

LISTEN.
THINK.
SOLVE.®

Model Predictive Control

Pavilion Advanced Process Control Overview

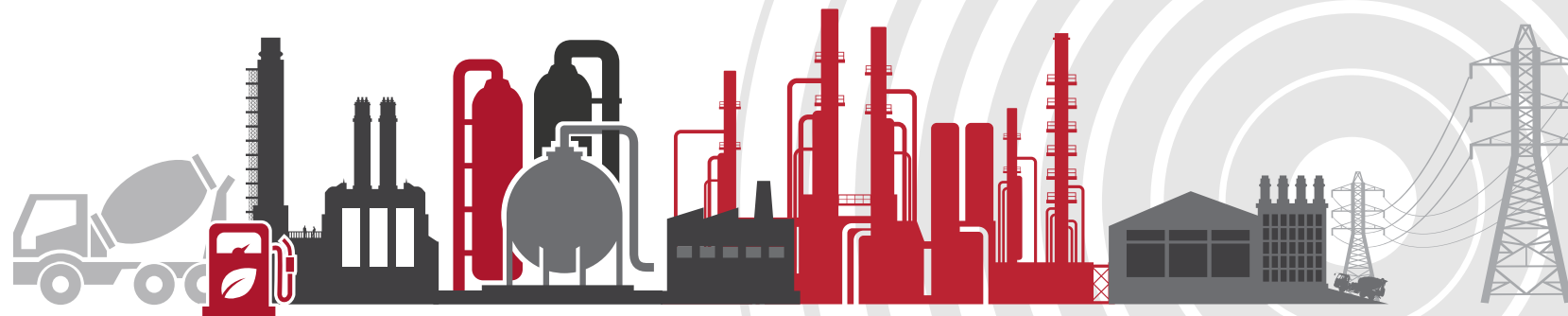


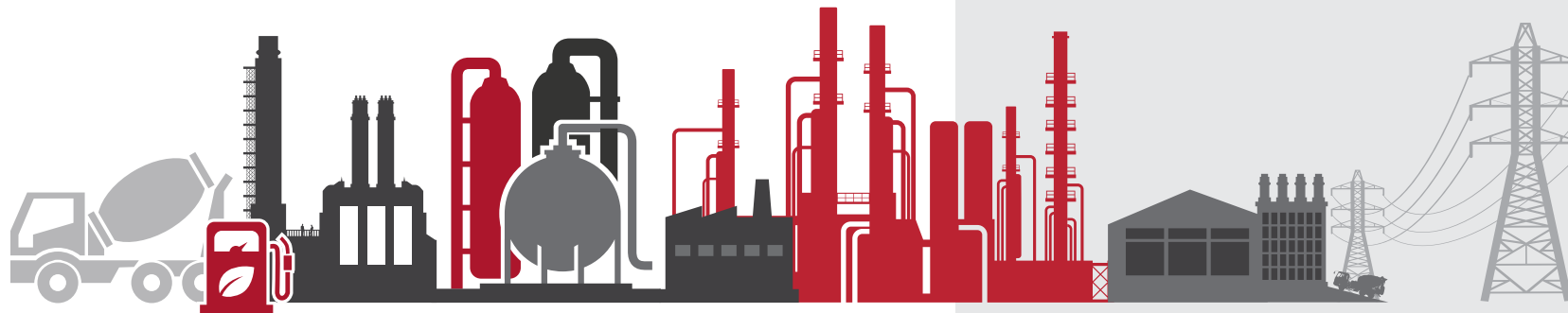
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Optimization using model predictive control in the Ethanol Industry

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Efficient production of renewable fuels is essential to a holistic energy policy, which remains a challenge among many cyclical industries. Energy savings, reduce costs of production, and increase your net positive CO₂ footprint. The most costly input to production is any shift in plant yields. Production capacity management in cyclical markets means that you can run faster when margins are excellent and turn-down rates run efficiently when margins shrink. All of these objectives can be improved with higher-level Pavilion8® model predictive control (MPC).



Rockwell Automation at a glance

22,000

employees



80+

countries



\$5.9B

fiscal 2016 sales



World's Largest Company Dedicated to
Industrial Automation and Information

20+

Industries



Serving customers for 112 years

- Technology innovation
- Domain expertise
- Culture of integrity and corporate responsibility



Bringing you a world of **experience**

PAVILION SOLUTIONS

Helping you exceed your business goals



Innovation

- The **most powerful** predictive modeling software in the industry
- **Enhancing** the profitability of global manufacturers
- Delivering the **highest ROI** in the industry

Domain expertise

- Combining technology and application knowledge
- Targeted industries
- Best practices from multiple industries

