How to Save Energy Through Enhanced Automation

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Speaker

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Advanced Applied Technologies

Process Systems and Solutions

Emerson Process Management

Many years experience designing, justifying, installing and commissioning advanced real time computer applications in the process industries.

EMERSON
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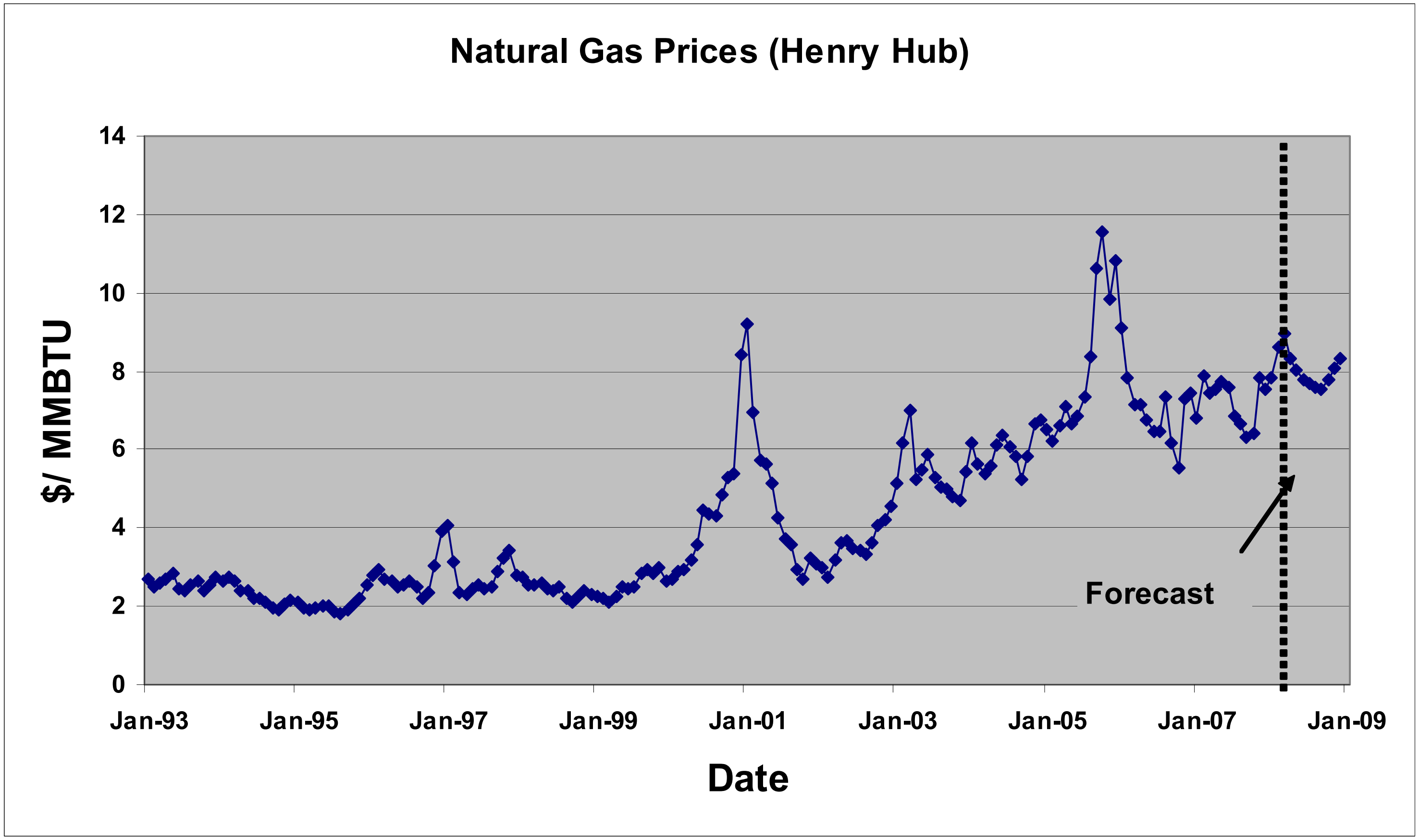
Natural Gas Prices



Process Energy Usage

	Process Energy; MM BTU/ Ton	Value; 10% Energy Reduction; $/ Ton ($7/ MMBTU)
Petroleum Refining	4.4	3.1
Integrated Pulp/Paper Mill	29.0	20.3
Cement Production	7.9	5.5
Chemicals		
Ethylene	7.1	5.0
Polyethylene	6.7	4.7
EDC	9.4	6.6
PVC	4.0	2.8
EO	6.2	4.3
EG	7.1	5.0
Ethylbenzene	2.9	2.1
Styrene	38.8	27.2

Largest Controllable Cost in Most Plants!

