Oil and Gas

Real-Time On Line Modeling of Upstream O&G Assets

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Authors:

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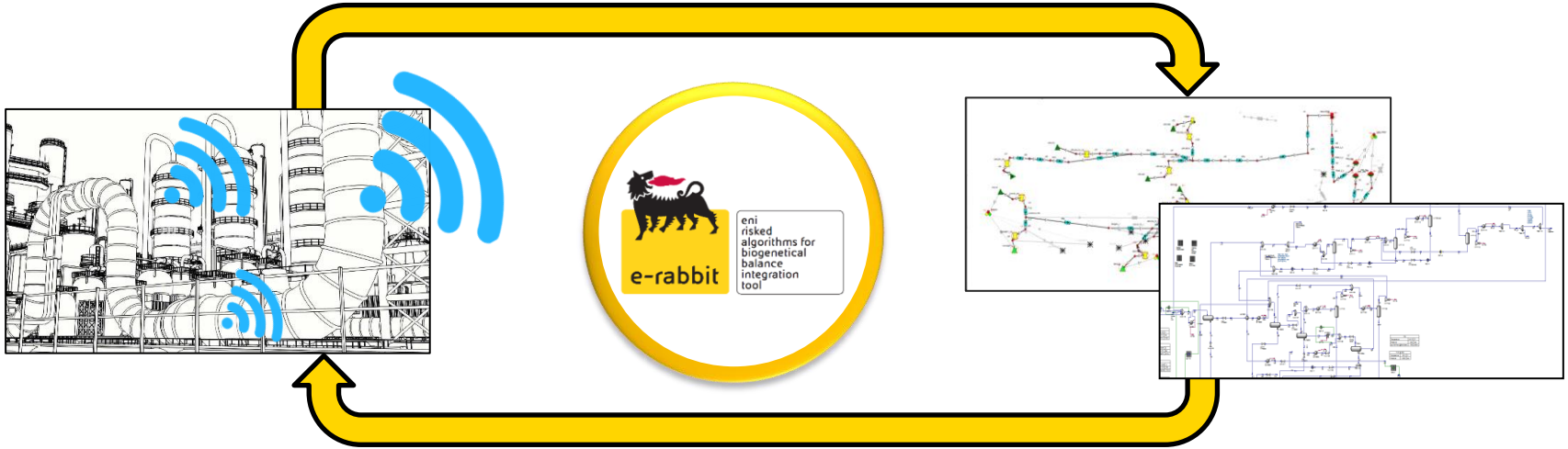
AGENDA

- **Project Scope**
- Integrated Production Optimization
- PI Connection: eDOF
- Pi Connection: Architecture
- Field Application
- Conclusions & Further Developments

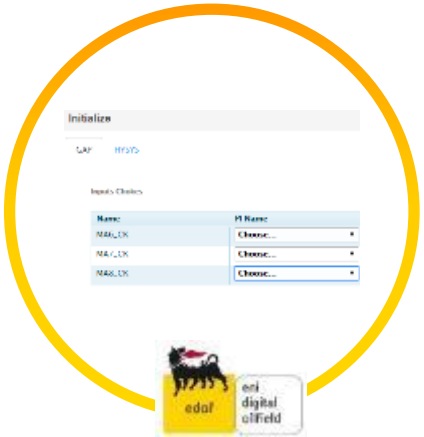
Project Scope

Build integrated production system models **fed by real-time data** and **able to:**

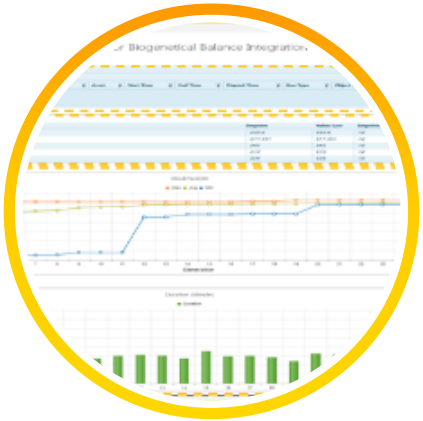
- **represent field operating conditions**
- **monitor & optimize asset performances**



Project Scope – Main Continuous and Real-time Features



1. Monitoring



2. Optimization

3. Updated Models

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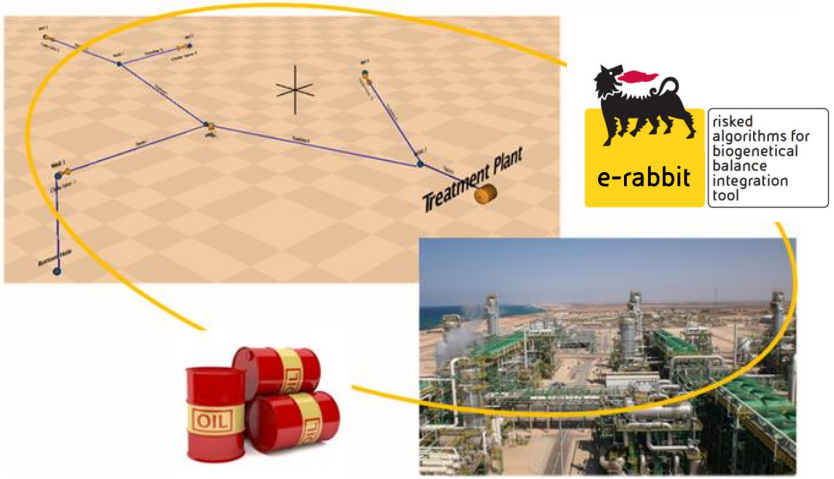
Integrated Production Optimization

- **Primary objectives are:**
  - Maximise asset value defining best configuration and optimising operating parameters
  - Identify residual potential and bottlenecks
  - Minimise intervention time and costs
  - Minimise/avoid shutdowns
  - Minimise structural interventions
- **Focus on Production Facilities: from wells to sales point:**
  - Reservoir
  - Gathering Network
  - Wells
  - Treatment Plant

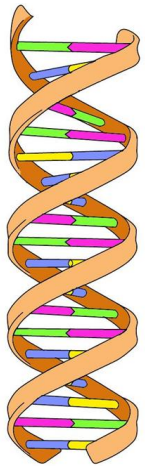
Integrated Production Optimization – e-rabbit

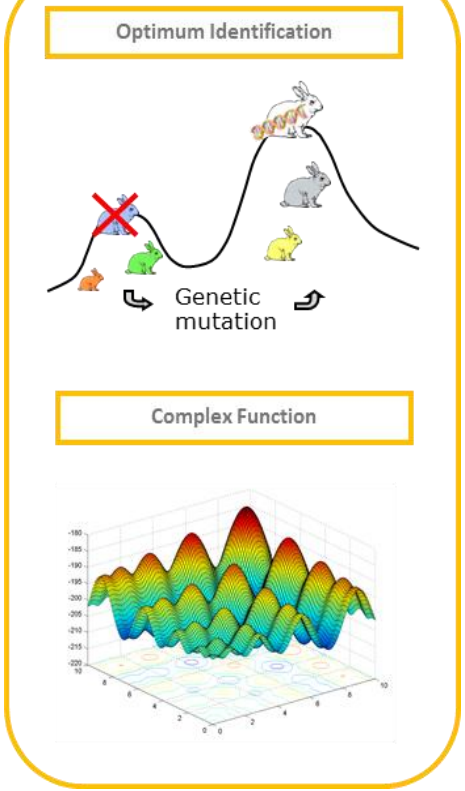
e-rabbit is the in-house developed optimization tool for a multi-objective fitness function:

- Equity production from wells to stock tank and Operating conditions;
- Consumptions, emissions, energy efficiency and operating costs;



e-rabbit: risked algorithms for biogenetical balance integration tool

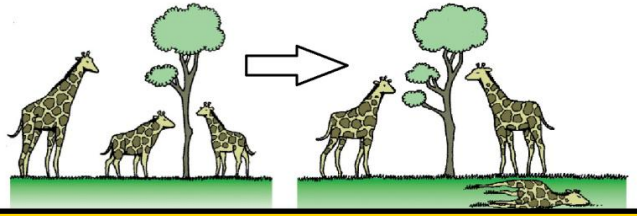




Global maximum identified through the use of an evolutionary algorithm

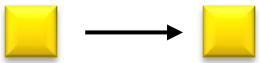
Integrated Production Optimization – e-rabbit genetic evolution

Method for solving optimization problems that is based on natural selection: the process that drives biological evolution.

