

Intelligent Pattern Operation based on Big Data Analytics

- Intelligent Manufacturing Applications on PI Platform

Dex. Sun

Director, Process Solutions, ChemChina Ltd.

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- ◆ Background

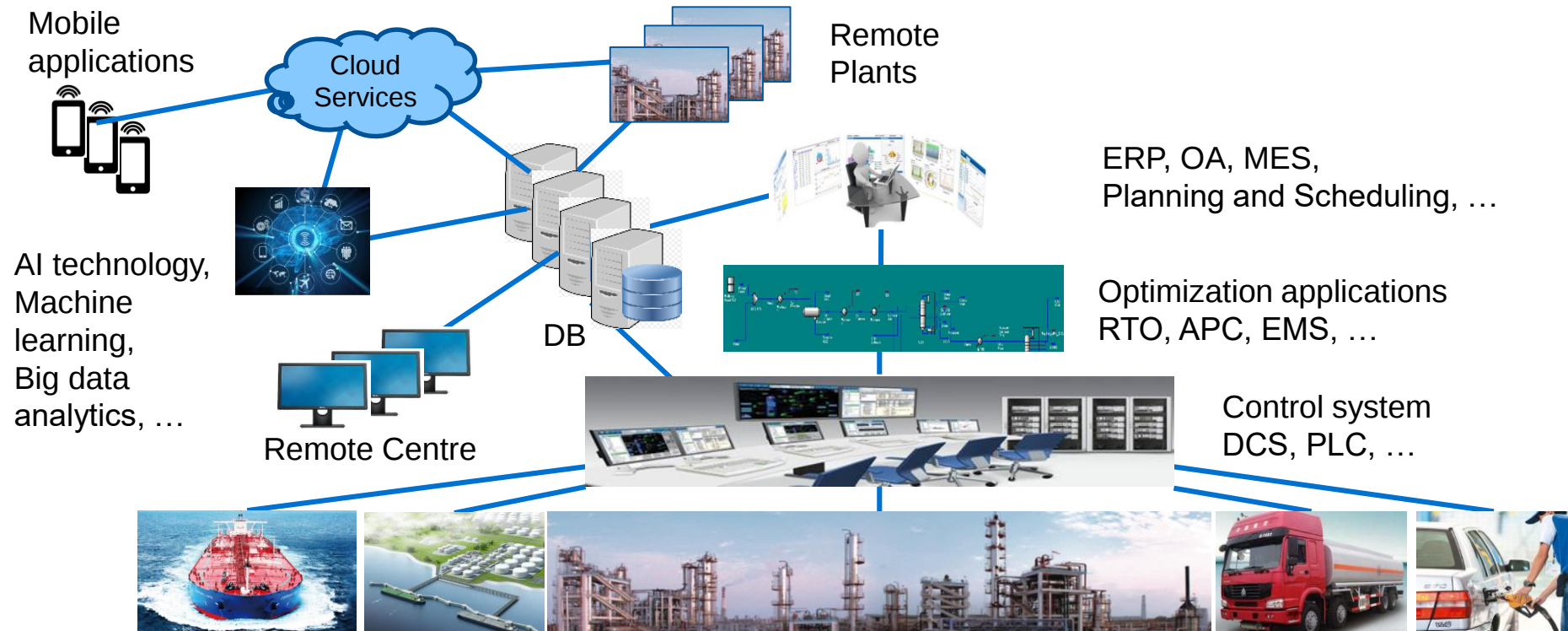
- ◆ Pattern Operation Application