Products

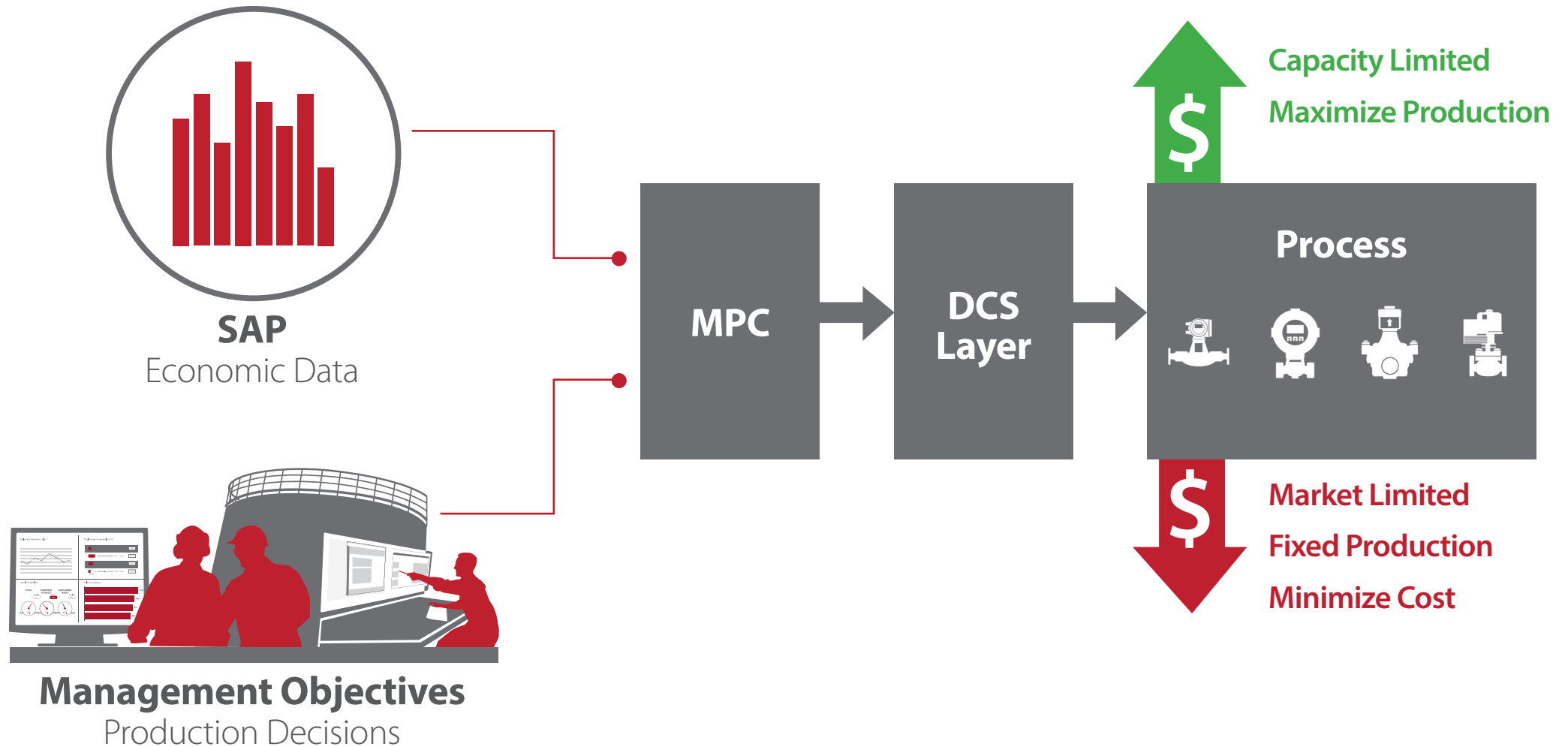
- **Pavilion8[®], Pavilion[®] RTO and Software CEM[®]**
- **Certified project managers**
- Repeatable, measurable, auditable
- **Risk management**

Biofuels | Energy Optimization | Environmental | Food & Beverage | Minerals, Mining, Cement | Natural Gas Liquids | Polymers | Water/Wastewater