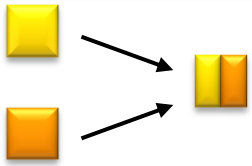


Individuals from the current population are used to produce children for the next one:

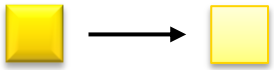
Elite children



Crossover children



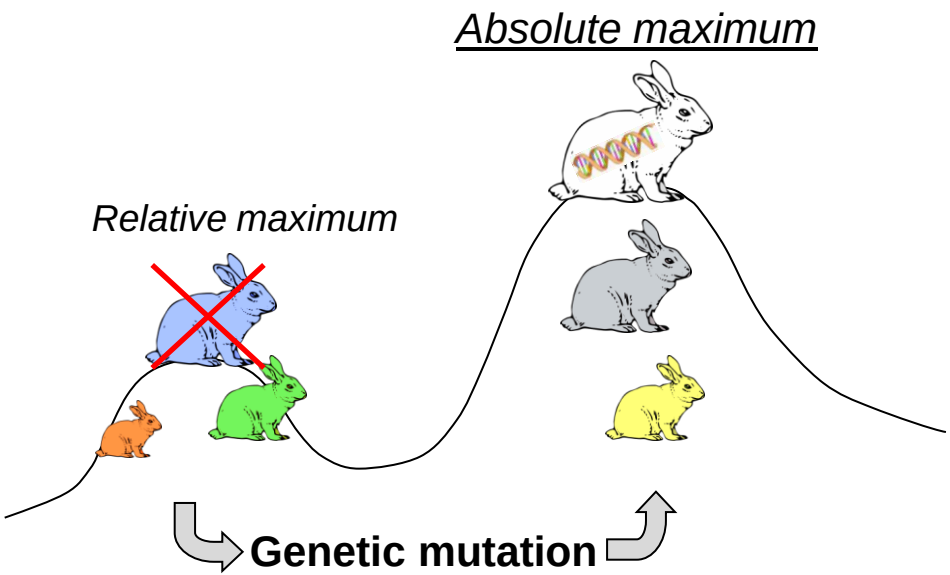
Mutation children



Over successive generations, **the population "evolves" toward an optimal solution**.

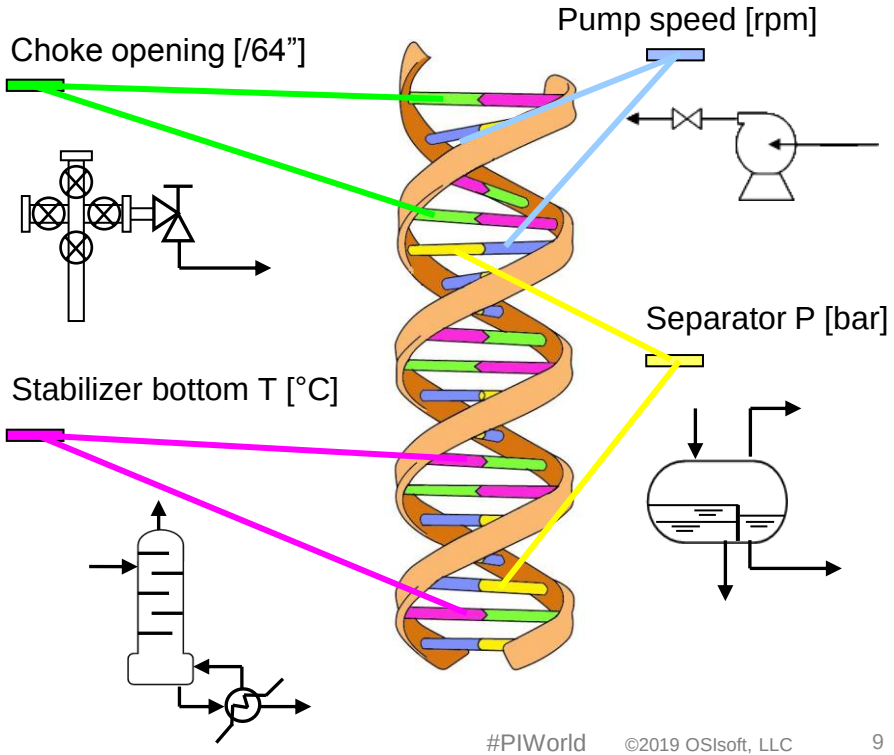
Integrated Production Optimization – Algorithm

e-rabbit: overcoming relative maximum

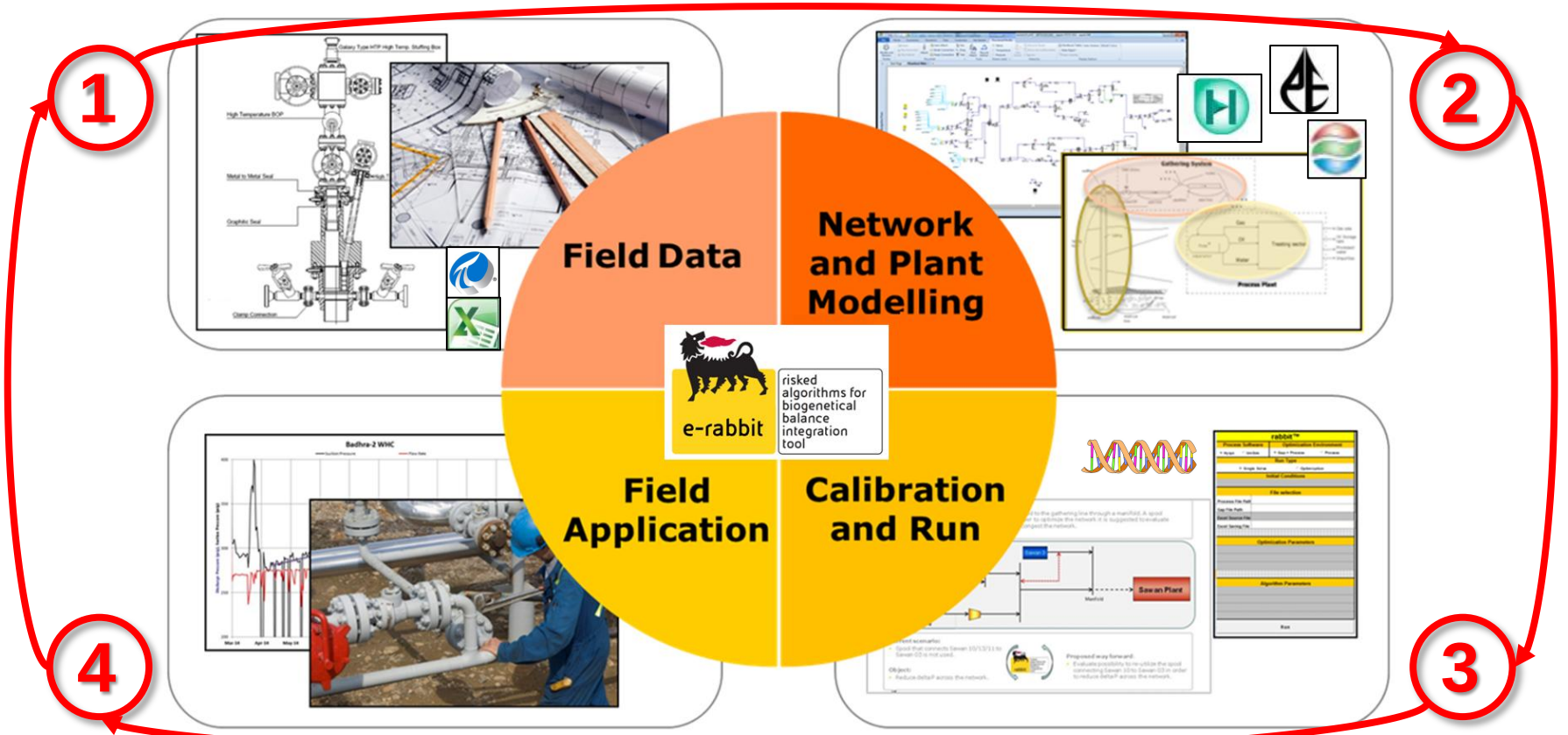


97% of probability success to achieve global maximum

e-rabbit: operating variable example



Integrated Production Optimization – Standard Workflow



Integrated Production Optimization – Field Data

Standard

- **Data Gathering from BU:**
  - Activity on demand. Discontinuous data availability
- **Site survey:**
  - Necessary information is collected through dedicated visits to the plant and meetings with the operator

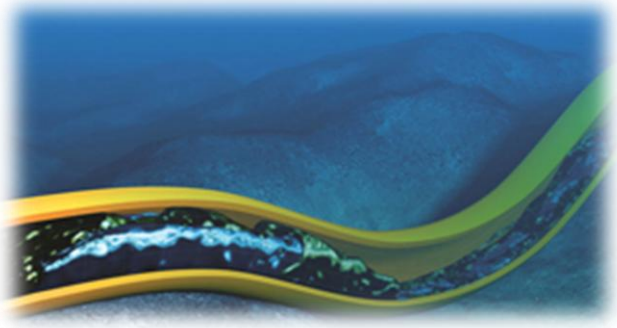
New development

- **Real time monitoring - Digital Oil Field**
  - Field data are available to the HQ in real time, through PI
  - Potential to extend the study to available historical data, identifying trends and recurring events, trough PI AF