- ◆ Best Practice



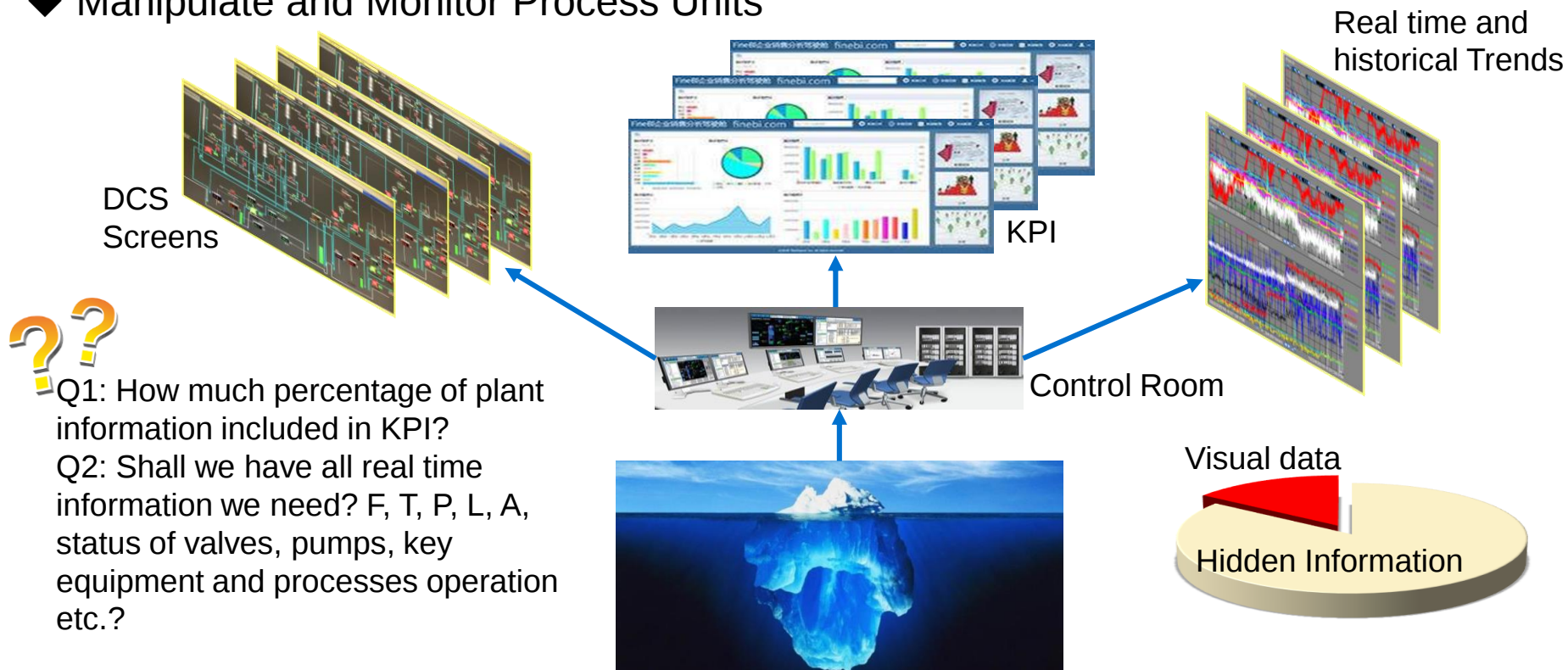
Background

◆ Typical Operation of Petrochemical Processes



Background

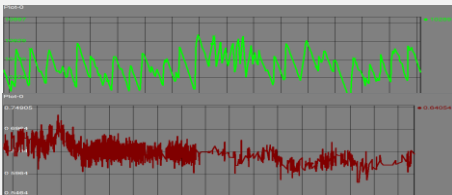
◆ Manipulate and Monitor Process Units



Background

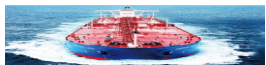
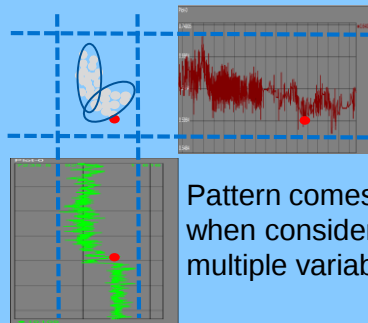
◆ Pattern Operation