80 Countries | 20 Languages | 2500 + employees | Average 13+ Years' Experience | Single point of contact

The Connected Experience

Responding to Market Conditions



The Connected Experience

Adapting to Market Conditions and Unique Priorities





The Connected Experience

delivers transformational value in
productivity and global competitiveness



*Faster Time
to Market*



*Lower Total Cost
of Ownership*



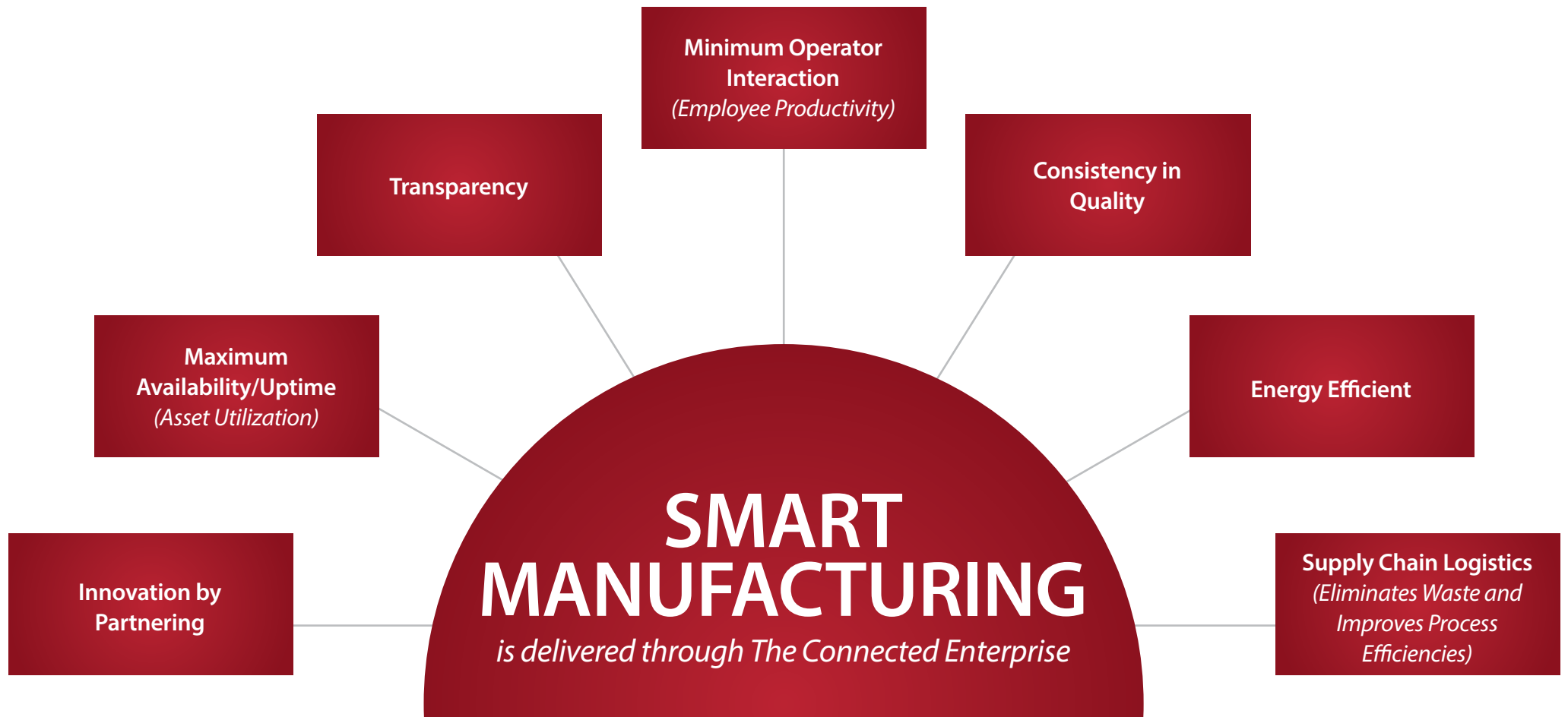
*Improved Asset
Utilization*



*Enterprise Risk
Management*

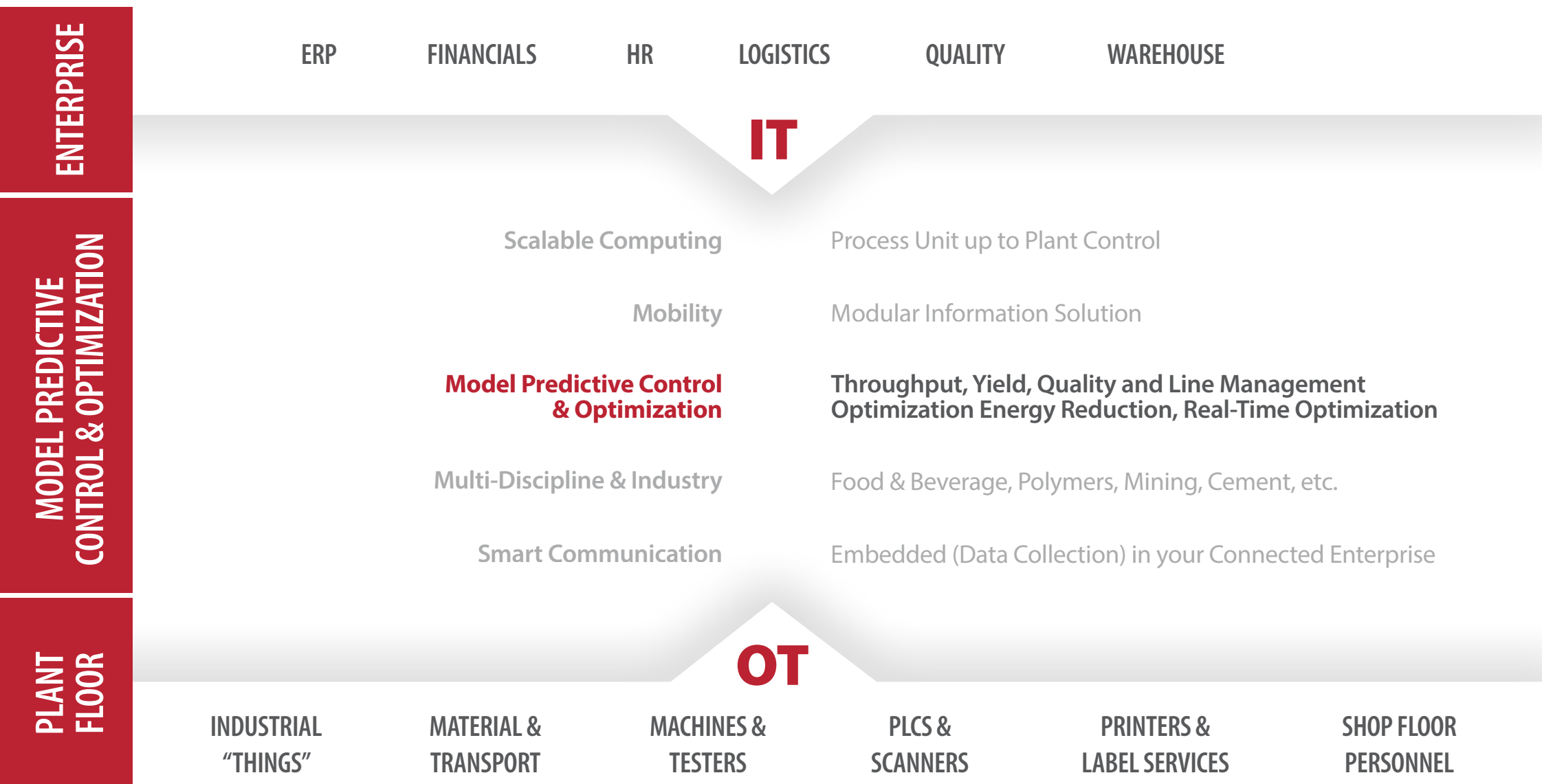
Goal

Smart Manufacturing



Model Predictive Control & Optimization

Increase Plant Stability Across the Entire Enterprise



The Connected Enterprise

PlantPAx MPC

ENTERPRISE

ERP

FINANCIALS

HR

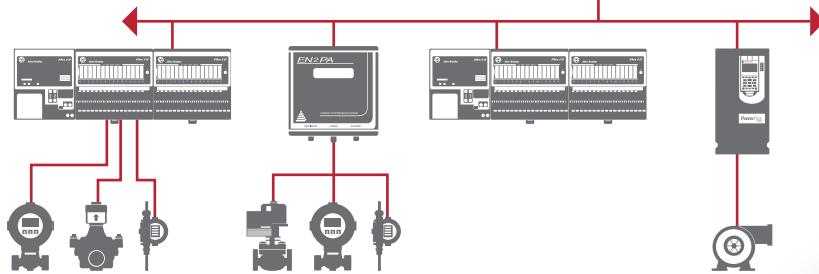
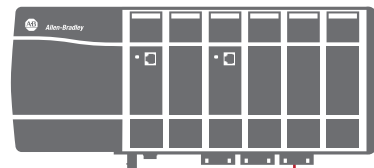
LOGISTICS

QUALITY

WAREHOUSE

IT

PlantPAx[®] MPC



Logix integrated: **Embedded**

- Closer to measurements & control elements
- Broadly familiar & simple Logix configuration & integration
- Simpler to use and maintain (TCO)
- Up to 5; 10 by 10 (MV, CV & DV)
- Full linear MPC, online parameter adjustments, e.g. adaptive gain scheduling

MODEL PREDICTIVE