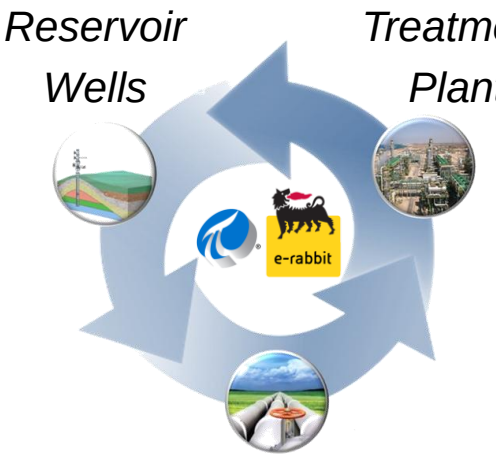
Integrated Production Optimization – Simulations models

Integrated simulation

Wells/Network simulation



- *Tools: GAP, OLGA, Eclipse*
- *Wells and Flowlines configuration*
- *Flow assurance*



Able to capture interaction phenomena among all the asset elements

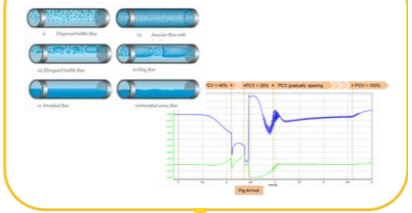
Process simulation

- *Tools: Hysys (Dynamics)*
- *Treatment plant configuration*
- *Equipment optimal parameters*

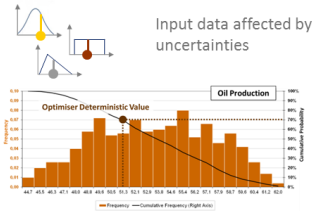
Integrated Production Optimization – e-rabbit historical development

Rabbit Definition 2011

Fluid-Dynamic Approach

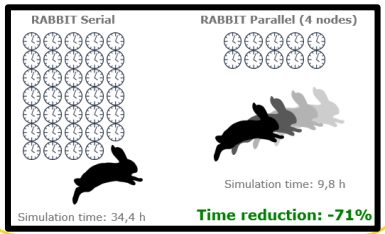


Uncertainty Management



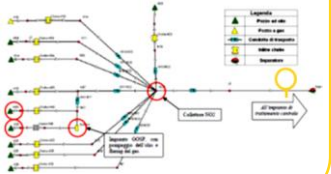
WHC: Ariel Integration

Rabbit Parallel Simulation

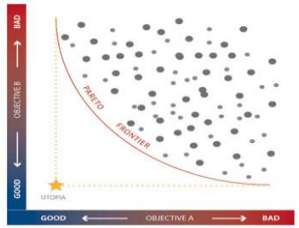


Rabbit Enterprise On-line Portal 2015

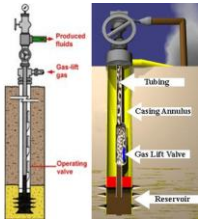
Pipeline switch & swing-wells control



Multi-objective Target Function



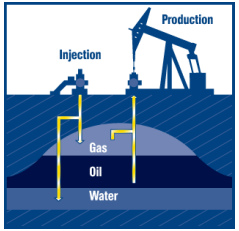
Gas lift



Integrated Production Optimization – e-rabbit historical development

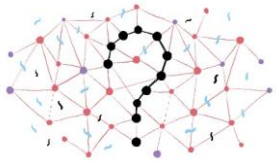
On-line models & Scheduled Simulation

Gas/Water injection

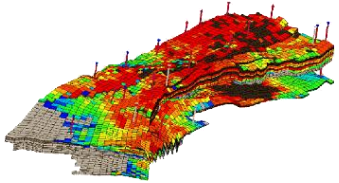


Rabbit Dynamic

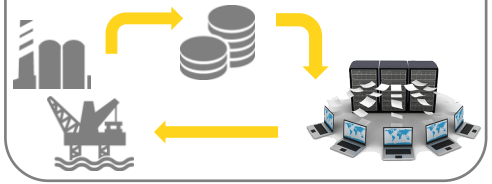
Exploration of new Optimization Algorithms



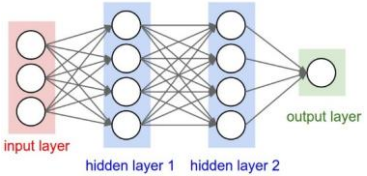
Reservoir integration



Auto-Calibration of model with real-time data



Speed-up with proxy models



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- **PI Connection: eDOF**
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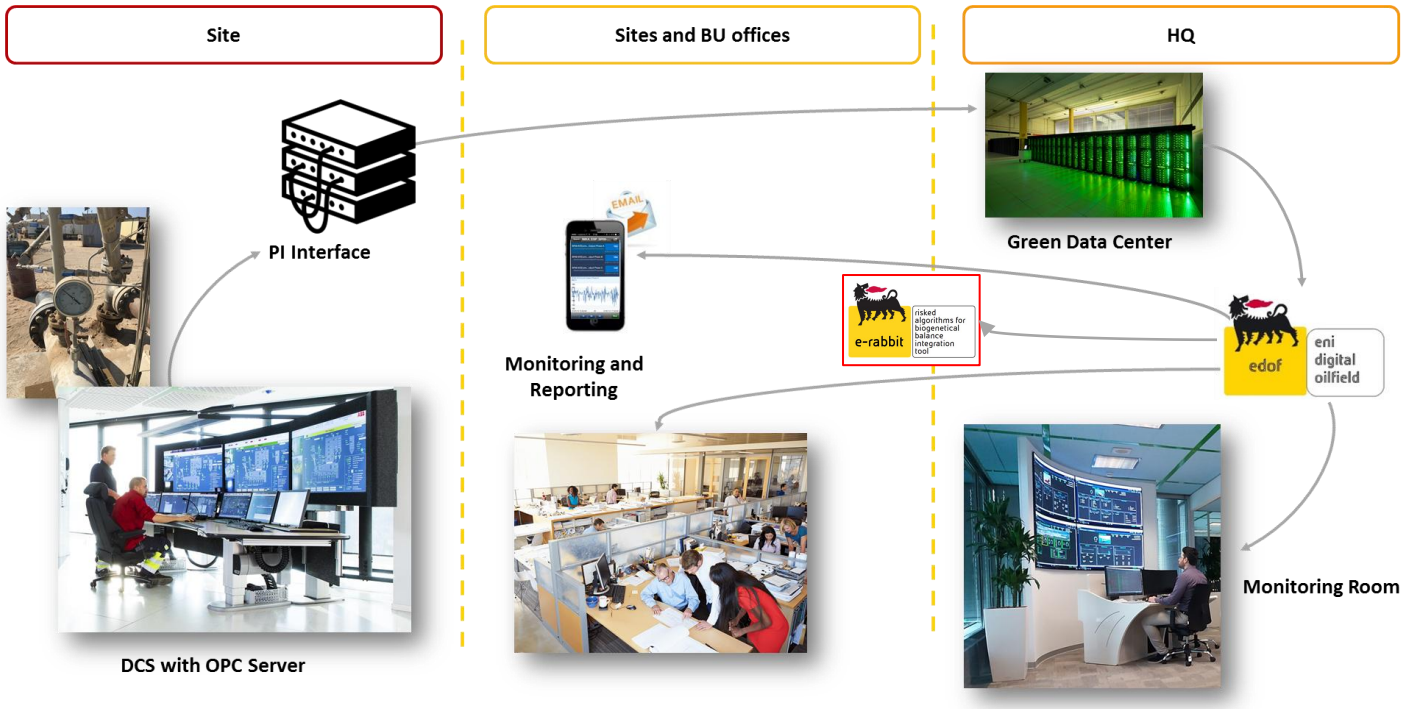
PI Connection – eDOF

- *Mature technology adopted by O&G Industry various names: Smart Fields®, Field of the Future®, i-Field®, Intelligent Field or Integrated Operations;*
- *Based on high frequency data acquired automatically in real time, integrated with lower frequency data (daily, monthly…), results of modelling and simulation and manually collected data to support better decision making processes;*

Eni standard configuration is named eDOF:

- based on configuration of state-of-the art off-the-shelf components
- design, implementation and deployment activities are performed by **Eni people**, both from IT and business disciplines, incorporating Eni Intellectual Property.
- eDOF is actually acquiring/calculating $350*10^6$ values every day, with an average frequency of 20 sec.