Parametric Control Mode



- Single PV
- Multiple PVs
- Hundreds PVs , KPI and Status

Pattern Control Mode



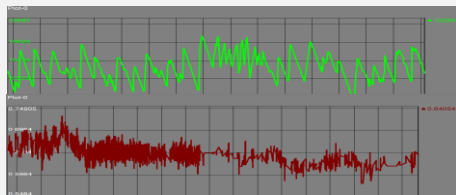
Background

◆ Pattern Operation

Parametric Control Mode



- Single PV

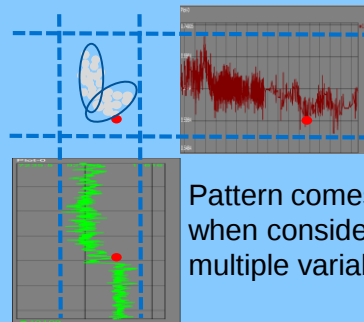


- Multiple PVs



- Hundreds PVs ,
KPI and Status

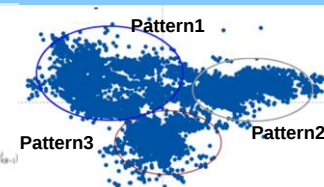
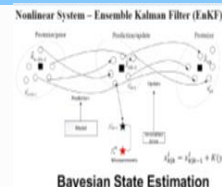
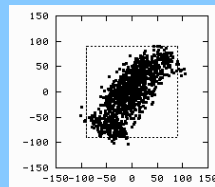
Pattern Control Mode



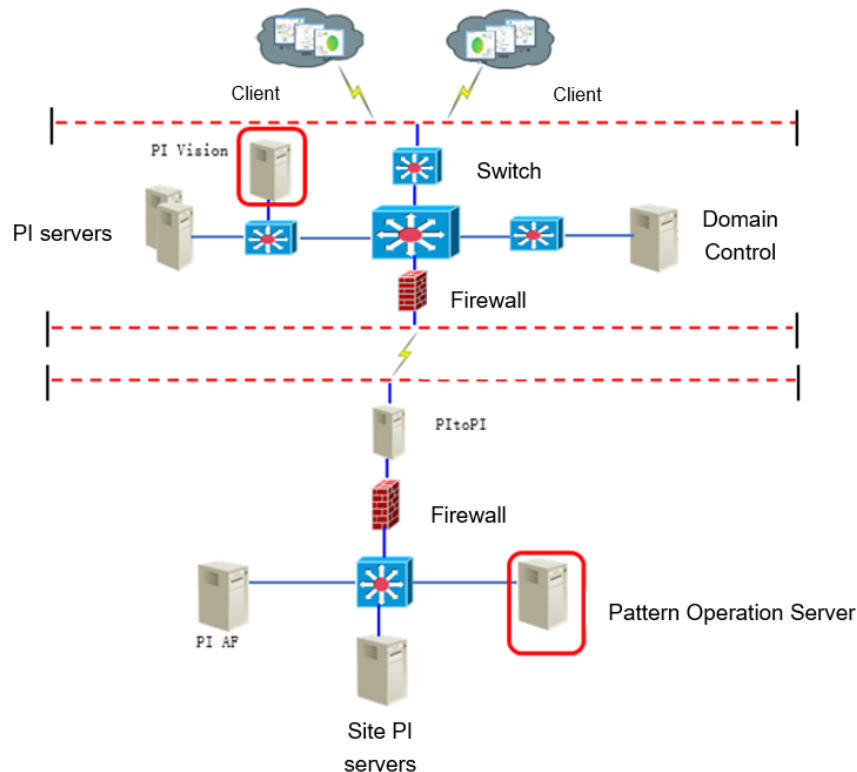
Pattern comes out
when considering
multiple variables.

Different Operation
Pattern:

- Normal/anomaly
- Stable operation
- Most efficient
- Maximum benefit
- Minimum energy
consumption
- Etc.