CONTROL & OPTIMIZATION

PLANT
FLOOR

OT

INDUSTRIAL
"THINGS"

MATERIAL &
TRANSPORT

MACHINES &
TESTERS

PLCS &
SCANNERS

PRINTERS &
LABEL SERVICES

SHOP FLOOR
PERSONNEL

PlantPAX[®] MPC

Key Advantages

Easy to set-up, Easy to understand, and Integrates easily with the rest of your process control system



1

One Control Platform

*More reliable/
robust platform*

Easy integration



1

One Platform to Maintain

*Maintenance
controlled on a
single platform*

One user interface



Faster Optimization

*Driving maximum
performance*

Easy to configure

The Connected Enterprise

Pavilion8

ENTERPRISE

ERP

FINANCIALS

HR

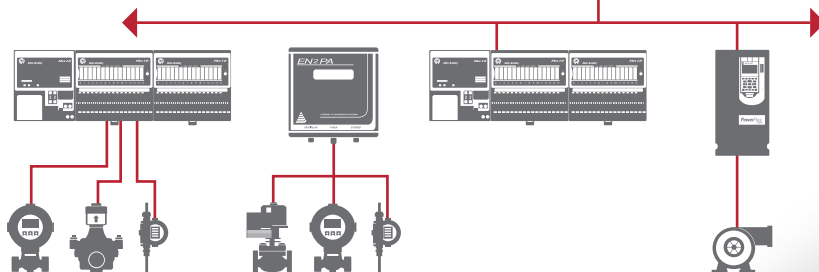
LOGISTICS

QUALITY

WAREHOUSE

IT

PAVILION8®



- Detached Server Pavilion8 MPC: Any DCS
- Hybrid Modeling, Linear & Nonlinear MPC
- Unlimited Size
- Integrated local optimization
- Console for KPI's, Value presentation and run-time visualization

OT

INDUSTRIAL
"THINGS"

MATERIAL &
TRANSPORT

MACHINES &
TESTERS

PLCS &
SCANNERS

PRINTERS &
LABEL SERVICES

SHOP FLOOR
PERSONNEL

PLANT
FLOOR

PAVILION8[®]

Key Advantages

Hybrid/flexible modeling | Rapid/Robust run-time MPC | Better models, better control | Integrated performance KPI's