PI Connection – Standard eDOF infrastructure

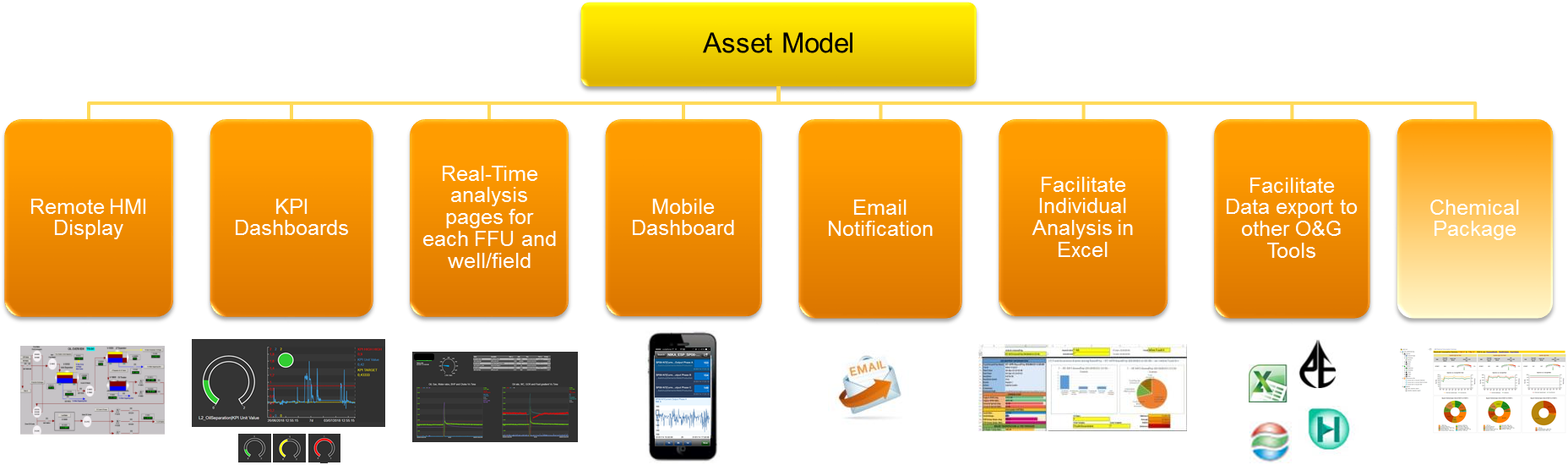


Data from the asset are historicized at HQ Green Data Center

Development of the system from HQ in tight collaboration with BU engineers

Full support from Eni HQ

PI Connection – eDOF



PI Connection – KPIs

DATA INFRASTRUCTURE

More than 5’000 raw data per asset per second stored in different TAGs

- Pressure
- Temp.
- Level
- Flowrate
- …

KPI DEFINITION

Raw data are elaborated in KPI through application of international standard

- API
- GPSA
- Best practice
- Standards

$$KPI_{vibration} = \frac{\rho v^2}{\rho v^2\ specific}$$

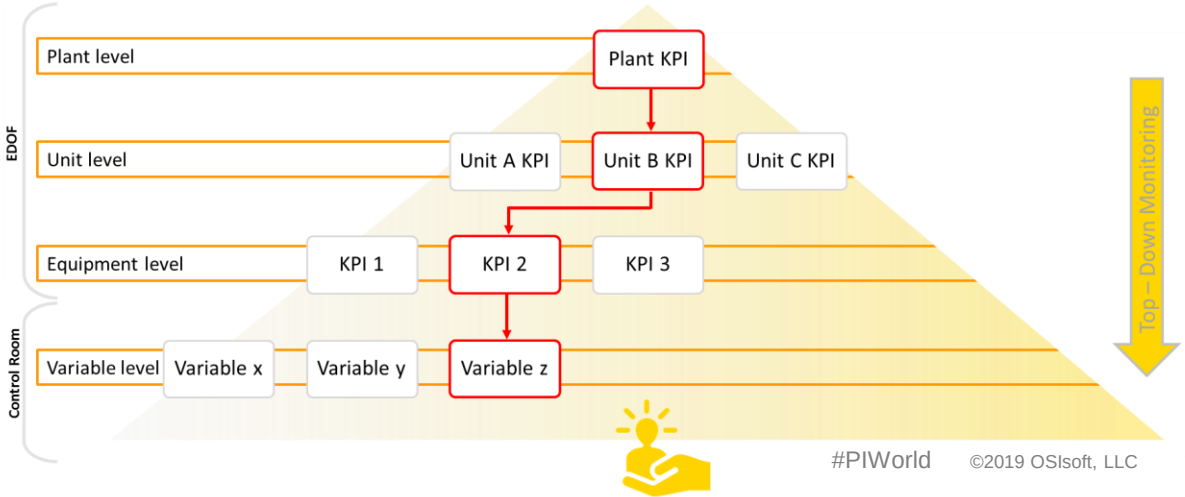
KPI MONITORING

KPI Implementation and Monitoring (around 100 KPI per asset)

PI Connection – KPIs top/down logic

- *Overall asset monitoring*
- *Fast identification of deviation from normal operation/design*
- *Notification/alert to dedicated person with suggestion to address the issue*
- *User defined dashboard*
- *Fast troubleshooting*

- *Focus on monitoring the entire asset or the digital twin*
- *KPI system with Top-Down logic (from asset to single equipment)*



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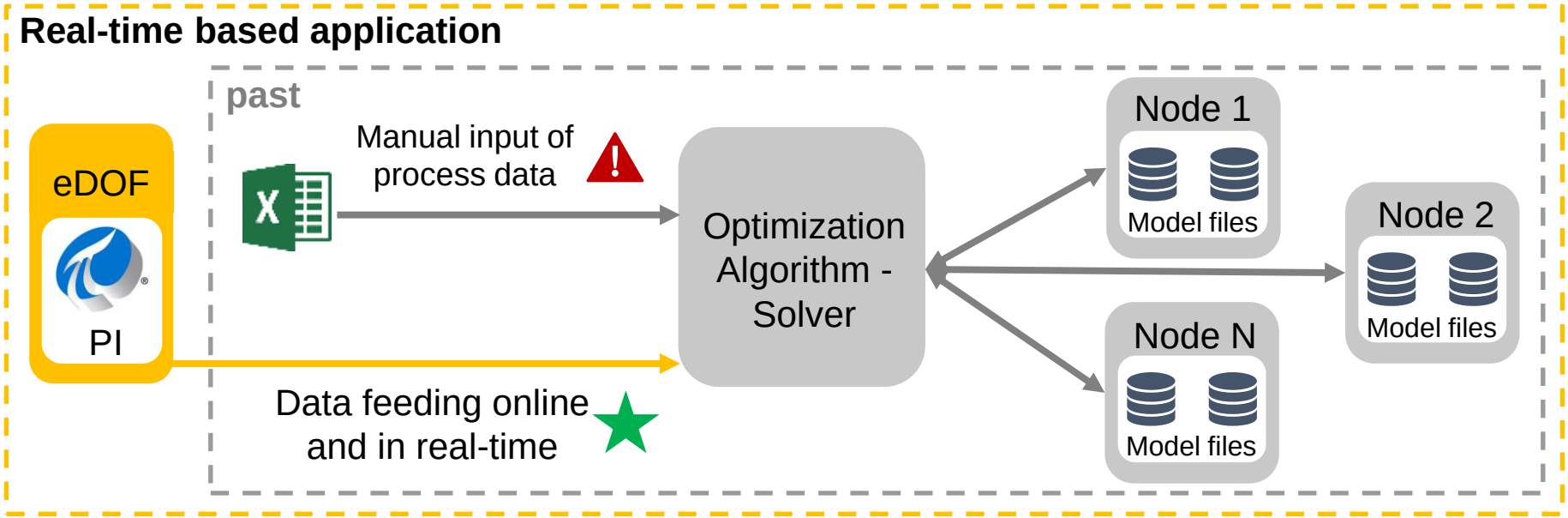
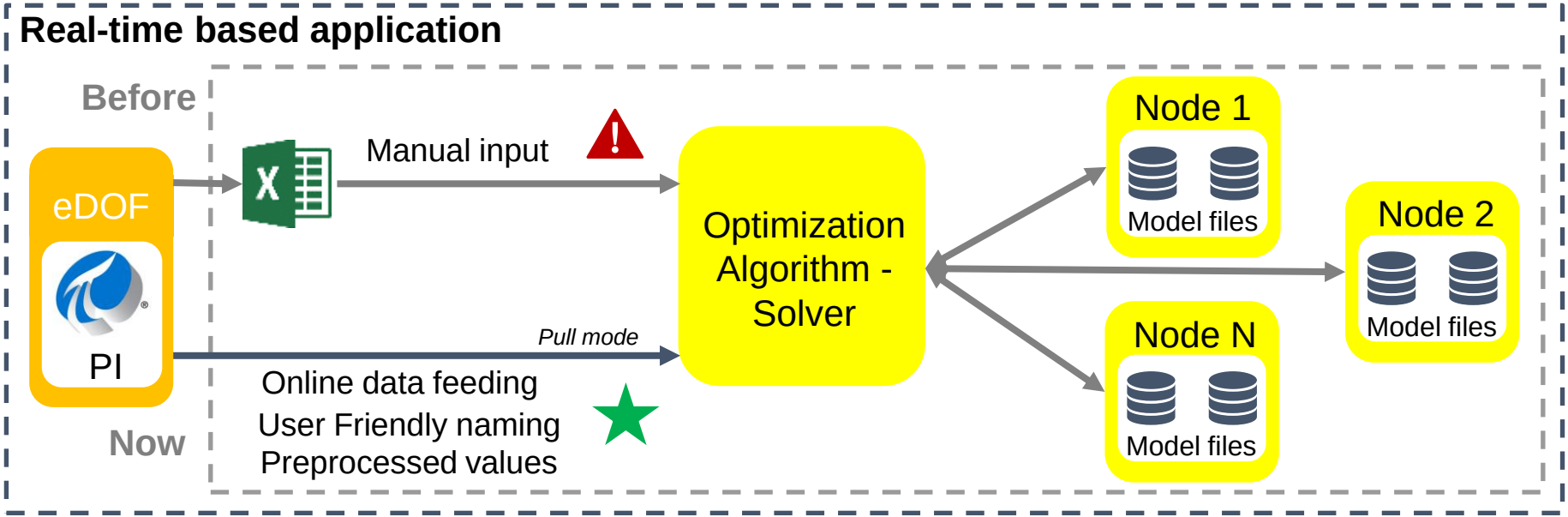
PI Connection – Architecture General Overview