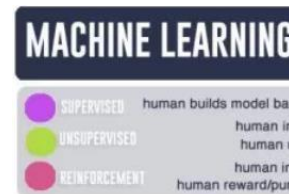
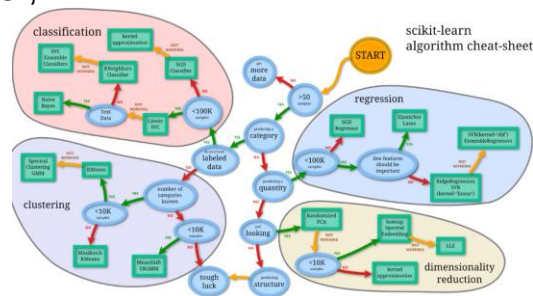
Pattern Operation System



- ◆ Pattern Operation – visualization operation performance and status monitoring system based on PI
- ◆ Pattern operation server accesses different type data from PI/LIMS, runs pattern models online and writes back results
- ◆ PI Vision server provides visualized interface and customized calculations
- ◆ PI AF supports additional calculations
- ◆ End users from management, engineering and operation browse PI Vision web pages to manage and monitor the plant

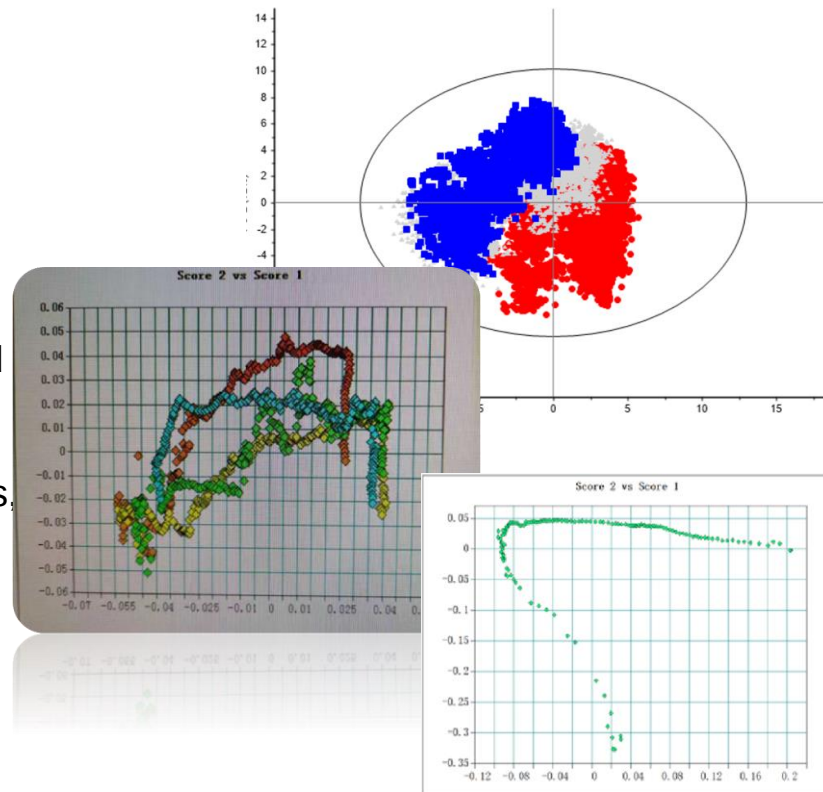
Pattern Operation System

- ◆ Pattern Operation – classify patterns from historian by applying big data analytics, statistic, ML, cluster, PCA, Bayesian, etc.
- ◆ Take advantage of ***sleeping data*** as much as possible
- ◆ Online assess operation status and level, device health performance every minute 24/7
- ◆ Rapid discovery and locate the causes of trouble in machine, devices and processes operation
- ◆ Early detect anomaly pattern and generate alert in advance (seconds, minutes, hours or days)