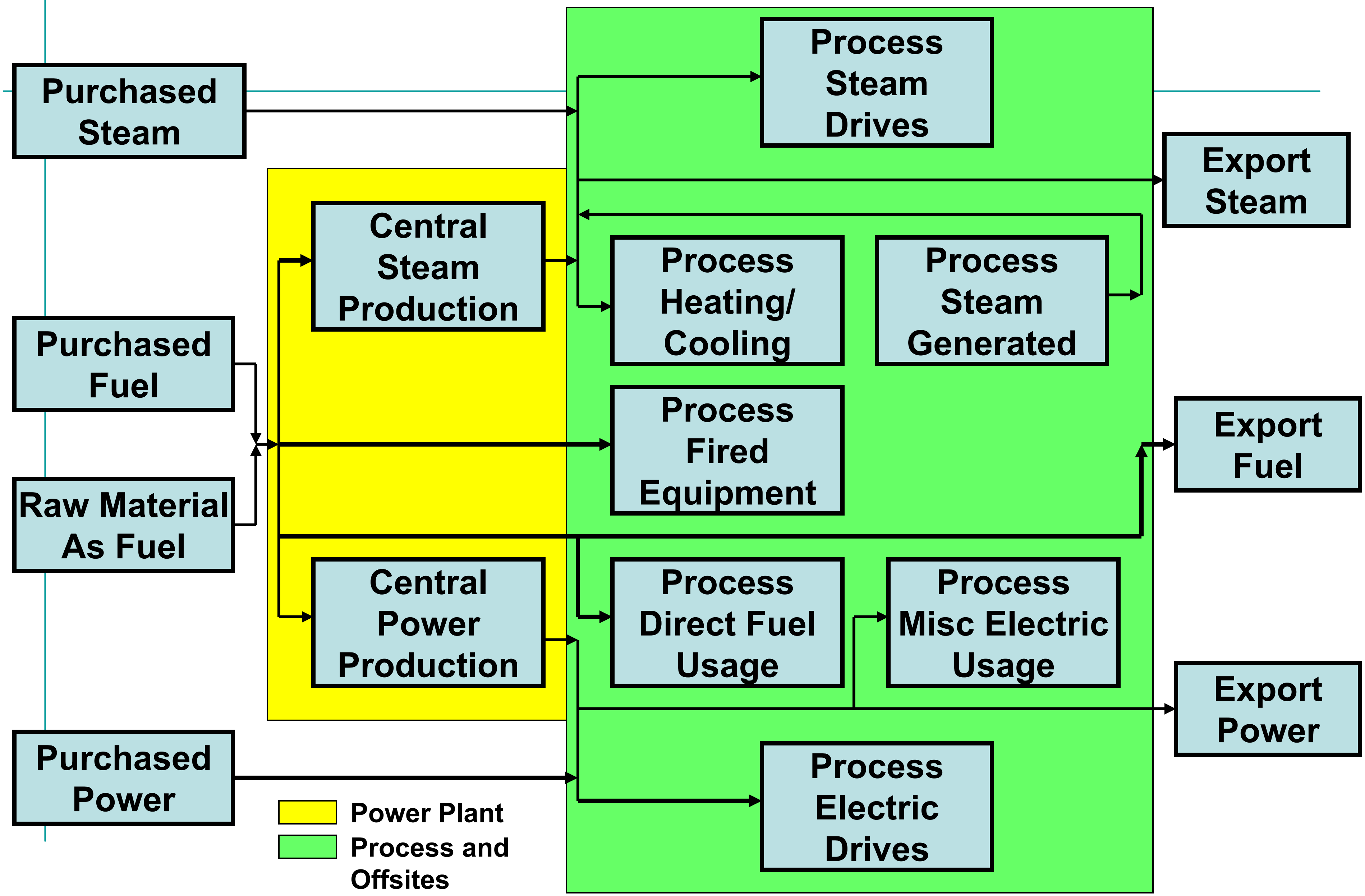
Session Objective

Present some case studies of the many ways that automation, advanced automation and asset management can save energy in process plants