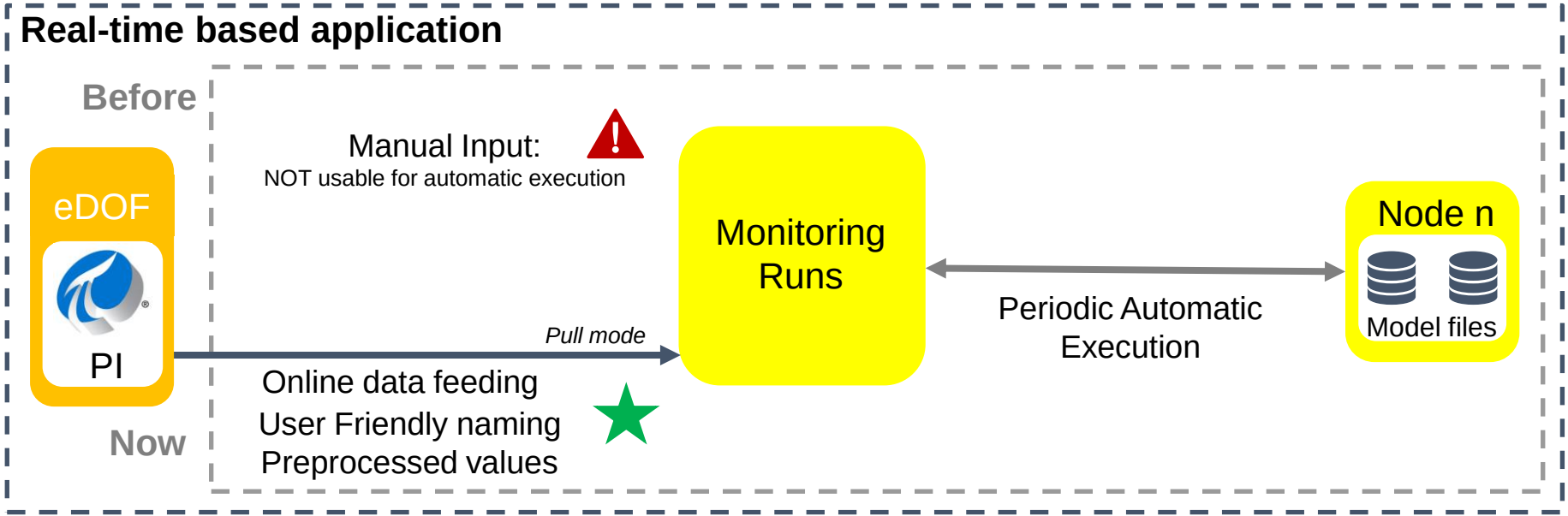
The new solution** ensures data feeding in real-time and **lets to use Rabbit for on-line monitoring and optimization via a user-friendly dashboard

PI Connection – eDOF to e-rabbit Optimization mode



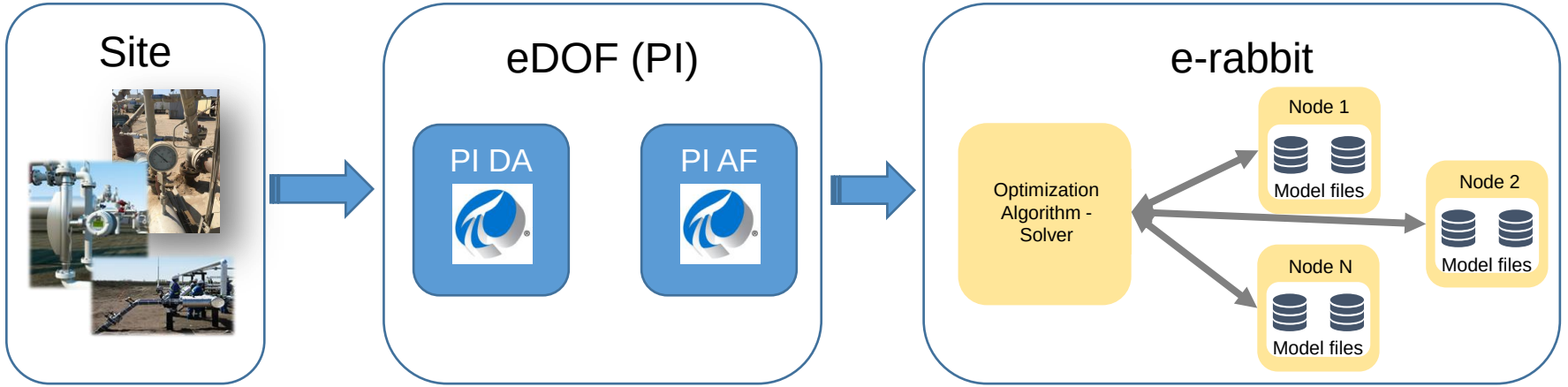
New real-time connection from eDOF to Rabbit
Enabler for Rabbit on-line Optimization and Monitoring

PI Connection – eDOF to e-rabbit Monitoring mode



New real-time connection from eDOF to Rabbit
Enabler for Rabbit on-line Optimization and Monitoring

PI Connection – User Friendly Naming for e-Rabbit



Tags

881_MFPM_101_FO_031
881_U12_105_DPA_031
881_U12_114_CVP

Organized by Country & Site

AF Elements

well01.OilFlowRate
well05.FLP
wellE2.CvEqOp

Physical Variables

Well 01 Oil Flow Rate
Well 05 Flow Line Pressure
Well E2 Choke Equivalent Opening

Preprocessed Values

PI Connection – Preprocessing for e-Rabbit

PI AF Analyses

Periodic execution (5m)

Raw Value

Checking for:
- Bad Value
- Spikes (low and high limits)
- Stales (standard deviation)
- Minimum Good Values (percentage)

Filtered Value and **Status** Value

As configured:
- Noise reduction (moving average)
- UoM conversion
- Value Mapping (linear interpolation)

toRabbit Value

PI Connection – Central Architecture

- **High Availability Architecture**
  centred on a couple of servers for each of the 4 main components
  - ✓ 2 servers for PI Data Archive (PI Collective)
  - ✓ 2 servers for PI Asset Framework (load balanced)
  - ✓ 2 servers for PI Vision (load balanced)
  - ✓ 2 servers for MS SQL (Always-On)

- Hosted inside **Eni GDC (Green Data Center)** in Northern Italy
  - ➢ 2 completely separated and independent buildings
  - ➢ 3 Data Rooms for each Building

- For each HA couple, the servers are located in a different GDC buildings

More details in Gothenburg
PI World EMEA…?!

