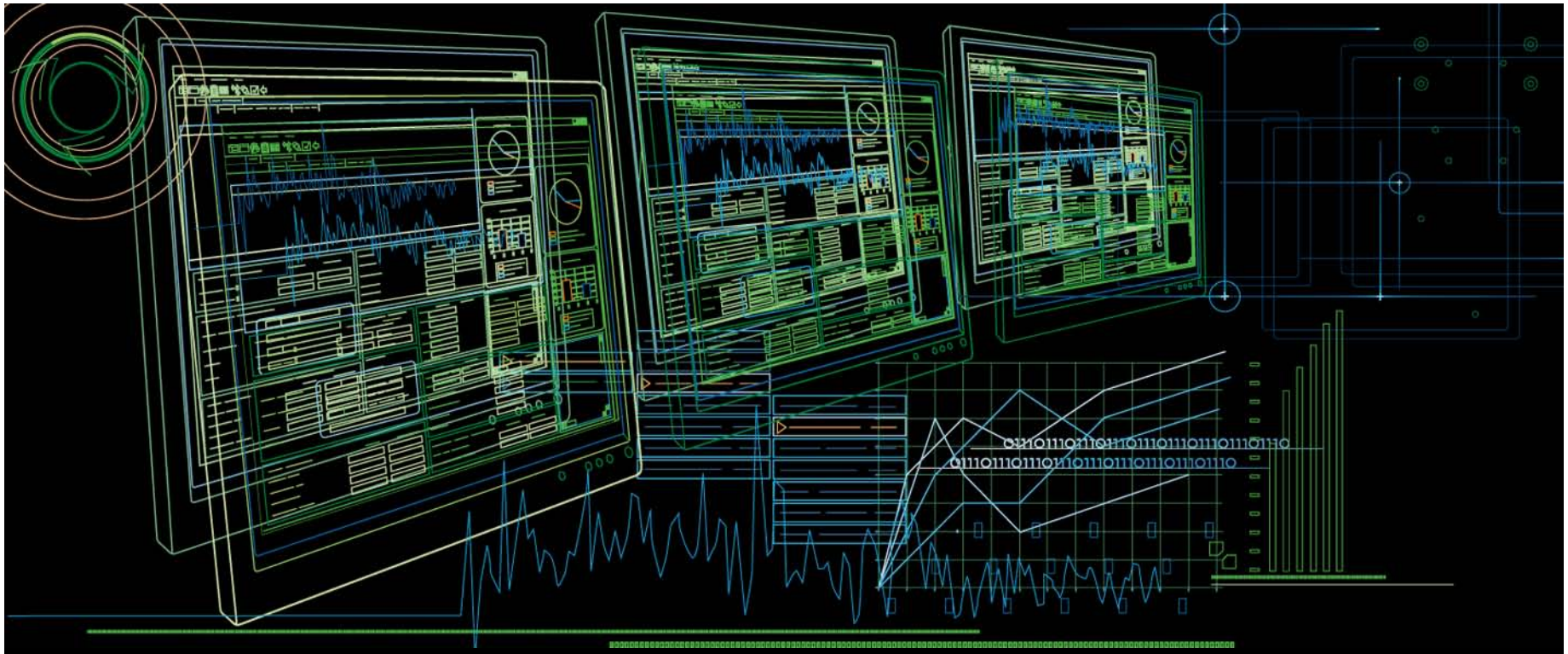


Marc Leroux, Marketing Manager, Collaborative Production Managment

The Business Value of Advanced Process Control

Imagine ….

If you could improve your bottom line revenue by 5% …

While lowering your energy consumption by 3% …

And reduce your carbon footprint ….

While improving your product quality.

Interested?

