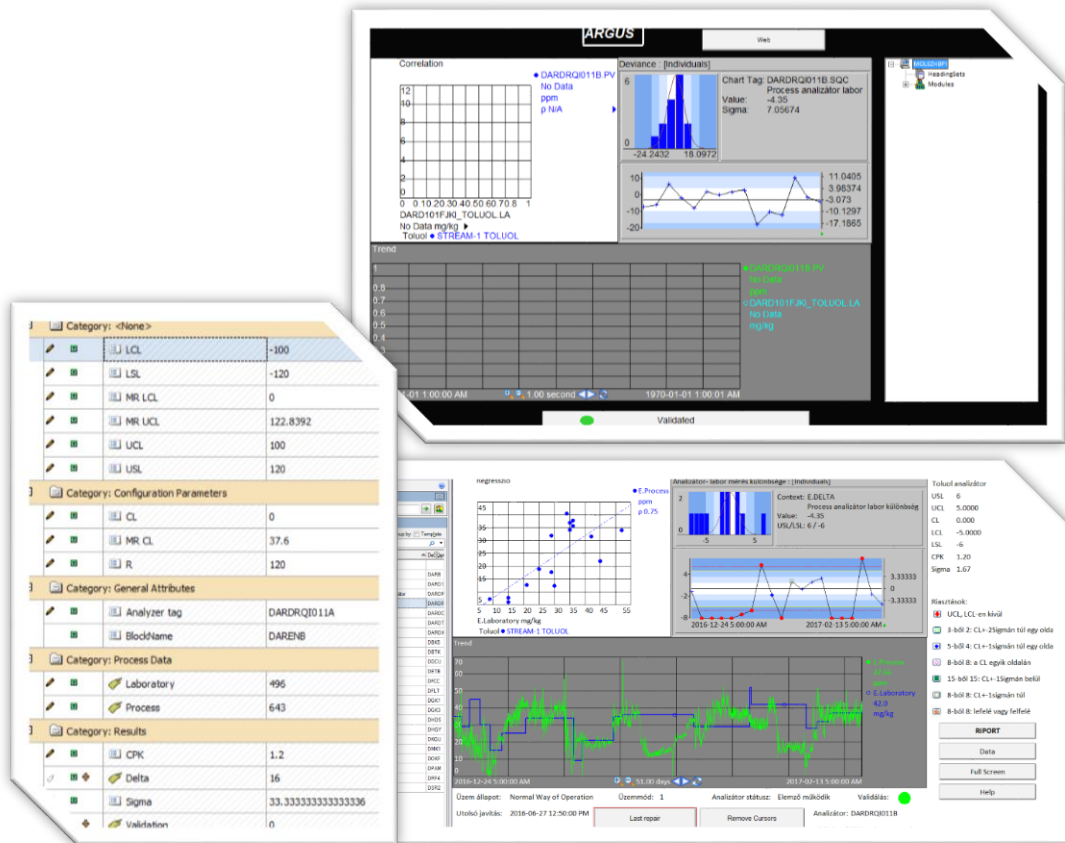
Valve ID	Norm áll	Preventív számítás aktív	Hátralévő ciklusok (db)	Hátralévő üzemóra (óra)	Számítási Hiba
V301	Norm áll	Yes	182,779	34,422	No Error
V302	Norm áll	Yes	197,572	34,846	No Error
V303	Norm áll	Yes	130,526	34,422	No Error
V304	Norm áll	Yes	111,643	34,466	No Error

Below the table, there is a section for 'PM finomítás javítás' (PM refinement improvement) with fields for 'tendelés' (194873), 'tendelenet' (SPTT EXAL 19487), and 'Jelentés' (Költségek, Karb.Telj, Eszk.Állap., Cim). There is also a 'Hivatkozott objektum' section with fields for 'Műc.hely' (DHG2 V306), 'Barendelés', and 'Szor.éges'.

```
'Rows': [  
  {  
    "ElementName": "MOP MP HearthBeat",  
    "ElementGUID": "811a3ce3-bd3f-11e6-a7db-54ee75770d4f",  
    "SAP MP ID": "111111",  
    "SAP MP Unit of Measure": "XXX",  
    "SAP Parent Object ID": "HearthBeat",  
    "SAP Parent Object Type": "Functional Location",  
    "Read Enabled": 1,  
    "Error Code": 0,  
    "Measuring Document Comment": "SAPPI PSA Valve calculation in PI AF",  
    "Last Calculation Time": "2017-02-18T14:45:00Z",  
    "MP Value": 1.0  
  }  
]
```