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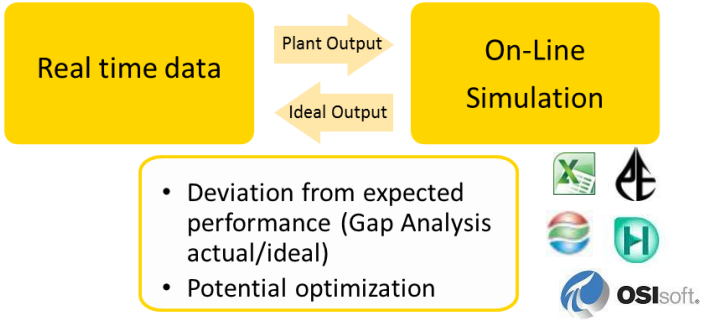
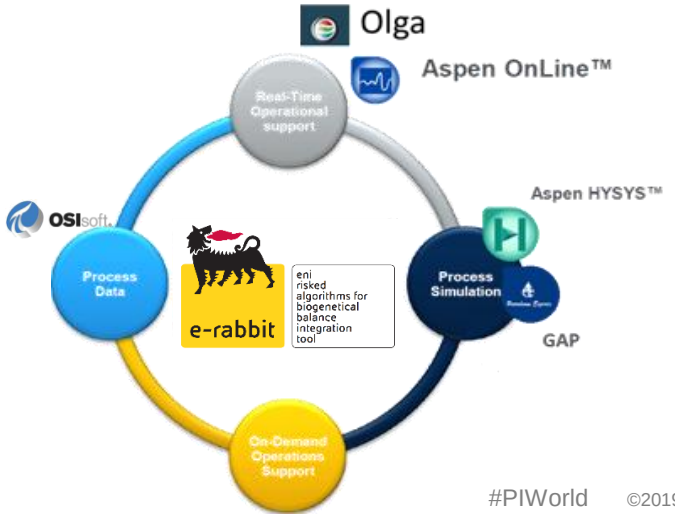
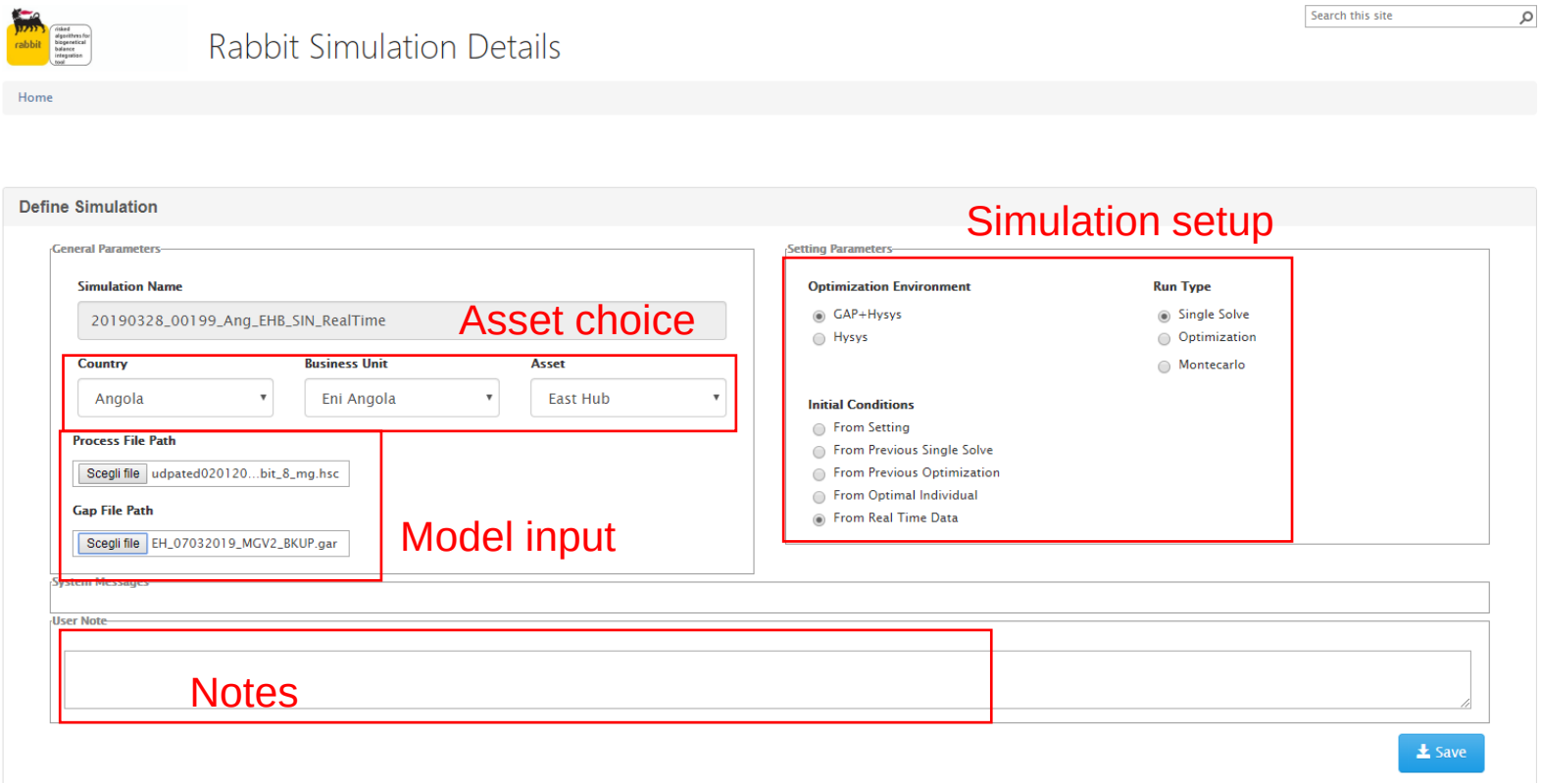
Field Application – Operating Advantages of Near Online Models

- *Integrated asset optimization*
- *Availability of simulation model up to date:*
  - *Link of real time data to simulation models*
  - *Data reconciliation*
- *Scheduling of Network and process simulation*
- *Identify deviation from expected behavior*