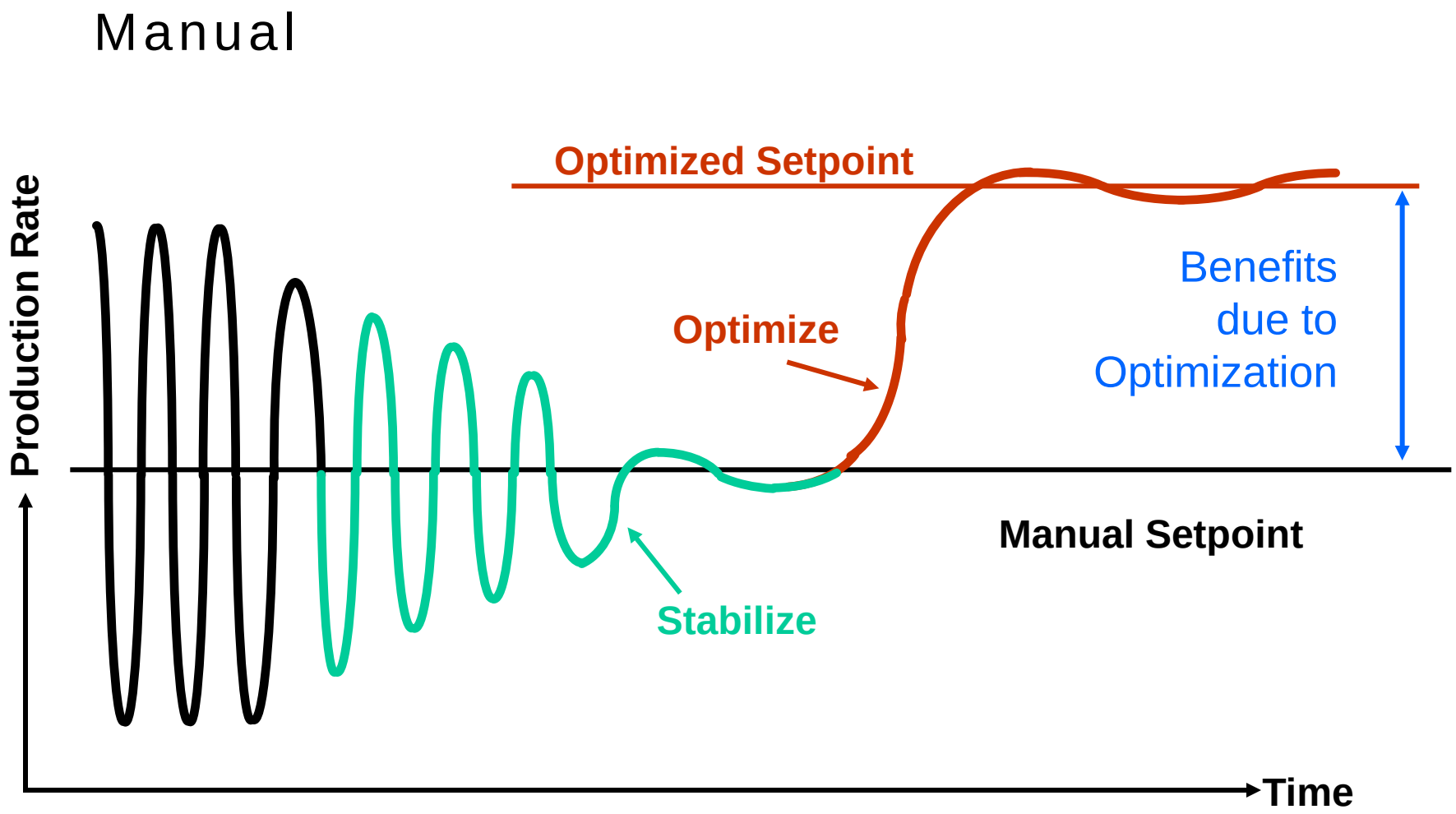
Let’s see how we can bridge the gap between automation and financial objectives.

In real-time.