Analyser Validation – ARGUS 3.0

- **ARGUS 1.0:**
 - Analyser validation with statistical methods in PI ProcessBook + VBA
- **ARGUS 2.0**
- **Centralized calculation with PI Asset Framework (PI AF)**
- **Missing components**
 - Further signal evaluation
 - Workflow management



Analytics & Decision Support Strategy–Distributed Analytics

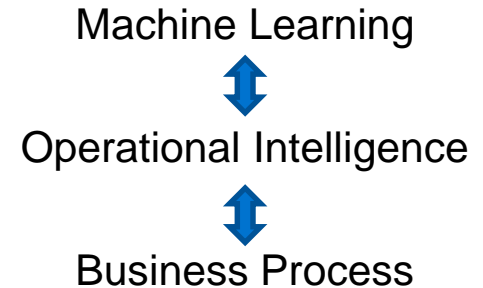
- **Analytics with different scope, scale and target:**
 - Online calculations
 - Machine learning
 - Maintenance scheduling
 - Etc ...
- **Refinery is more than the sum of independent business and technological processes**



„The whole is greater than the sum of its parts.”
Aristotle



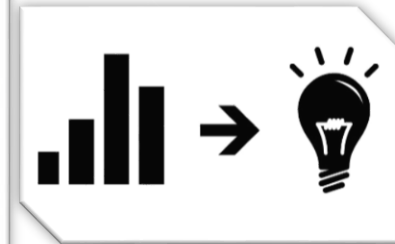
- **Decision supporting tools have to be organized in an integrated system:**
 - **Analytics are distributed across components**
 - Data and information flow through each element



Offline Analysis



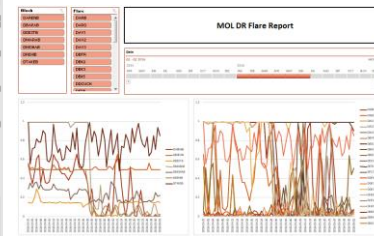
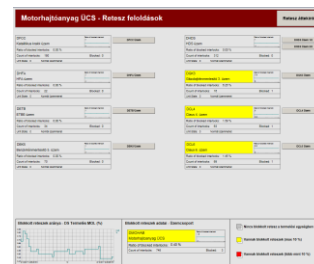
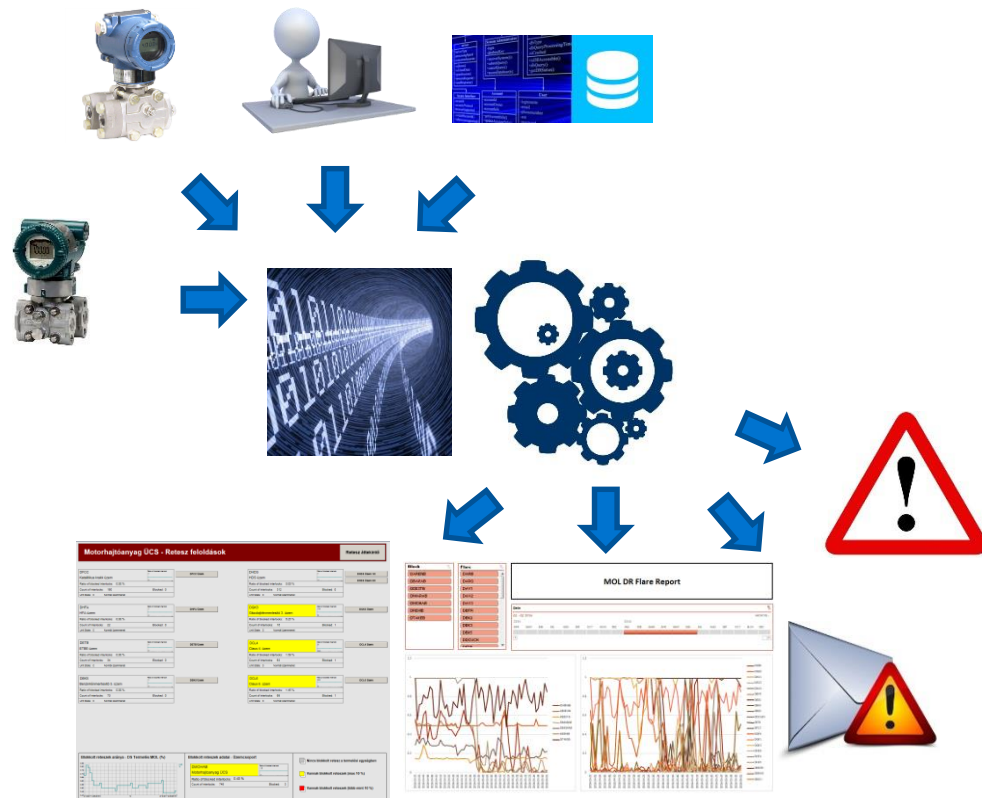
- **Visual Analysis or Machine Learning:**
 - Model building
 - Investigation
- **Data sources:**
 - Process database: PI System
 - Relational Databases
 - There are always extra Excel files
- **Tools:** PI Coresighttm, RStudio, Azure ML
- **Result:**
 - Insight, Knowledge
 - Model