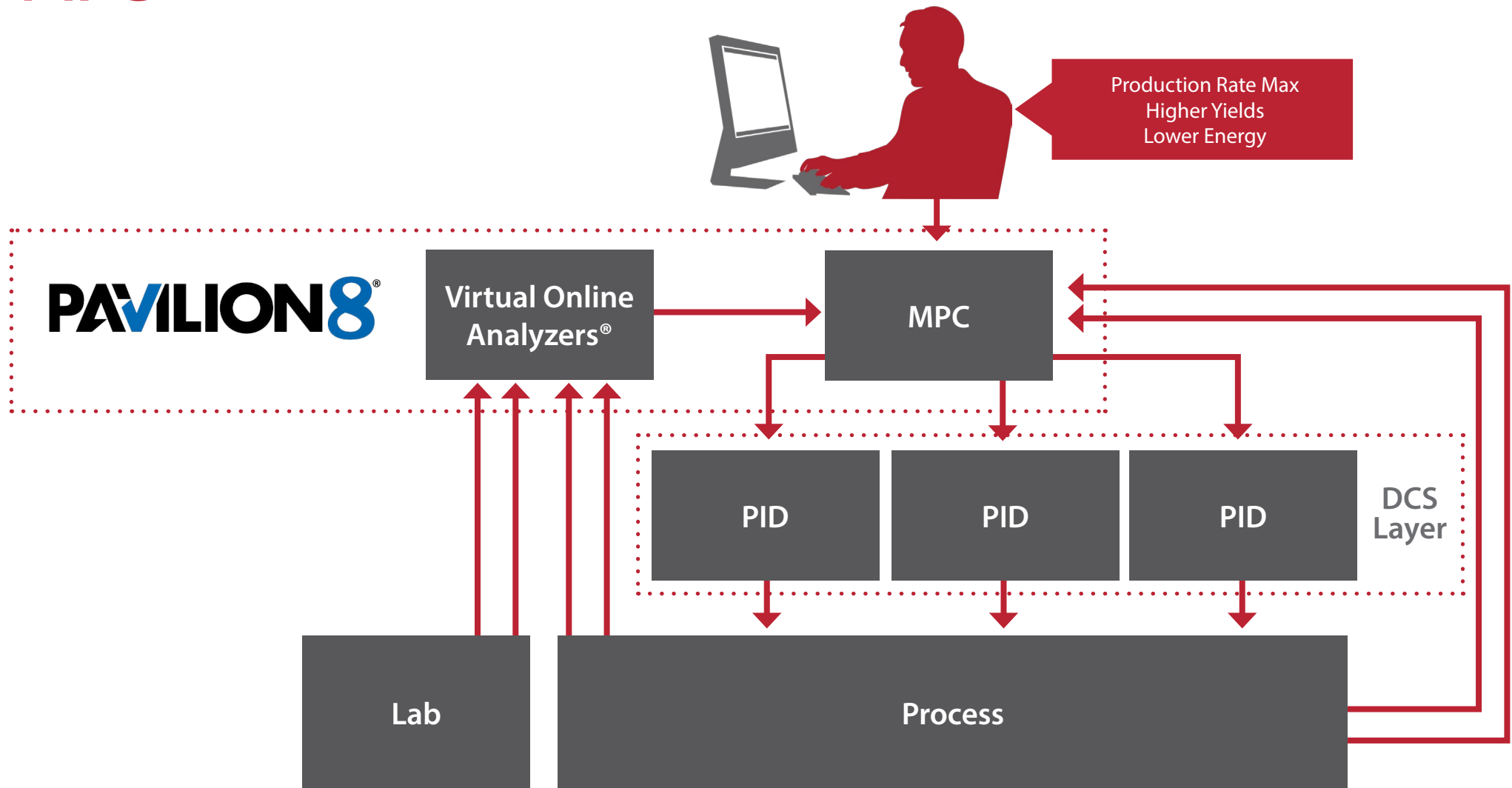
5%
*Increase in
Throughput*

5%
*Specific Energy
Reduction*













50%
*Reduction in
Variability*

Optimization Architecture Overview

MPC



Controller Matrix

	CV1	CV2	CV3
MV1			
MV2	NO MODEL		NO MODEL
MV3			
DV1			
DV2			NO MODEL



Controller consists of a matrix of process model pairs that explain **IMPORTANT INTERACTIONS** in the process

PREDICT future values of the CVs by movement of all the MVs and DVs

PROACTIVE CONTROL to coordinate MV setpoints to minimize CV deviations from targets, hence reducing variability



So what makes **MPC** different?

PID

Single variable in and single variable out

Set up a target and control process variable to the target - no awareness of how control changes impact other PID loops

Feedback control

The controller will take no action unless PV deviates from target

Indirect control of lab measurements

Control property variables through proxy (temperature, pressure, etc.)

Poor ability to handle process delays

During complex dynamic interactions

Constraints

Only Internal awareness of loop's limits on setpoint and output



MPC

Multivariable in and multivariable out

Control strategy based on a holistic comprehension of key process variables and their interdependencies

Predictive control

Dynamic models developed through process step tests - controller action based on current and anticipated future PV deviations from target

Direct control of lab measurements

Controller predictions of lab measurements used for control updated as available

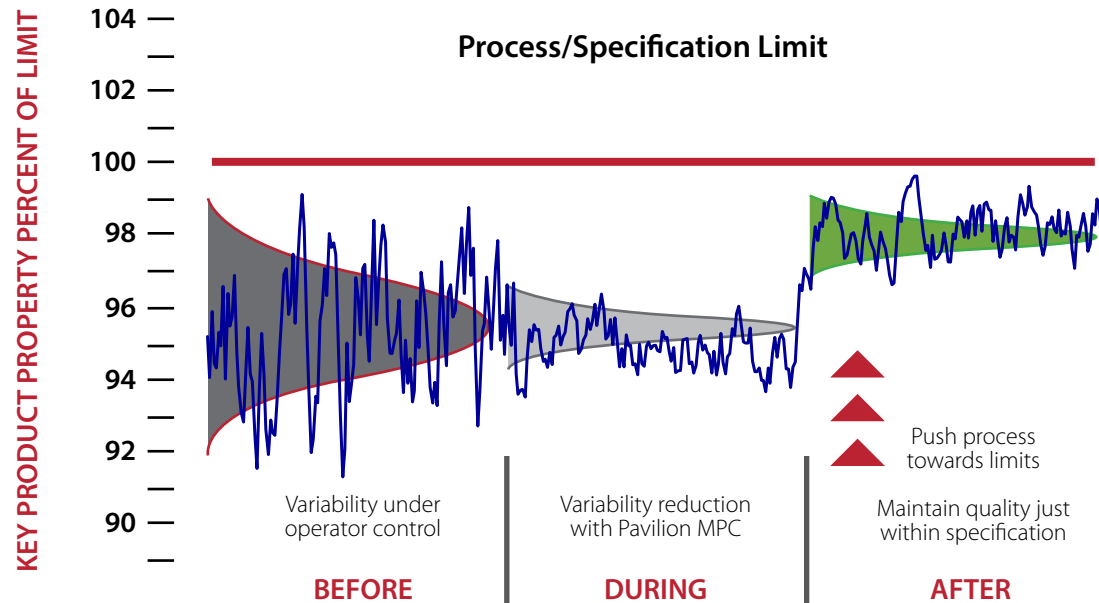
Explicit dynamic models

Full understanding of process dynamics and interactions

Constraints

Predict and monitor future values of constraints

How **MPC** generates benefits



REDUCES Variability

ACHIEVES
'Plant Obedience'