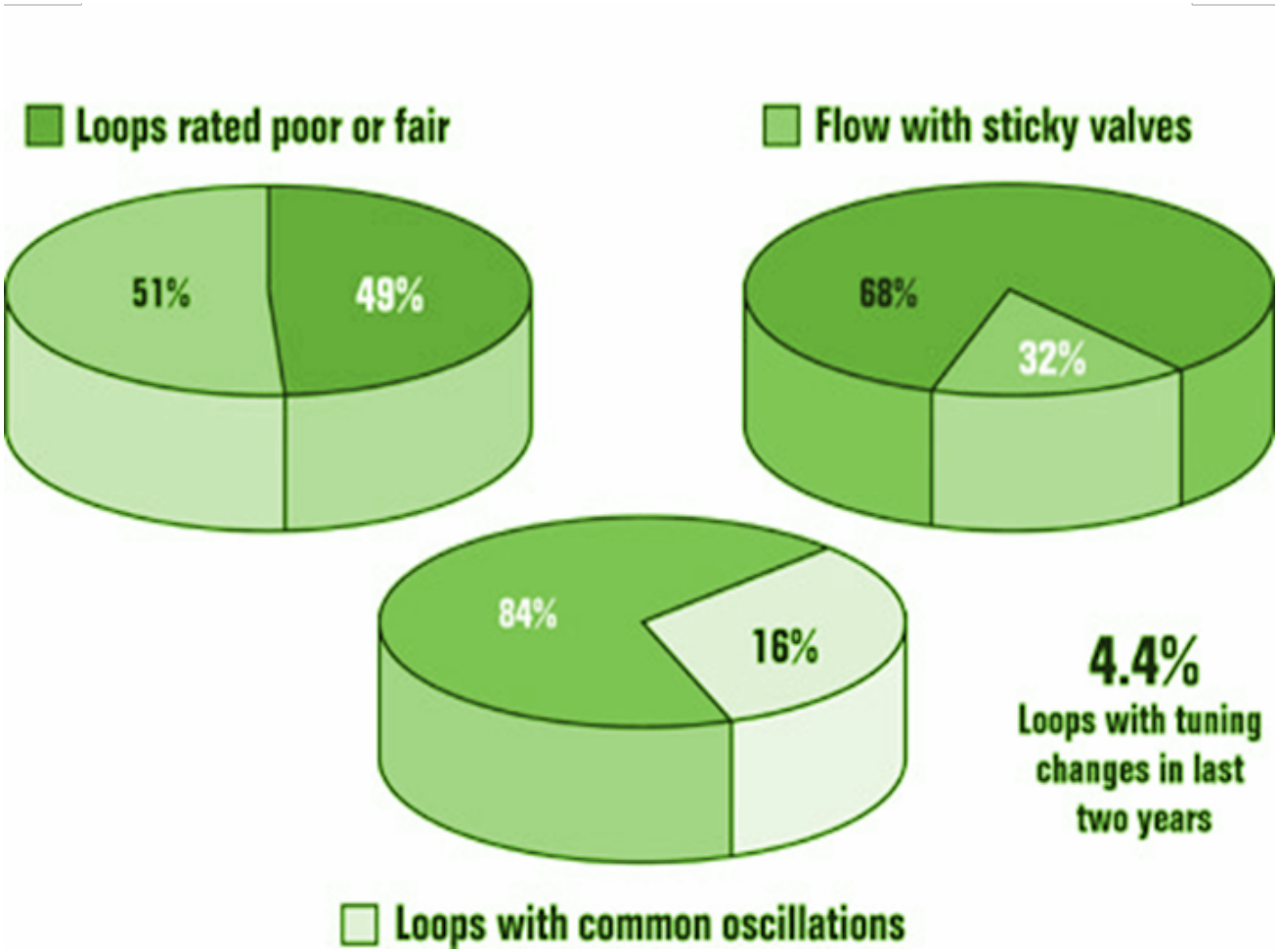
Discussion points

- **Starting out**
  - **A stable environment - the foundation for APC**
  - **Some definitions of APC**
- **Some practical examples**
  - **Some practical examples**
    - **Manipulated variables, and their effect**
    - **The optimal solution**
- **Benefits and Conclusions**

Stabilize then Optimize



Real world performance of loops is suboptimal!



Why isn’t it being addressed

The basic issue is the magnitude of the problem

Loop Tuning Benefits

- Typical process contains 2,000 – 4,000 control loops
- Typical control loop as a $25,000 asset
- Much of it is lost
  - 25 % ineffective control
  - 25 % decreased performance
  - 50 % well tuned
- Half time of good performance = 6 months
- Average process engineer in charge of 400 control loops
- 2 – 4 hours to investigate and improve control performance

Example:

25% X 1,000 loops X $10,000 = $ 2.5 M

Managing Overall performance

PRECONDITIONS

Acceptable performance index
Harris index

Acceptable setpoint crossings index
Setpoint crossing index (not for Level Control)

Variability random
Oscillation index of control error

Controller output within range
Saturation index

Loop automatic
Automatic mode index

Acceptable cascade tracking
Cascade tracking index (if in cascade)

Acceptable response speed
ACF to horizon index

Acceptable Overall performance

GENERAL				
Loop	Category	Area	Performance	mean loop e
FC101	Liquid Flow	Refining Section (Auditing)	Good	-0.
FC102	Liquid Flow	Refining Section (Auditing)	Good	0.
FC103	Liquid Flow	Refining Section (Auditing)	Good	0.
FC104	Liquid Flow	Refining Section (Auditing)	Fair	-0.
FC105	Liquid Flow	Refining Section (Auditing)	Good	-0.
FC106	Liquid Flow	Refining Section (Auditing)	Fair	0.
FC107	Liquid Flow	Refining Section (Auditing)	Poor	0.
FC108	Liquid Flow	Refining Section (Auditing)	Poor	0.

The difference between Process Control and APC

- **Regulatory Process Control**
  - Controller brings a **single** value close to a setpoint using a **single** manipulated variable
  - Reactive process based on currently measured conditions
    - Example: Manipulating the heater to set the temperature in a tank
- **Advanced Process Control**
  - Controller brings **several** values close to optimal targets **at the same time** using **several** manipulated variables **simultaneously**
  - Predictive process is based on a process model that foresees how variables will behave in the future.
  - Controller finds optimal tradeoff in case of conflicts among the goals.
    - Example: Temperature Profile ***and*** Flame Conditions in Furnaces

Pros and Cons of Advanced Process Control

- **Advantages**
  - Several actuators act simultaneously to achieve best trade off
    - Benefits: achieve goals in the fastest or most efficient fashion
  - Predictive approach allows early recognition of potential violations and implements corrections
    - Benefits: Improve stability and reduce defects
  - Work closer to process constraints
    - Benefits: Reduce costs
- **Disadvantages**
  - Modelling effort
  - Computational load
  - Maintenance