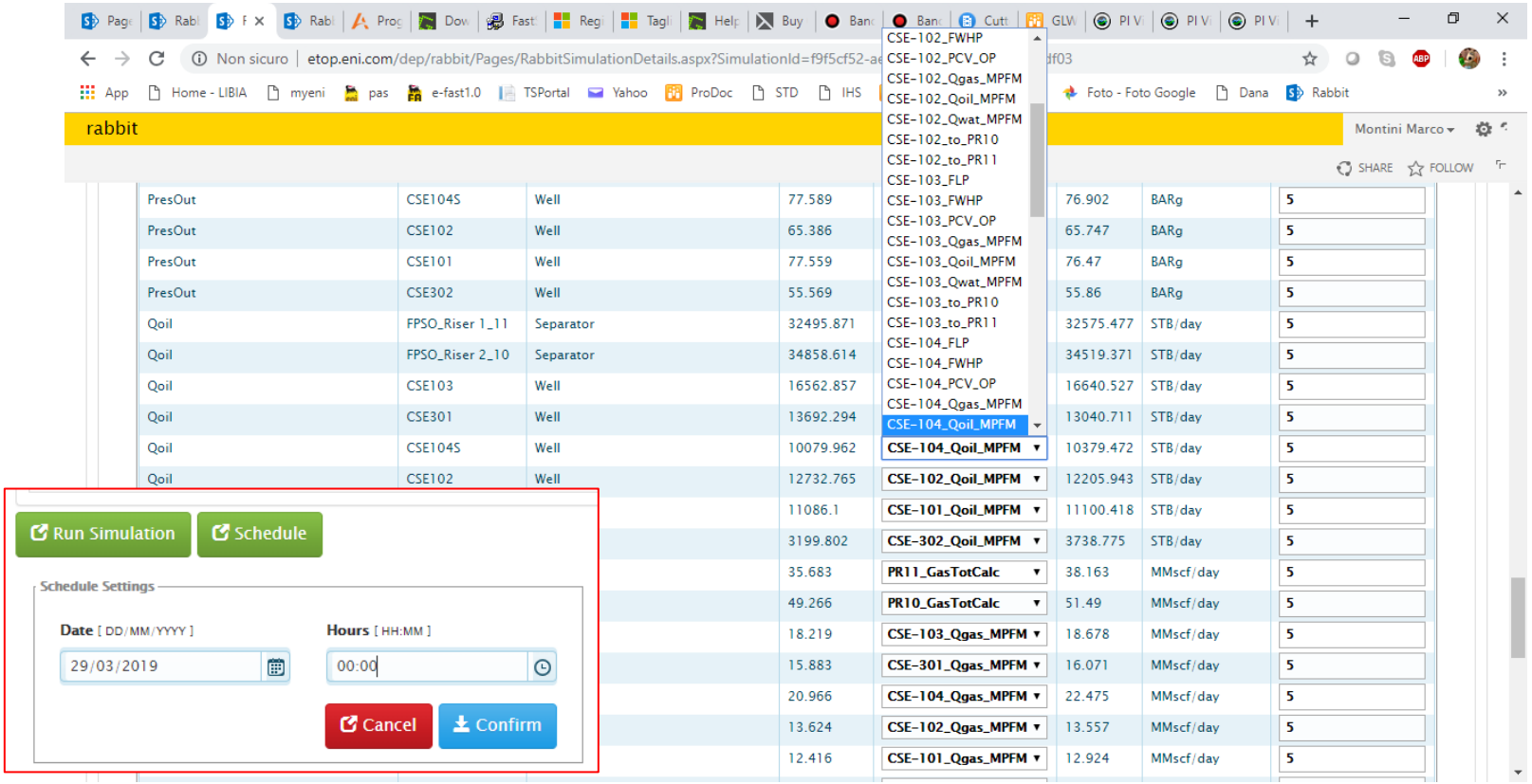




Field Application – Simulation Set up



Field Application – Mapping of AF elements with GAP input



Field Application – Output Comparison for Monitoring and Tuning

GAP sim. output

AF element value

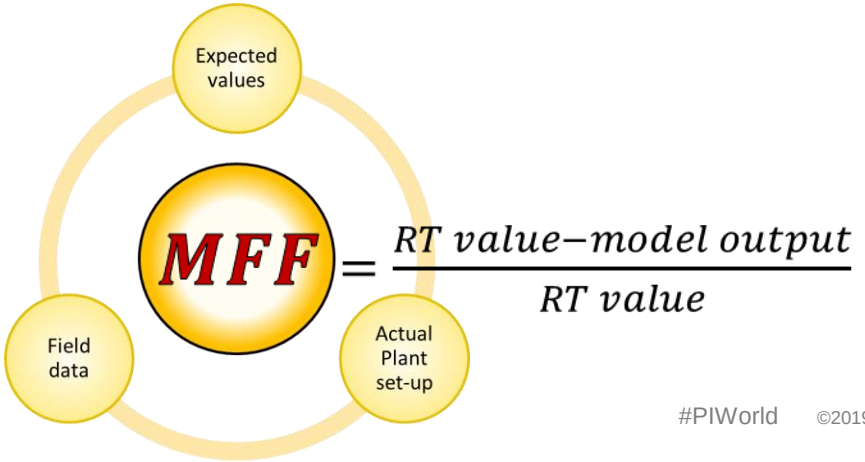
Threshold definition

Comparison

Drag a column header and drop it here to group by that column

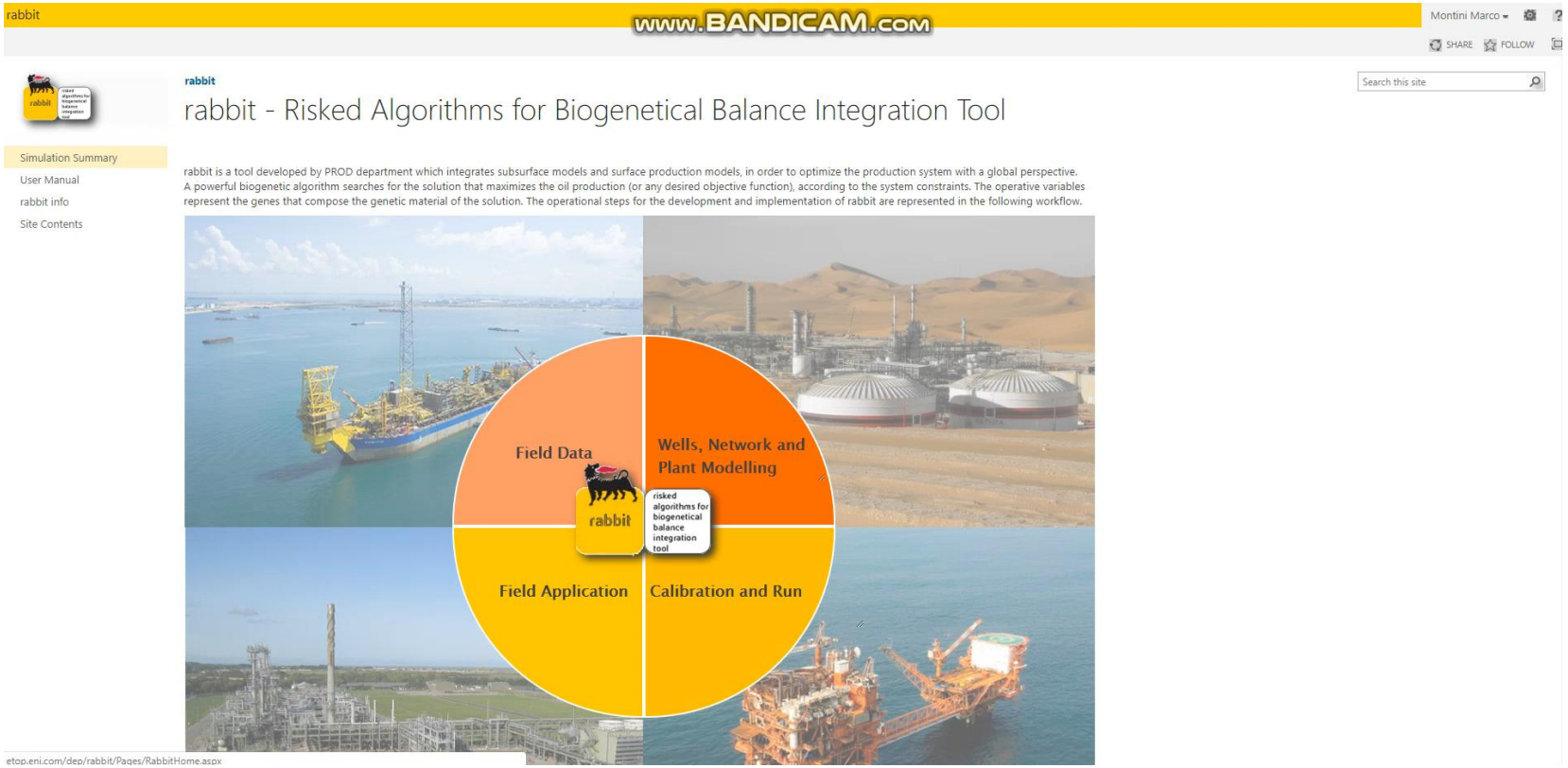
Section	Object	Element	Name	Value	PI Name	PI Value	Uom	Threshold	Data Comparison
HYSYS			StockTankOil	228,931,171.4...				%	
GAP	Well	CSE103	HCMassRate	112,435.448			Kg/hr	%	
GAP	Well	CSE103	FWHP	72.092	CSE-103_FWHP	71.998	BARg	5 %	
GAP	Well	CSE103	PresOut	66.111	CSE-103_FLP	66.144	BARg	5 %	
GAP	Well	CSE103	Qgas	18.129	CSE-103_Qgas_MPFM	18.683	MMscf/day	5 %	
GAP	Well	CSE103	Qoil	16,480.463	CSE-103_Qoil_MPFM	16,644.354	STB/day	5 %	
GAP	Well	CSE103	Qwat	132.907	CSE-103_Qwat_MPFM	130.769	STB/day	5 %	

Similarly to the KPI structure, we need to define a ***new*** indicator that relates field data quality and model outputs with the real plant operating configuration



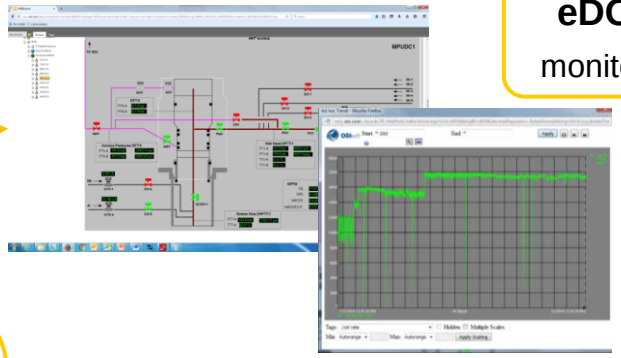
$$MFF = \frac{RT\ value - model\ output}{RT\ value}$$