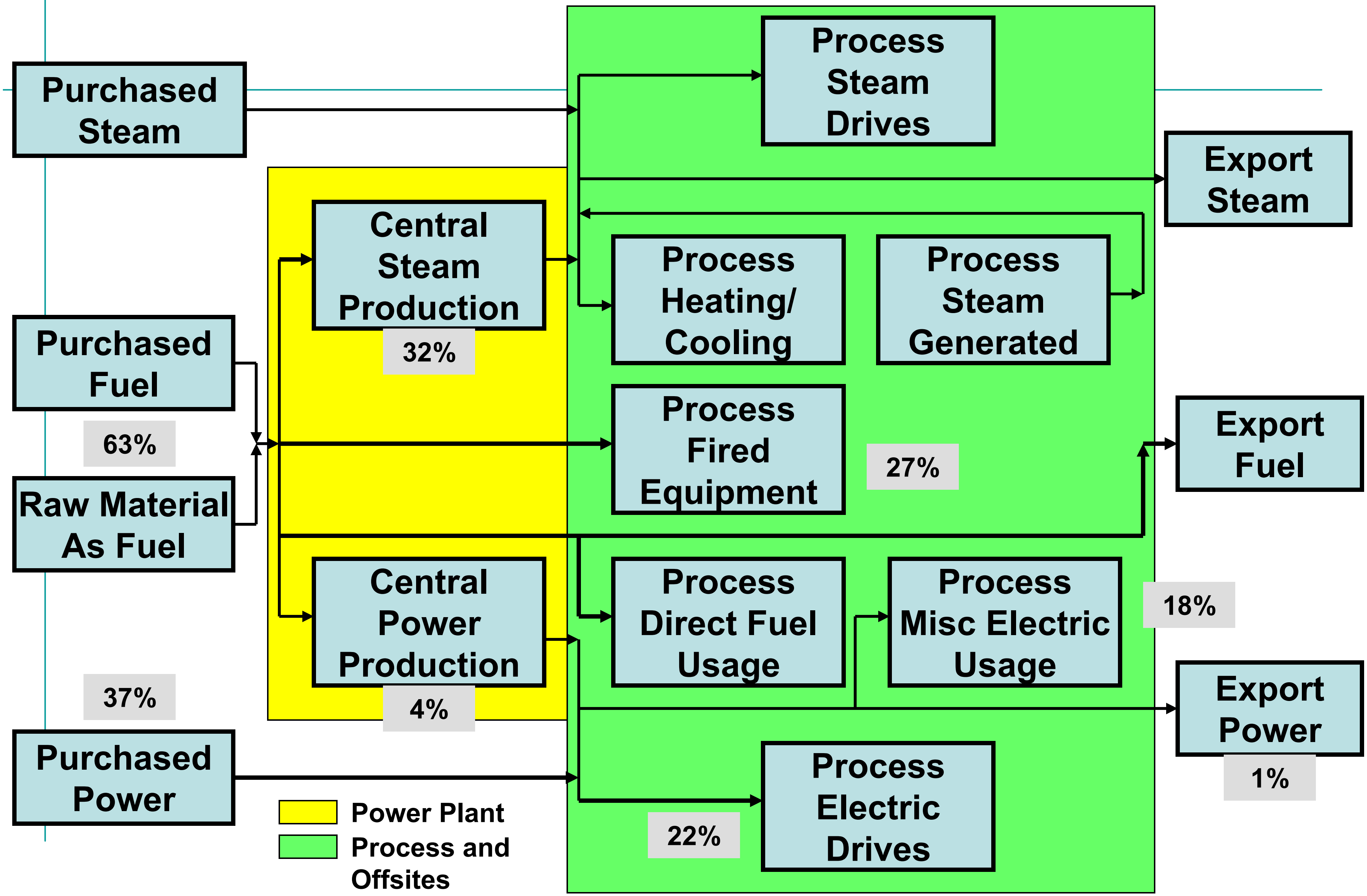
Outline

- How is energy used in process plants?
- How can automation help save energy?
- How do we implement an energy reduction program?