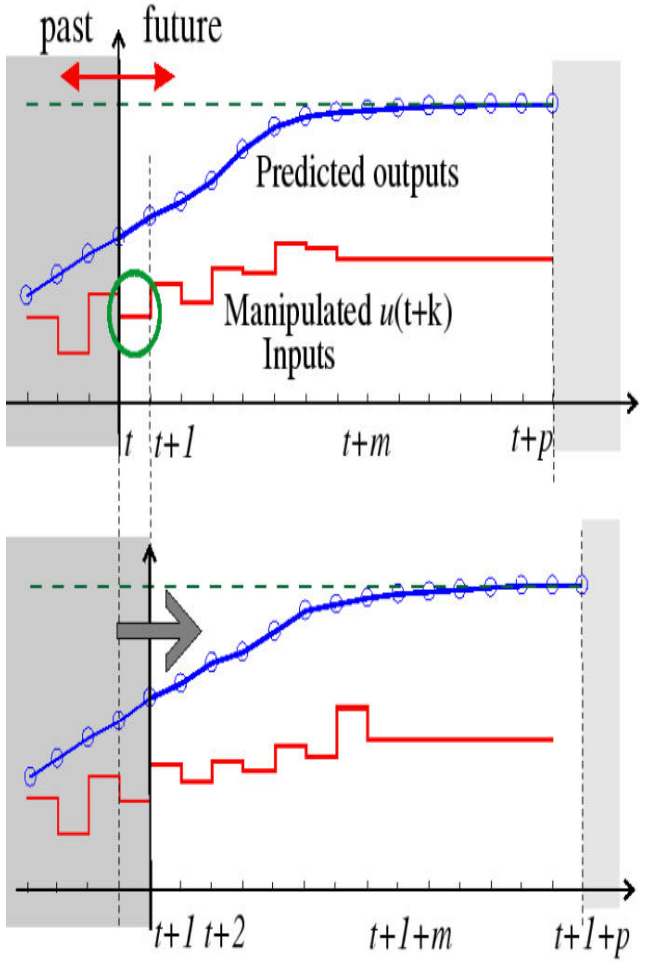
APC strategies differ based on requirements

- Fuzzy Logic
  - Best used for cases where rules can be used to react to process conditions. Good solution where the number of rules is not too large.
- Neural Networks
  - Best used for cases where online measurements are hard to obtain reliably, such as virtual sensors.
- Model Predictive Control (MPC)
  - Best used for process with strong coupling among variables, competing optimization goals and limiting process constraints

An APC platform shouldn't dictate which strategy to use

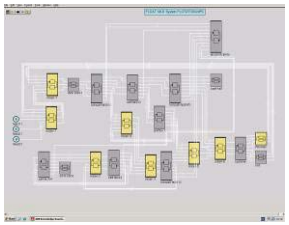
Your process should!

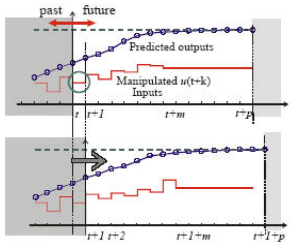
Model Predictive Control (MPC)



- Method for handling disturbances and forecast changes
- Main ingredients are
  - Plant model
  - Objective function
- Model predicts system behaviour some steps into the future
- Requires solution of optimization problem at every sampling time

How does Advanced Process Control work?





Signal processing

Measurements

Estimation of process state variables

(Moving Horizon Estimation, Fuzzy Logic, Neural Networks)

State estimates

Computation of optimal set-points

(MPC, Fuzzy Logic)