MANAGES the
process within
constraints

ACHIEVES UPLIFT –
operate closer to
specifications and
performance limits
while maintaining
safety margins



PAVILION8[®]

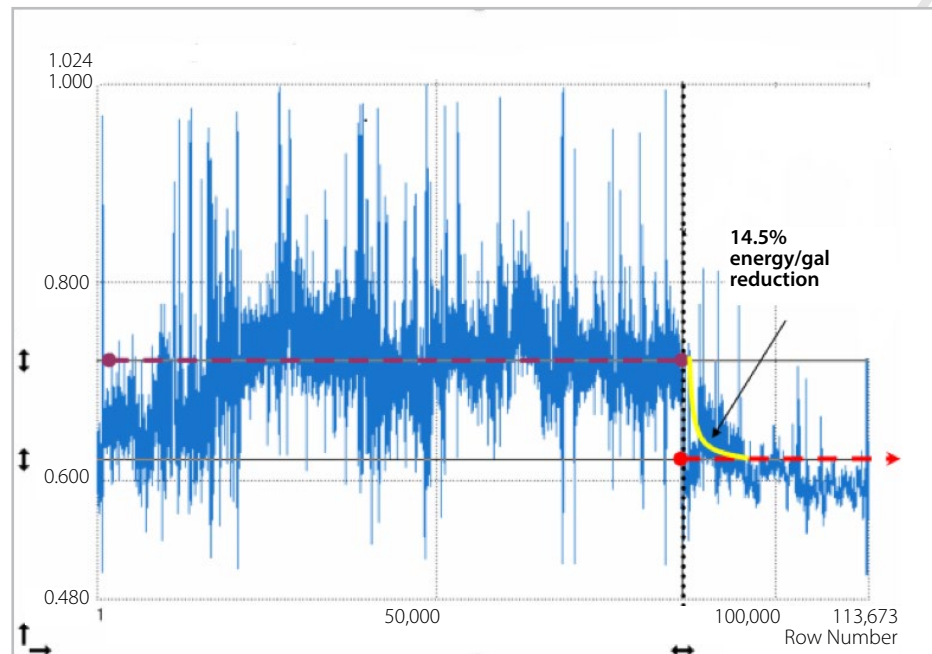
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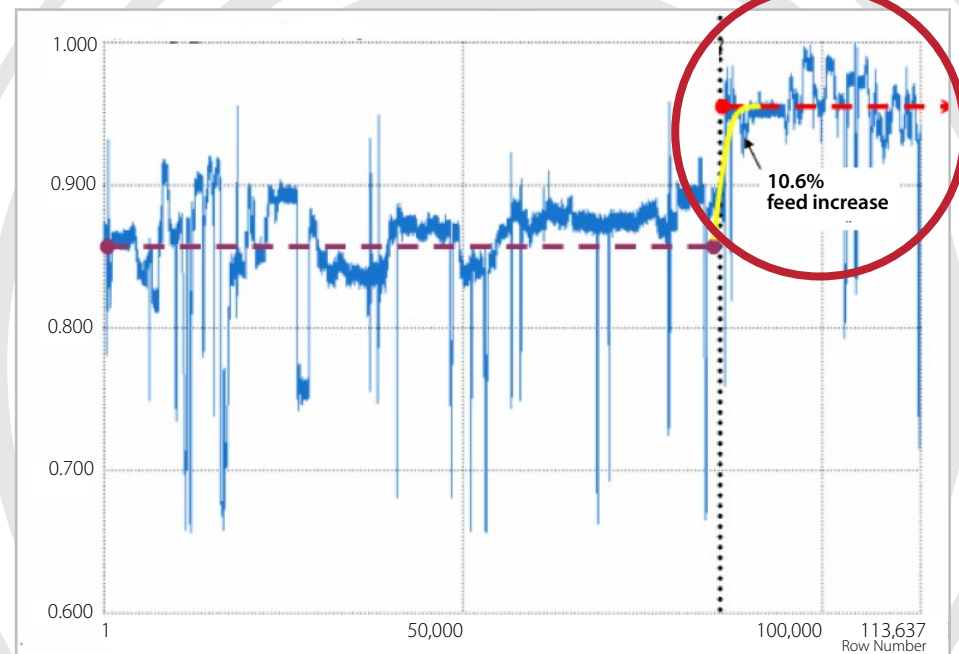
PlantPAX[®] MPC