Field Application – Operating Workflow VIDEO



Operating Workflow – Results Examples

eDOF/PDMS
monitoring system



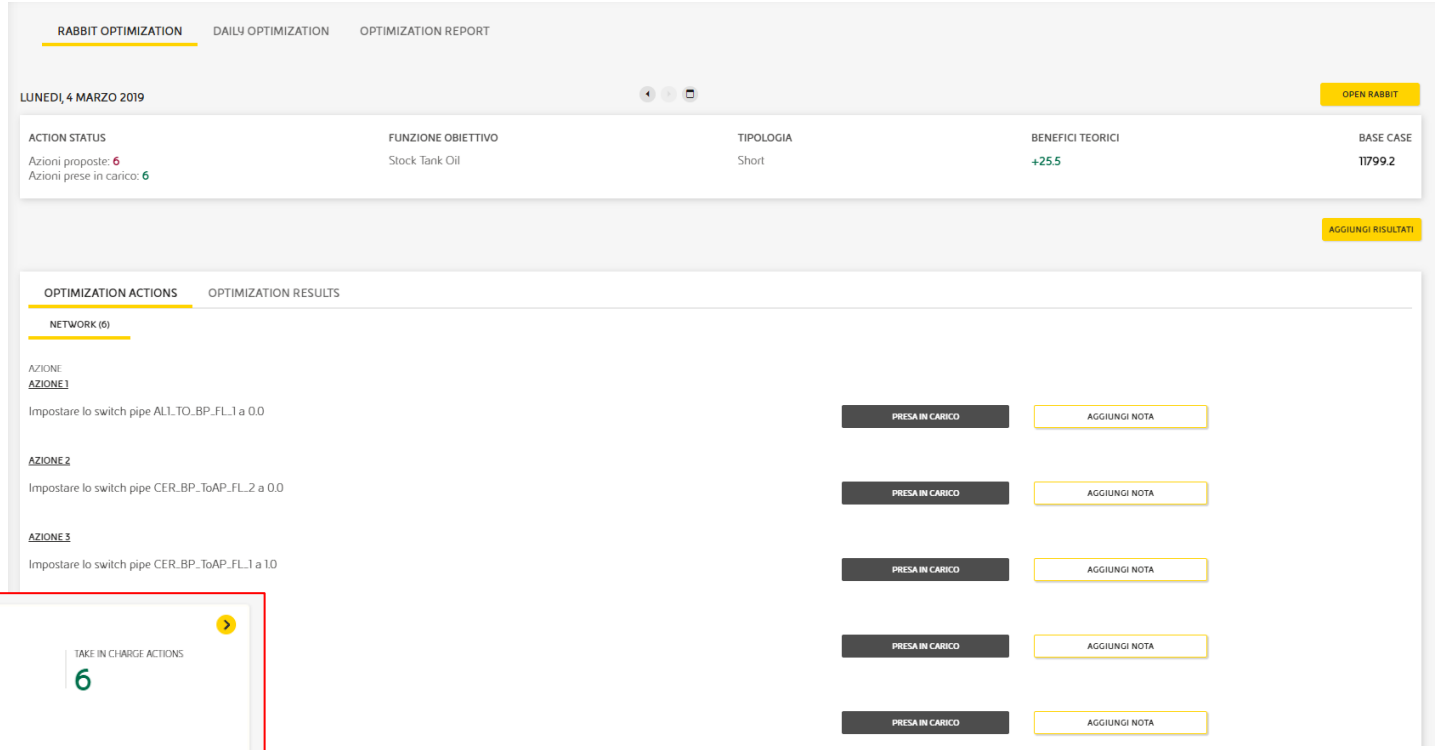
Surface & Subsurface Sensors

- Downhole P&T
- Well Head P&T
- Multiphase flow meter & ASD
- Prod. Network P&T
- Topside process (manifold, separator, compressors)

+60% oil rate

Production Optimization
(Choke up, gas lift, debottlenecking)

Operating Workflow – User Friendly Interface/Collaborative Environment



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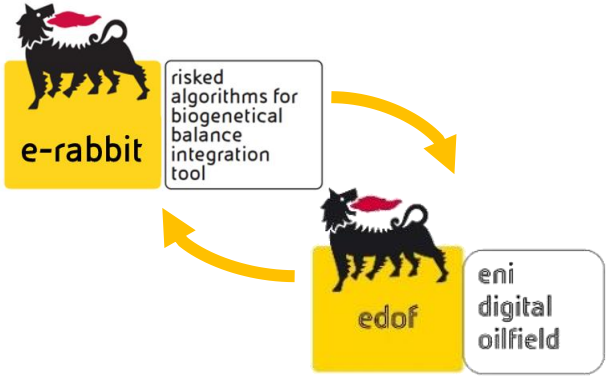
ENI

Real-Time On Line Modeling of Upstream O&G Assets

The project has been developed with a team of integrated professionals: HQ Process Engineers, ICT Specialists and Site Engineers. The final framework has been implemented on Eni 4.0 Assets (Digital Lighthouse Project)



CHALLENGE

Lack of updated simulation models for:

- **Diagnosis/Monitoring** of (manifest or possible) production system
- **Design / verification of particular production modes**, often temporary/transient
- **Check of operating procedures** for special conditions
- **Debottlenecking and production optimization** new field operating conditions/constraints

SOLUTION

Near on-line digital twin based on advanced algorithm (e-rabbit, KPIs), simulators and PI (eDOF) system

- **PI tools:** PI AF, PI DA
- **Simulators:** GAP/Prosper, Hysys
- **Orchestrator:** e-rabbit
- **Test Field:** on-shore south Europe, off-shore West-Africa
- **Potential application:** asset served by eDOF (PI based system)

RESULTS

Real-time monitoring of the assets through simulated results based on real-time data and Updated model for scheduled Asset optimization

- Significant **reduction of time** during model updating process (**2-3 working days**)
- Early and continues support to **detect issues**, **bottlenecks** and **optimization** opportunities
- **Licenses optimization** and model tuning standardization
- Support to daily and long term **asset management**

Conclusions – Central & Local Sites

eDOF app

e-rabbit app

Green Data Center

Centralized system, collecting worldwide data from near to 40 different local data sources

Thank you for the attention

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Thank You!!

PI Connection – KPIs scope and architecture

$$KPI\ Separation\ unit = (f1\ Dp\ H2O\ 1°st + f2\ Dp\ H2O\ 2°\ st) * \mathrm{P1°st} * \mathrm{P2°st}$$

KPI:

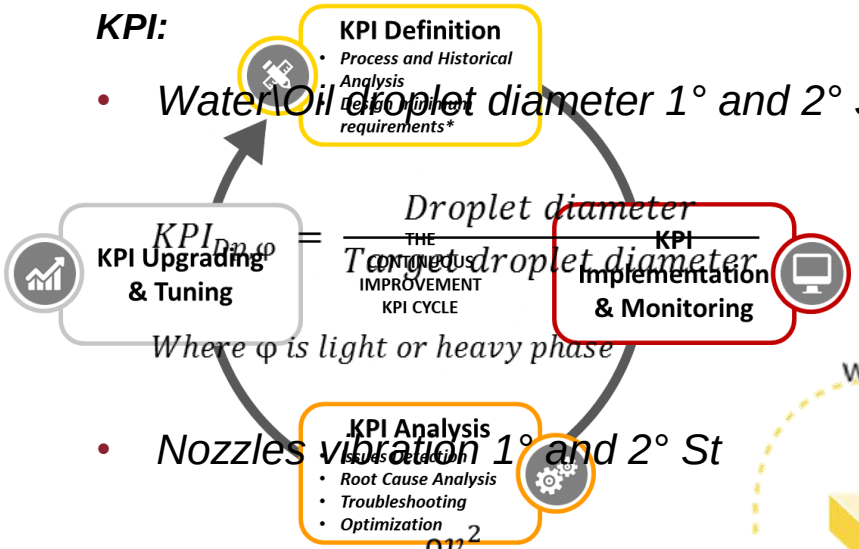
- *Water\Oil droplet diameter 1° and 2° St*

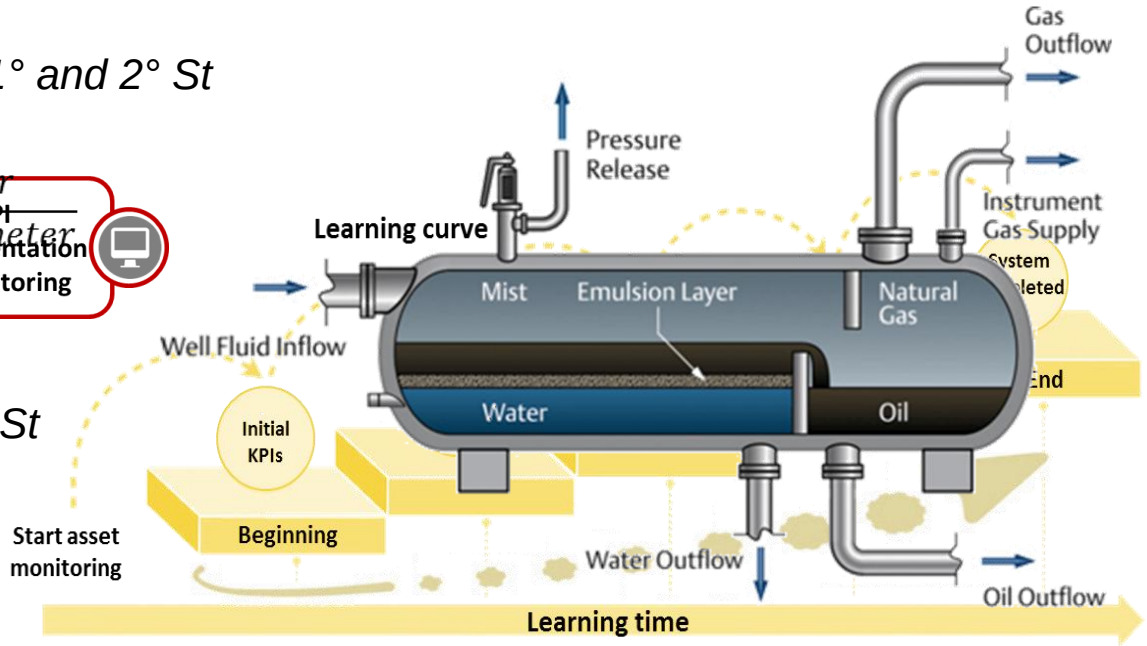
$$KPI_{Dp\,\varphi} = \frac{Droplet\ diameter}{Target\ droplet\ diameter}$$

Where φ is light or heavy phase

- *Nozzles vibration 1° and 2° St*

$$KPI_{nozzle} = \frac{\rho v^2}{\rho v^2\ specific}$$





Questions?

Please wait for the **microphone**

State your **name & company**

Please remember