Set-points

Post-processing of set-points

OPC/proprietary protocol for communication

Process Control System

Sensors

Actuators

Process

Table of contents

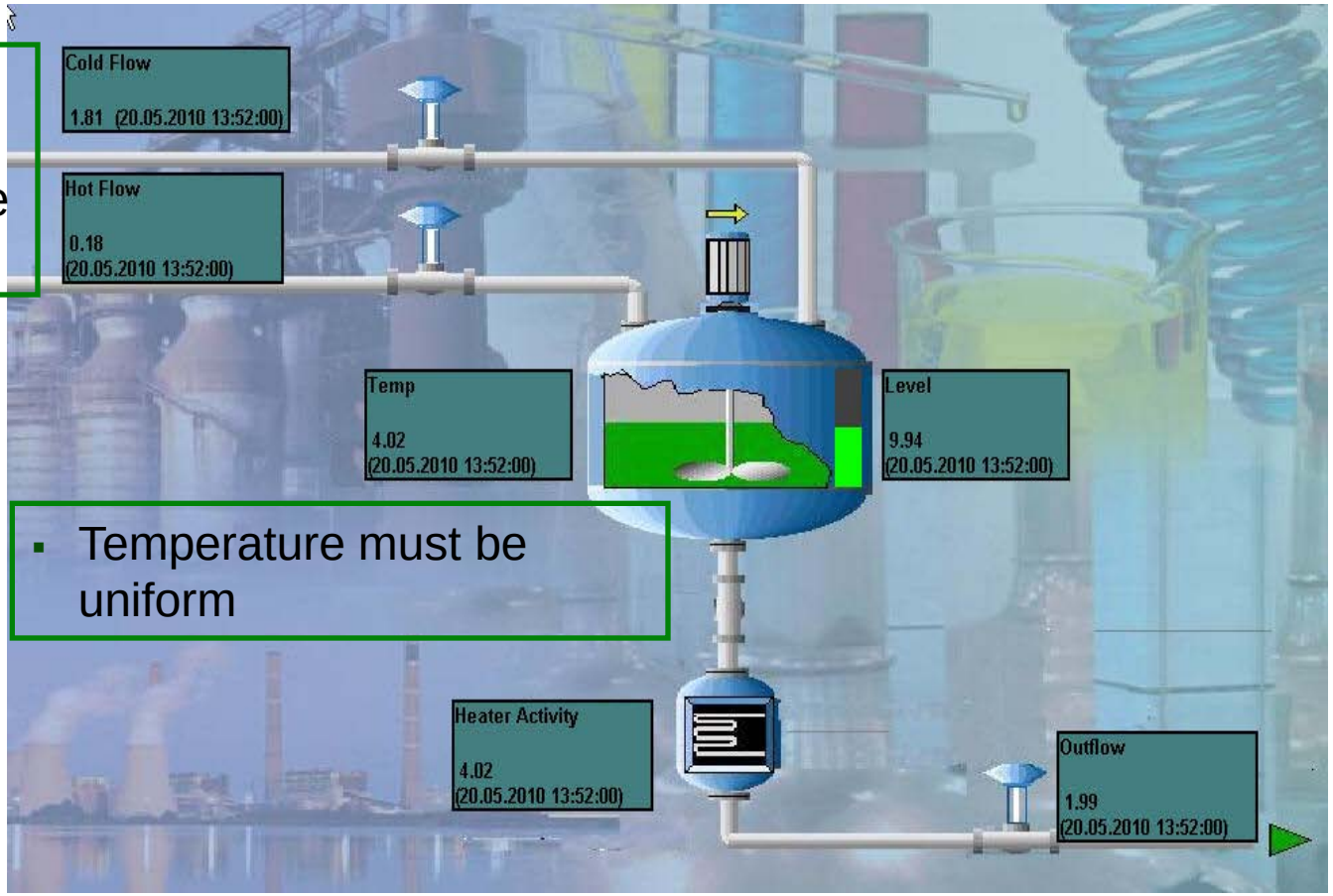
Economic Process Optimization

- Real-time integration of automation, information, and collaborative business systems across the enterprise
- Economic Process Optimization is now possible because of improved enterprise systems integration and optimization techniques

Closing the gap between financial goals and the process. In real-time!