General Process Site Energy Flow

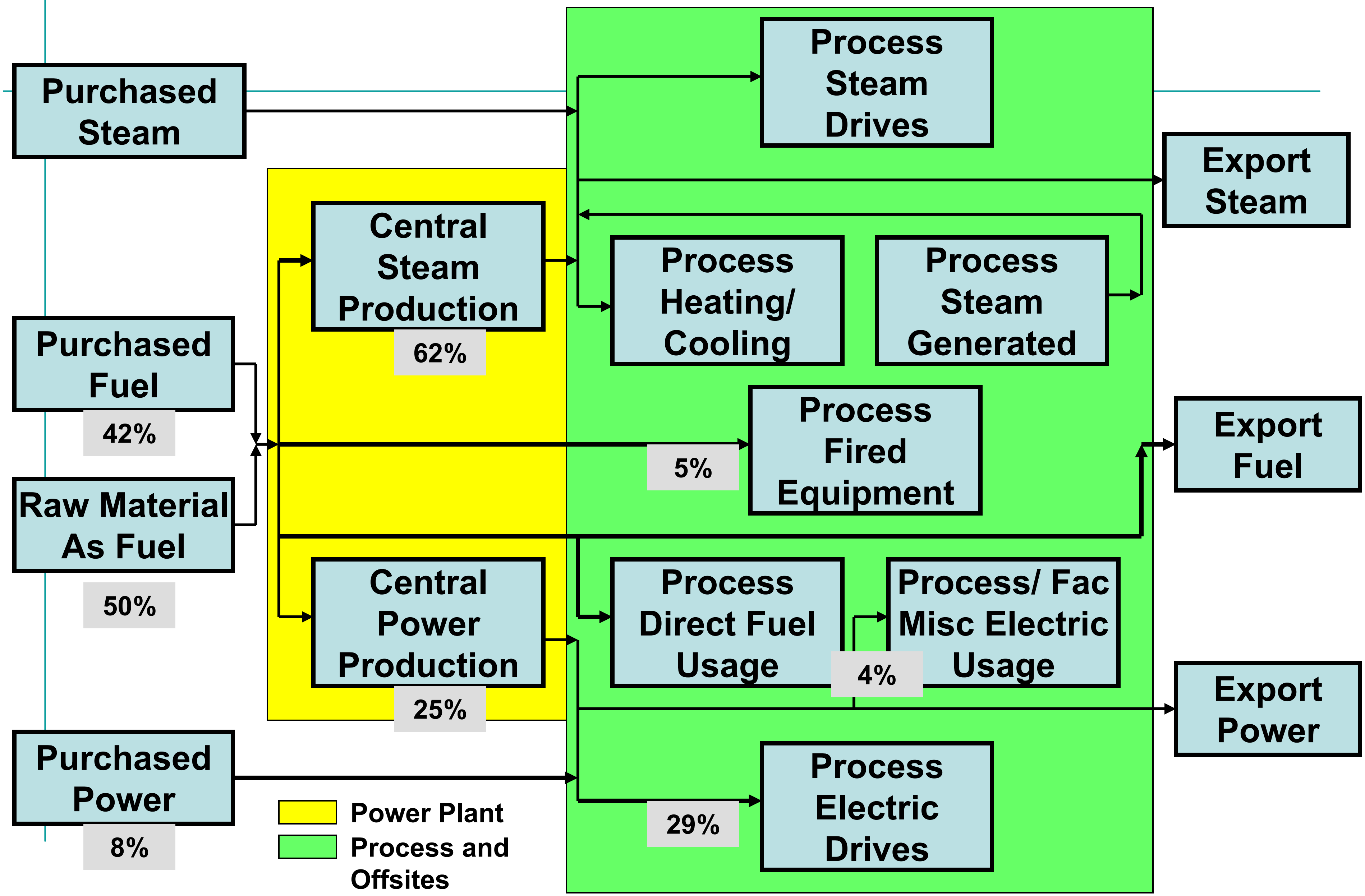


"Average" Chemical Site Energy Flow



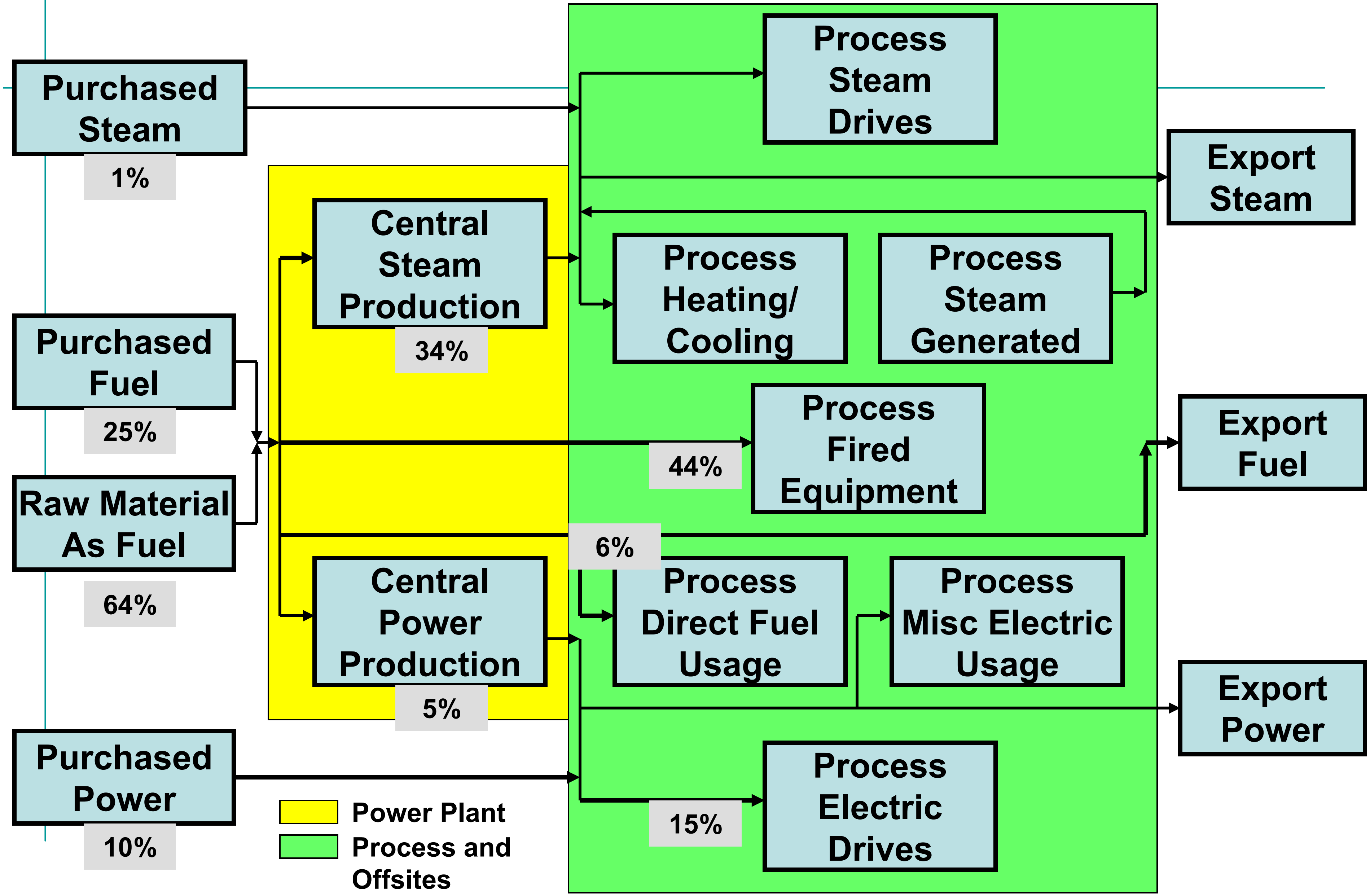
%-Equivalent BTU basis (including losses) on total input

Integrated Pulping Paper Mill Energy Flow



%-Equivalent BTU basis (including losses) on total input

Oil Refinery Energy Flow



%-Equivalent BTU basis (including losses) on total input

Reducing Plant Energy Costs

- Reduce Usage
  - Individual Equipment
    - Improve Efficiencies – Boilers, Heaters, kilns
    - Maximize Useful Recovery - Preheat
    - Minimize Losses
      - Cooling water
      - Minimize Motor Losses
  - Unit Savings
    - Optimize Process Unit Operations
      - Distillation/ Fractionation
    - Maximize Waste Heat Recovery
    - Minimize waste/ off spec
  - Site/ Multi – Unit Savings
    - Minimize Steam Losses and Downgrading
    - Switch of steam drives for electric or vice versa
    - Seasonal effects

- Reduce Cost of Production and Purchase
  - Fuel Substitution
  - Generation Maximization
  - Boiler and Turbine Allocation
  - Electric Purchase Optimization