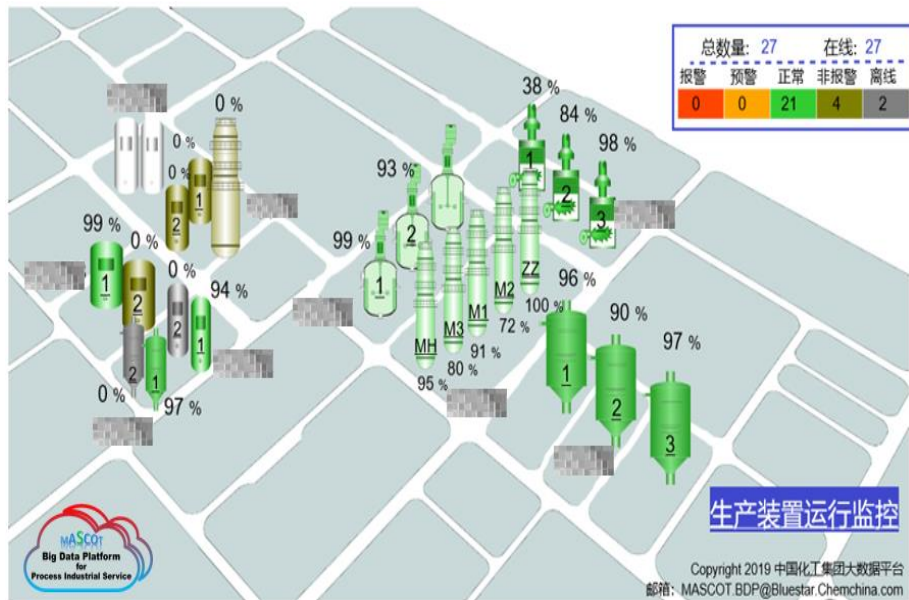
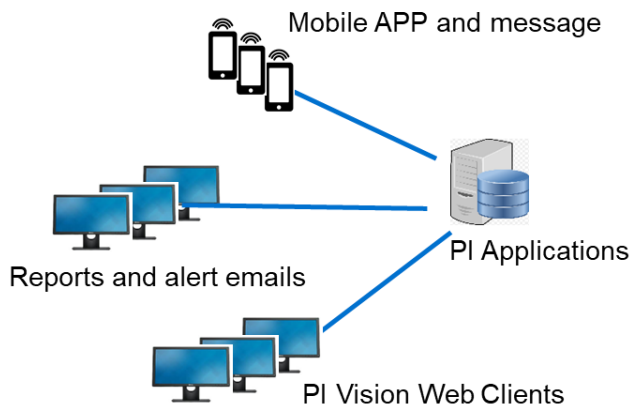
Pattern Operation System

- ◆ Online/offline provide possible solutions according to processes, root causes, operation plan and schedule
- ◆ Real time recognize operation pattern, provide operation guide by locking on optimum pattern
- ◆ Multi-layers model structure produces detailed and precision operation pattern
- ◆ Support multi-type data : classic process variables, spectrum data, lab data, commercial data etc.
- ◆ Pattern operation for both continuous and batch processes



Pattern Operation System

- ◆ Visualization operation
- ◆ Generate message and detail report email once alert detected



Best Practices

Over hundred applications of Pattern Operation in chemical and refining processes

Petrochemical Processes

- ◆ Synthesis reaction process
- ◆ Fractionating tower
- ◆ Hydrolysis process
- ◆ Cyclization process
- ◆ Air separation process
- ◆ Furnace
- ◆ Polymer reactor
- ◆ Dehydration process
- ◆ Suspension crystallization process
- ◆ Falling-film crystallization process (batch)
- ◆ Steam net
- ◆ Distillation column