“Simple” example using Advanced Process Control
Tank problem

- Hot water more expensive than cold



- Temperature must be uniform

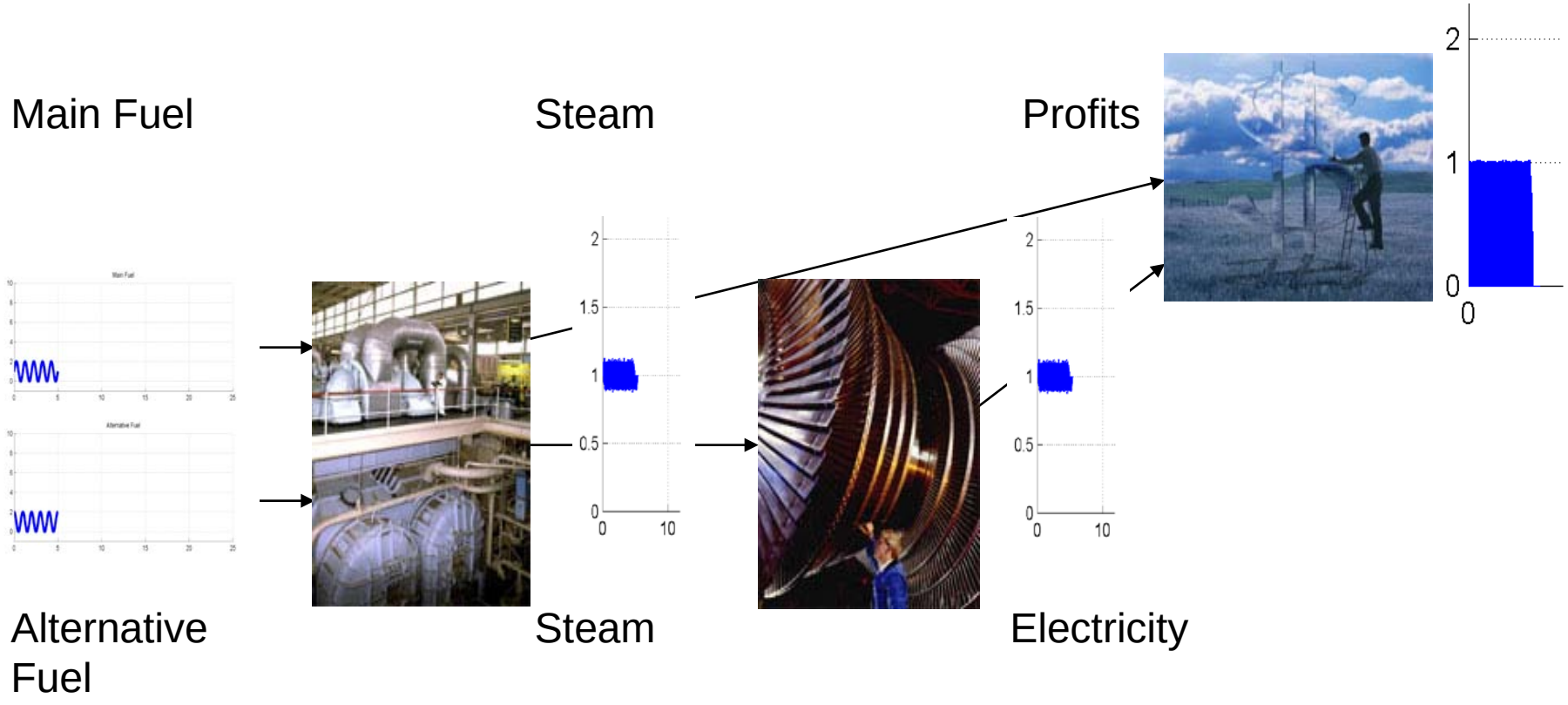
- Heater consumes electricity
- Heats faster than hot water