Into Operation



- **Goal:** put knowledge into operation
 - Results from an investigation
 - Model to run continuously
- **Platform:**
 - Asset Framework (AF), the foundation
- **Connection**
 - Maintenance: SAP PM
 - Operation: Shift Logbook + DCS
- **Visuals**
 - PI Coresight™ dashboards
 - PI DataLink™ reports



Business Process



- **Online issue and disturbance identification**

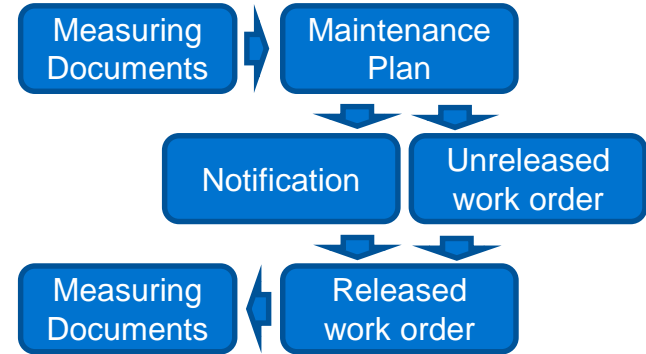
Action



- **Solution**

- **Actions:**

- Workflow management
- Feedback collection
- Support collaboration



Event based entries to inform operation or collect feedback

- **Tools:**

- SAP PM, Shift Logbook
- PI Coresight™, PI Notifications



Targeted notifications with suggested actions

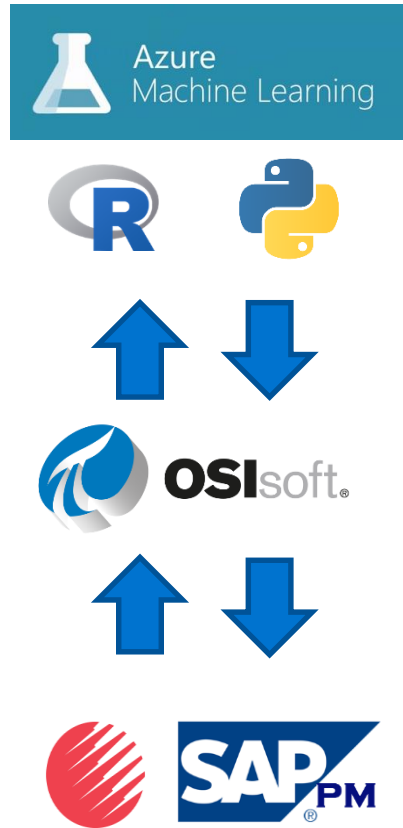
Current State - Next Steps

- **Existing architecture:**

- Offline analysis (RStudio or Azure Machine Learning)
- Real-time analysis (AF and Asset Analytics)
- Visualization with PI Clients and trigger in other systems
 - PI Coresight™, PI DataLink™
 - Opralog, SAP PM, DCS

- **Possible developments:**

- Integrated Advanced Analytics and Operational Intelligence
 - Data transfer from PI System® to analytical tools
 - Machine Learning model implementation with direct output to PI System®



Addressing Operational & Reliability Issue from the Processing of Opportunity Crude

COMPANY and GOAL

In its 2030 strategy, MOL Group is aiming **increased flexibility** and **quicker response** to market changes with a **crude basket of 50+ grades** to improve EBITDA.



CHALLENGE

Alternative crude processing brings benefits, but also risks and disturbances in process.

- Benefit with increased flexibility and discounted price
- Changing feed quality can cause disturbances in the process, new corrosion mechanisms, & asset performance/reliability issues

SOLUTION

Operational Intelligence, online analytical solutions, & advanced analytics to support faster decisions.

- PI System® supported workflow initiation and management
- Real time decision support tools
- Integrated system: investigation – online analysis - reaction

RESULTS

Ability to react faster, prevent or eliminate disturbances and keep the process stable with changing feed quality.

- Stable operation with changing crude quality
- Longer asset lifecycle
- **Strategic goal: 33 % seaborne crude by 2030**

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Questions

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



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谢谢

Danke

Merci

Gracias

Thank You

Köszönöm

ありがとう

Спасибо

Obrigado

“In God we trust; all others bring data.”

W. E. Deming