Devices

- ◆ Heat exchanger
- ◆ Boiler
- ◆ Chiller
- ◆ Compressor



Others

- ◆ Plant commercial operation
- ◆ Plant environment safety

Best Practices - Pattern Operation Application in chemical plant

Plant layer



Unit layer



Device layer

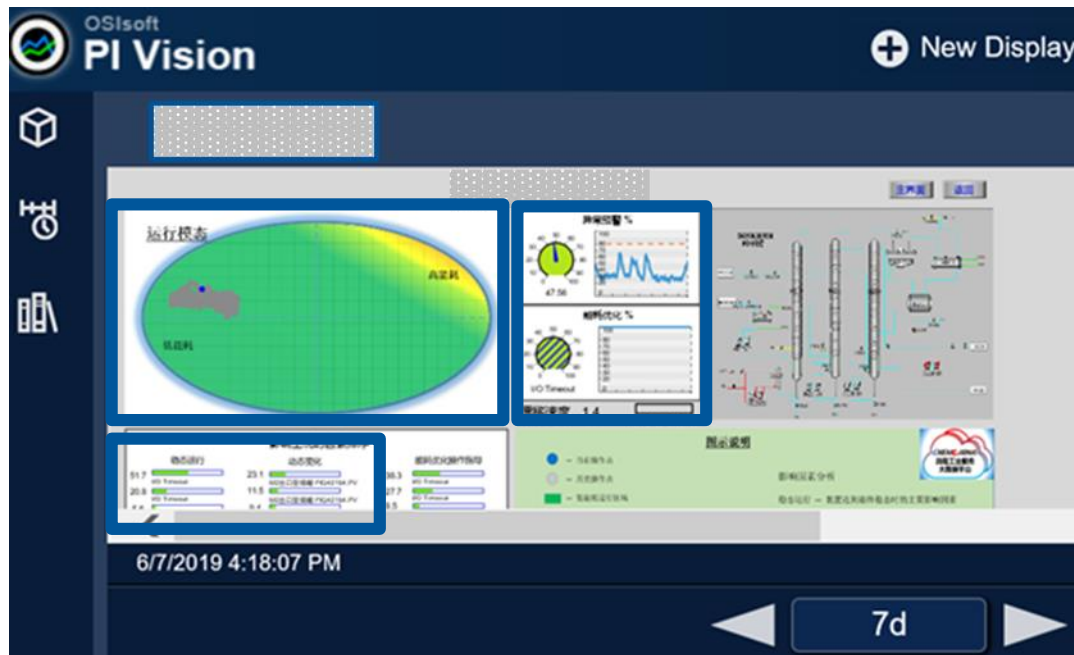


- Visualization overview of plant operation
- Real time commercial status
- Real time plant safety pattern
- Units' and key devices' operation and health pattern
- Early alert of anomaly
- Improvement of control and guide of optimization operation
 1. Improve stability of operation
 2. Minimize energy consumption
 3. Minimize monomer consumption

Best Practices – Stabilize Operation

Operation Stability Index – State Drift Rate

- ◆ SDR indicates operation stability, control robustness, ability to reject disturbance, and rapidity of transition process and load changing process
- ◆ Root cause analysis provided direct guide for operation
- ◆ Stabilizing operation is the first step to achieve optimization in intelligent chemical process



Best Practices – Optimize Operation

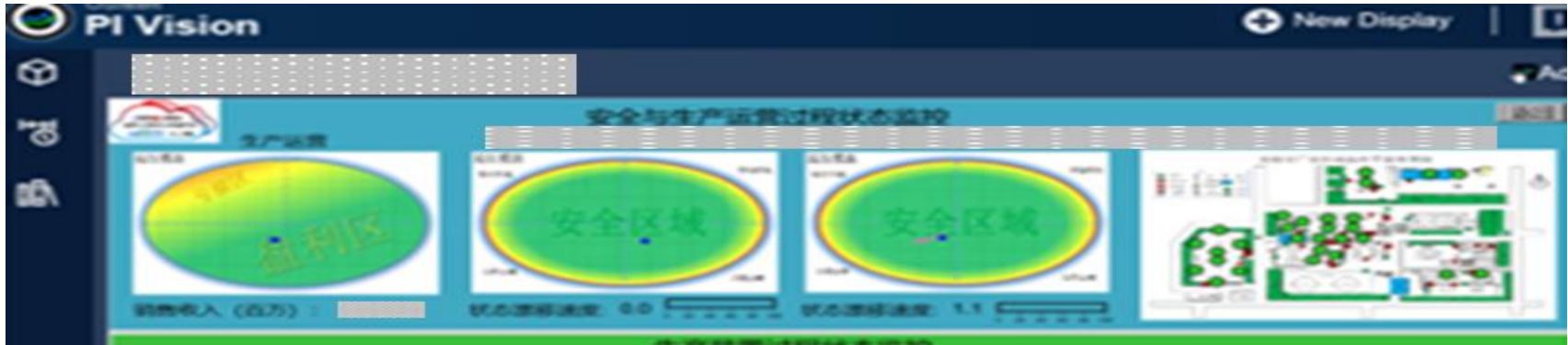
Optimization – Minimize Energy Consumption