- Output flow is variable

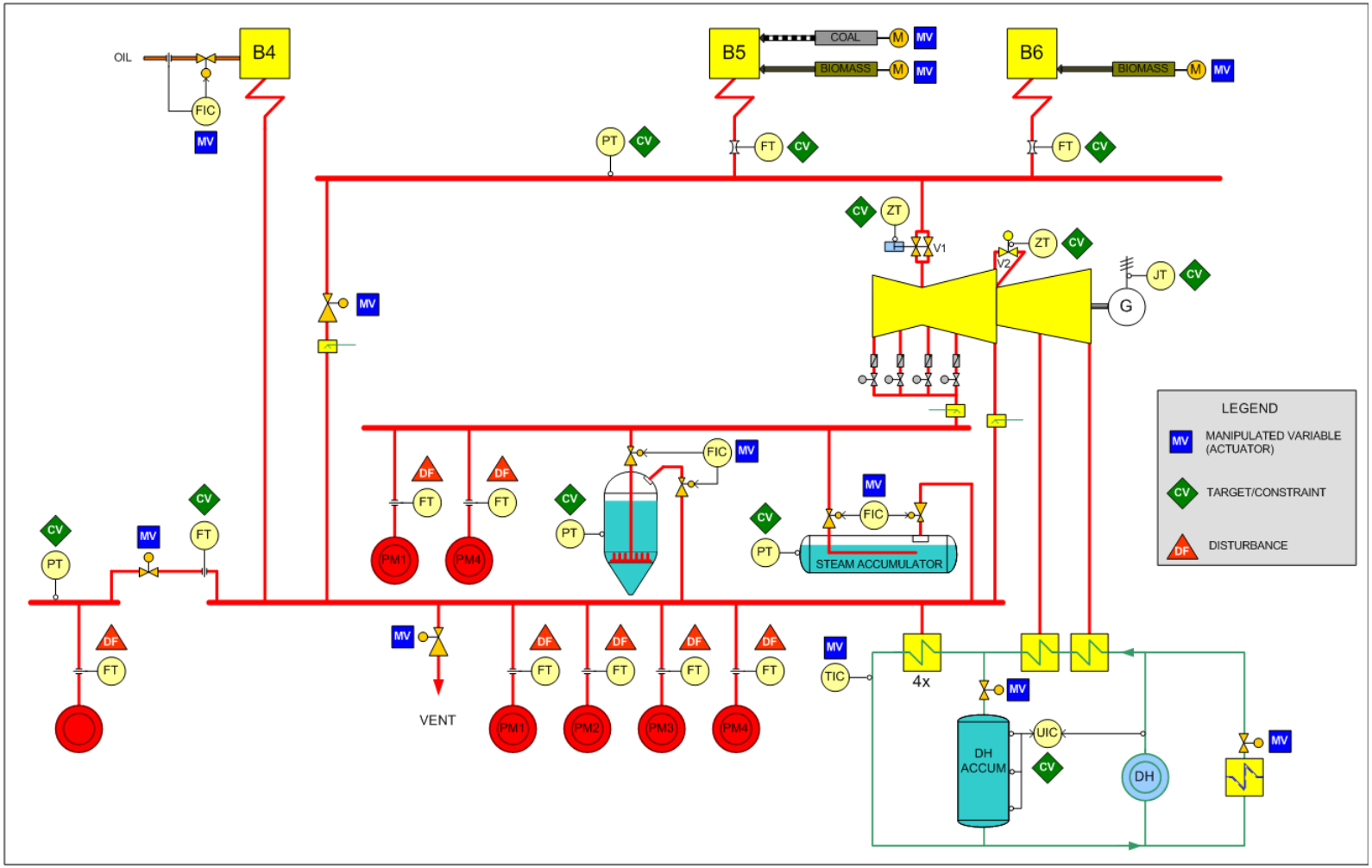
Optimal solution

- Use hot water to regulate tank temperature when:
  - Electricity is expensive
  - Penalty conditions will apply
  - Output flows are low
- Use heater when:
  - Electricity is cheap
  - Contracts will not be violated
  - Fast heating not required
- Use tank level to moderate costs

Industrial Steam Plant: dealing with variability



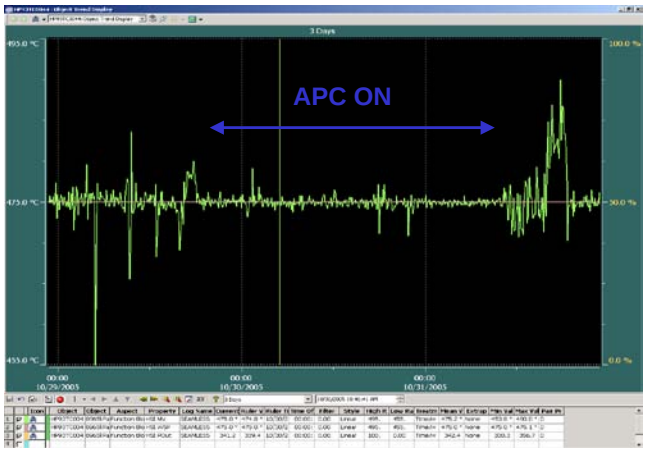
Industrial Steam Power Plant Optimization



Production and Quality targets achieved while …

- Optimal mix of cogenerated and purchased power is used.
  - **Results**: Lower costs based on current market conditions. Excess power sold back to the grid, offsetting purchase cost.
- Steam conditions are optimized to deliver required steam to the process, while maintaining steam in the turbine.
  - **Results**: Appropriate amounts of steam used to satisfy production while maintaining cogeneration.
- Burning conditions are regulated based on fuel used and conditions in the process.
  - **Results**: Lowest cost fuel mix used, lowering costs.