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Ethanol Dryer MPC Results



Energy Savings
14.5% Less BTU/Gal

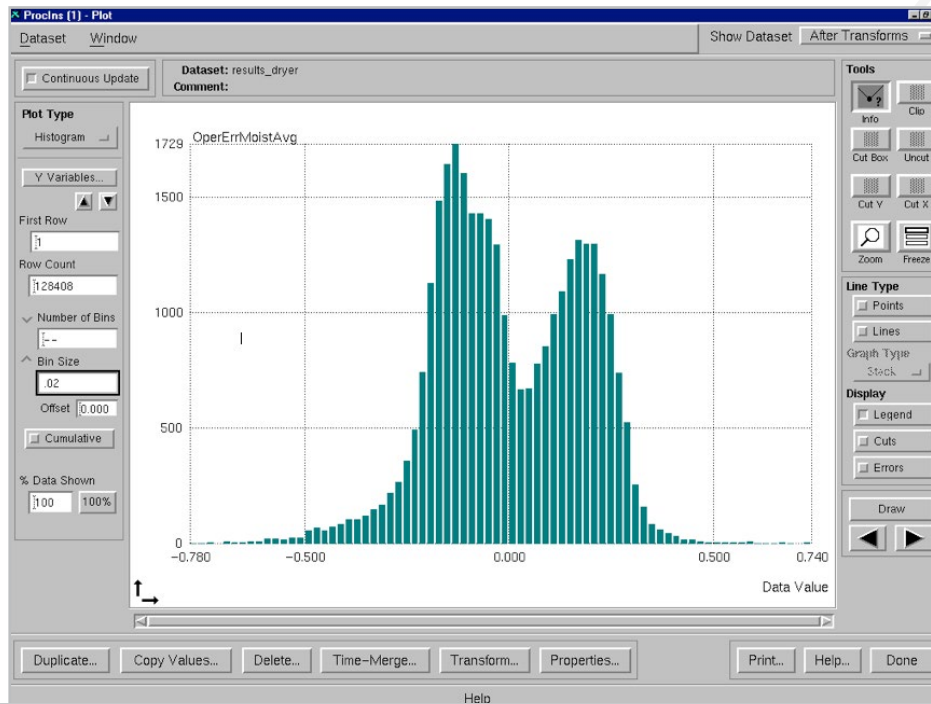


Throughput Increase
+10.6% Gal/Year

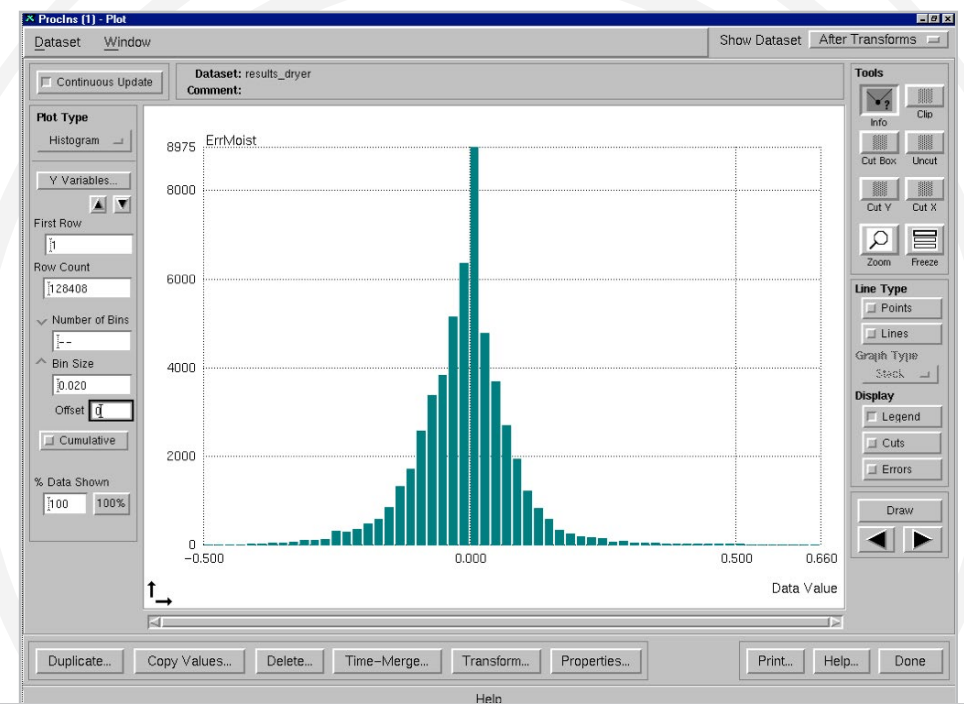
Dairy Drying

Reduction in Variability

Example - Dryer Results (Moisture) 49% improvement

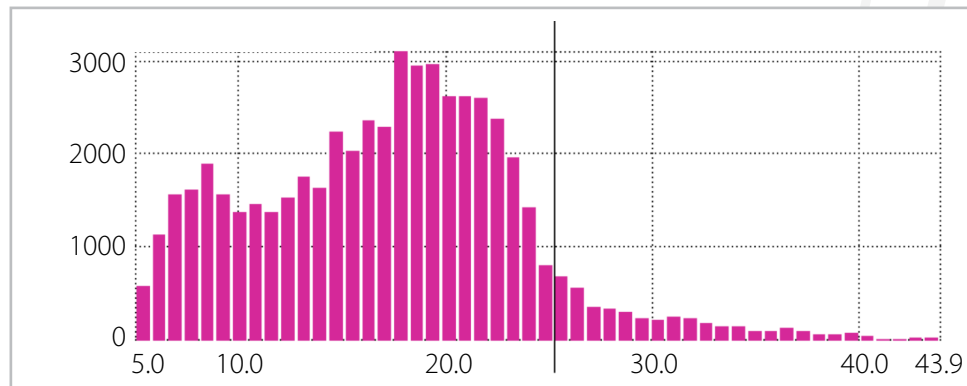


Before
Pavilion8



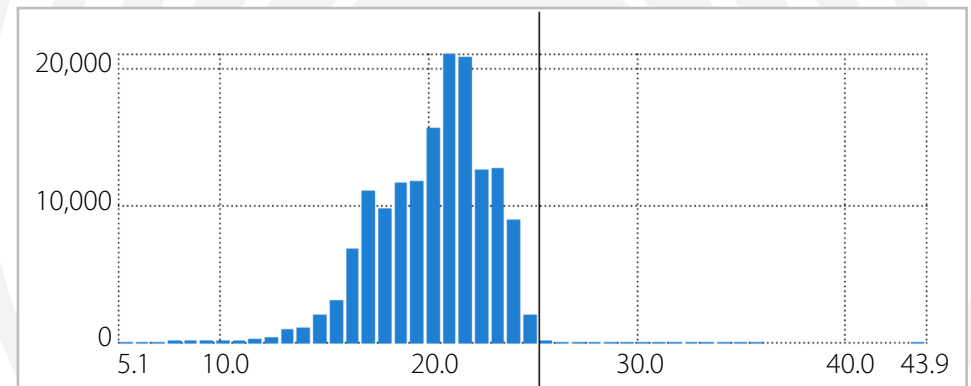
After
Pavilion8

Dryer Exhaust Relativity Humidity Control



Pavilion8 OFF

- Humidity frequently exceeds limit
- Wide distribution = poor manual control
- Over drying = wasted energy



Pavilion8 ON

- Keeps process Relative Humidity under limit even with changes in Ambient Humidity
- Narrow distribution = tighter control with Pavilion8
- Less over drying = energy savings

MPC – Value Across the Operation

Increasing plant stability through the entire Enterprise

Better Response

to changing market conditions

Real-Time Response

to dynamic process conditions