- ◆ Recognize energy consumption pattern online
- ◆ Estimate minimum cost of the pattern moving to the optimum zone
- ◆ List top five factors for pattern changing
- ◆ Pattern operation reduces steam consumption by 3.5 ~ 5%



Best Practices – Operation Management

Plant Level Pattern

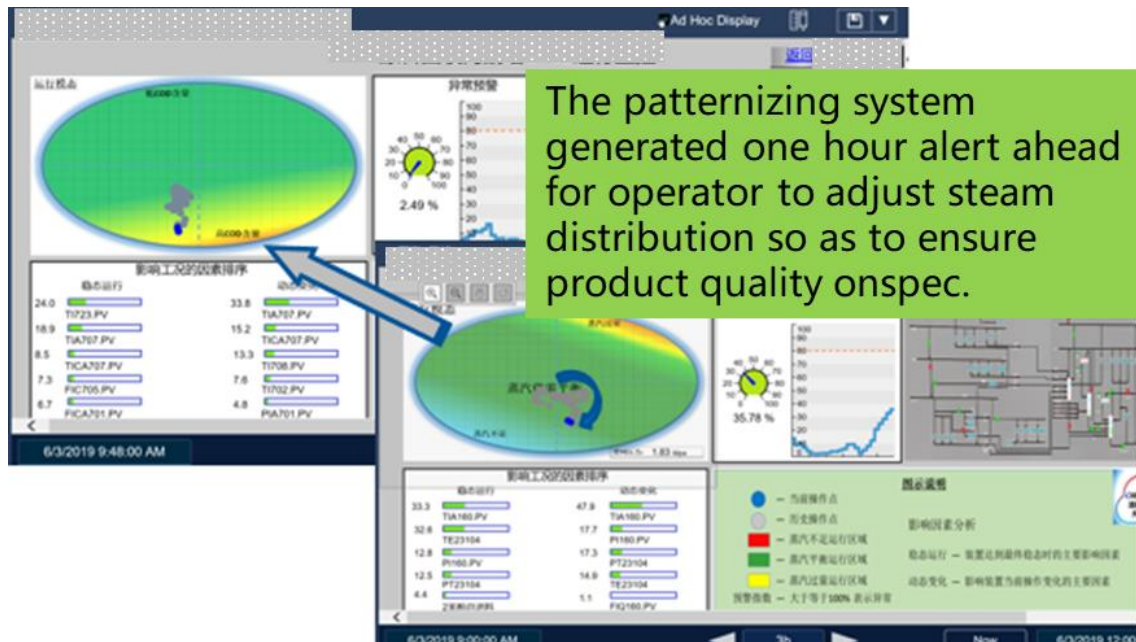


- ◆ Plant commercial pattern provides visualization full picture of plant operation including profit, cost, material, product etc.
- ◆ Plant safety pattern covers major hazards, leakage of inflammable and explosive or poisonous content, operators/contractors safety behaviors etc. and assesses rank of operation safety

Best Practices — Alert of Anomaly

Early alert of anomaly

- ◆ Recognize unstable or anomaly pattern and generate alert in advance
- ◆ Produce guide report from root cause analysis
- ◆ The pattern system buy operator enough time to make adjustment by providing early alert



Best Practices – Device health monitor and diagnostic

Device health monitor and diagnostic

- ◆ Visualization state of device health
- ◆ Real time monitor of device operation status
- ◆ Predict time of device failure, analyze possible reasons
- ◆ Devices under monitoring in the plant have air compressors, coolers and pumps etc.