Industrial Steam Plant: dealing with variability

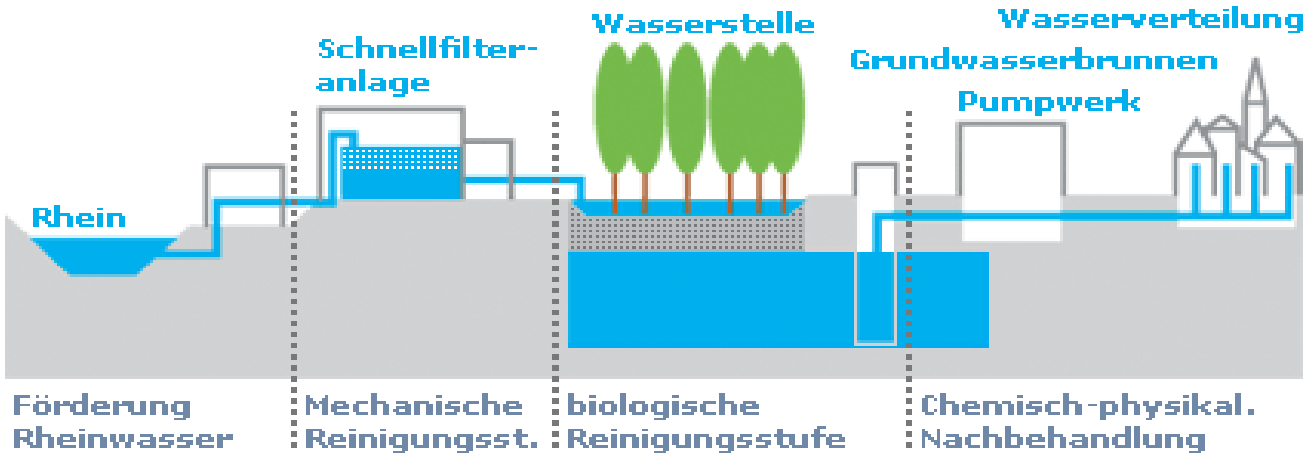


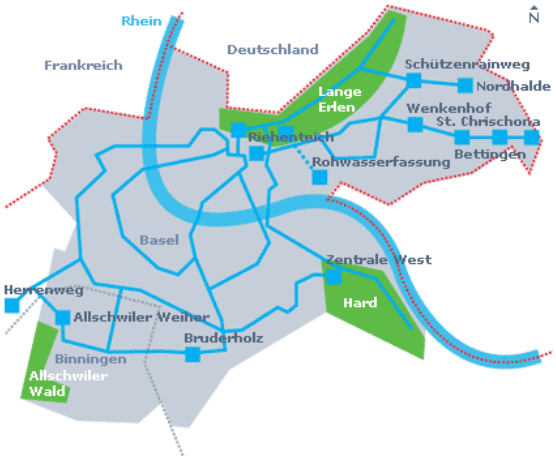
Temperature Control

Steam Flow Control

- Results achieved using Advanced Process Control
  - Best-case optimization of energy purchased and sold
  - Optimal trade off among steam consumers (including power generation) in order to maximize profit
  - Consistently using the lowest fuel mix that meets the constraints
  - Optimal reaction to disturbances such as alternative fuel failures and varying steam demands

Basel Region Water Production Process





- Collecting raw water from river/lake
- Filtering, distribution for drainage
- Pumping from wells (low pressure)
- Pumping into pipe system and to reservoirs (high pressure)

Benefits in Boiler Management for Pulp & Paper
Steam Temperature and Boiler Steam Flow Control

- Better process stability: avoidance of boiler trips and loss of production
- Additionally
  - 7°C average steam temperature increase translates to 1.2 MW of power
  - 29 tons/hr average steam flow rate increase translates in removal of steam limited process conditions
  - 5% savings in overall purchased energy costs

ROI: under 6 months

Benefits in Kiln Optimization for Minerals

Calciner Temperature and Alternative Fuels Control

- Savings due to substitution of 5 tons/hr of coal by an alternative fuel
  - $50/ton * 8000 hr/year * 5 ton/hr = **2 MUSD/year**
  - 3 tons CO2/ton coal * 8000 hr/year * 5tons/hr = **120 ktons CO2/year**
- More stable process conditions, more production
- No cyclone blockages, less loss of production
- Better product quality

ROI: 2 months

Benefits in O&G Industry

Butadiene Purification Process

- Reduction of steam consumption
- Reduction of solvent use
- Lower product quality variability
- Process key variables closer to their setpoints
- Less work load for operators at all levels

ROI: 11 months

Table of contents

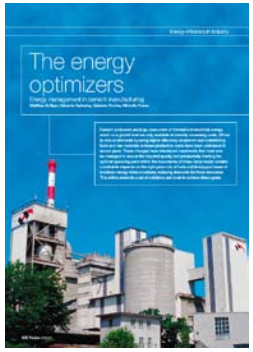
Moving forward

- The right tools
  - Choice of right technology for your process
  - Modular and scalable software packages
- The right approach
  - Experienced personnel
  - Maintenance of models
  - Project Management
  - Mitigate risk

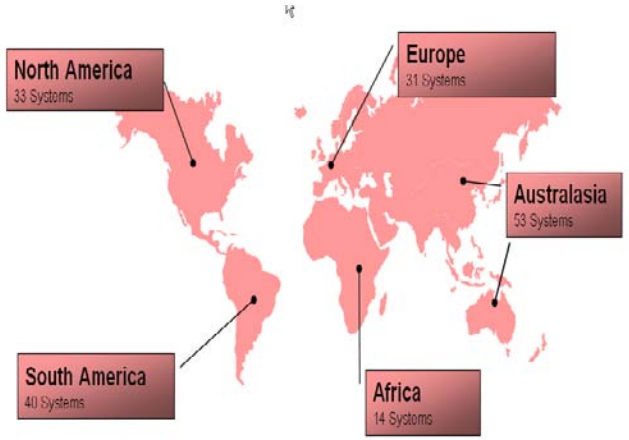
Results: High ROI at low risk

Successful Products, Stories and Teams

- Global Fuels Conference Award for “most innovative technology for electrical energy savings”
- More than 30 new projects per year in process industries



Customer Value with cpmPlus Expert Optimizer



- Value we deliver to customer
  - Increased Output **2% to 8%**
  - Reduced Fuel Consumption **3% to 5%**
  - Reduced Emission Levels **3% to 5%**
  - Reduced Electricity Consumption **2% to 10%**
  - Reduced Quality Variability **10% to 20%**
- Customers
  - Oil & Gas
  - Pulp & Paper
  - Minerals, Metals
  - Industrial Power

Power and productivity
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