Run Efficiently

throughout the entire operation

Increased Profit

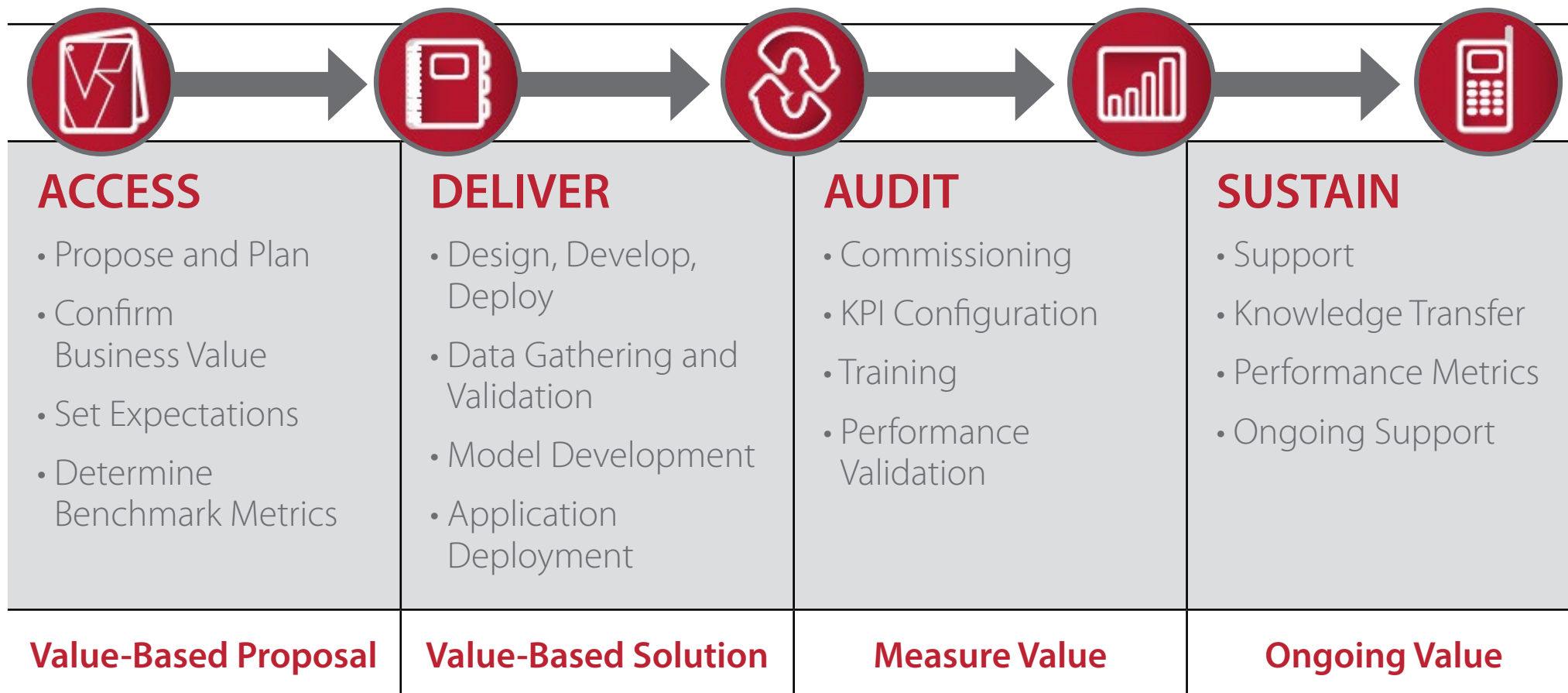
by managing complex applications

High Operator Approval

for a better peace of mind







ValueFirst

Application Support



Email and live
telephone support

Web-based Pavilion8
Support Knowledgebase
and annual onsite visits
available for APC

MPC System recovery
assistance from
server failures

Quarterly Pavilion8
MPC status reporting
and troubleshooting
APC application issues

Service-Pack Releases
provide updates and
system changes



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Power, Control and Information Solutions Headquarters

Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444

Europe/Middle East/Africa: Rockwell Automation NV, Pegasus Park, De Kleetlaan 12a, 1831 Diegem, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640

Asia Pacific: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

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