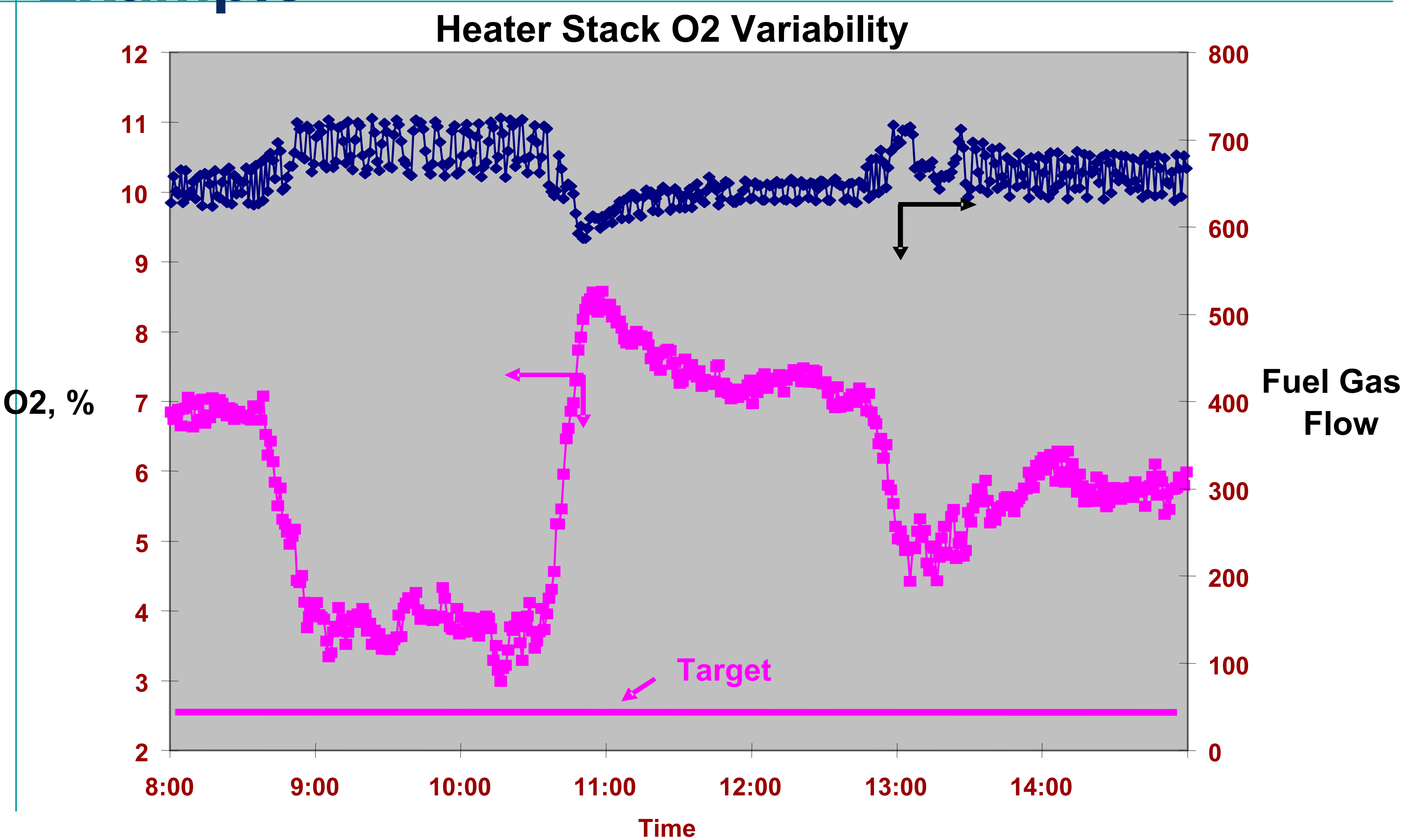
Automation and Advanced Automation are the keys to effective operation and minimum ongoing energy usage

Process Industry Energy Saving Primary Targets

- Fired Heaters
- Distillation/ Fractionation
- Central Power and Steam Production

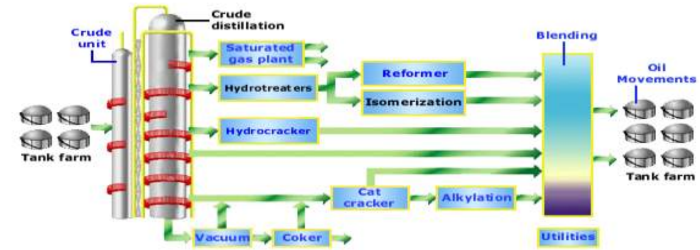
How can Automation Reduce Energy Usage?

Variability – Potential Energy Savings Example

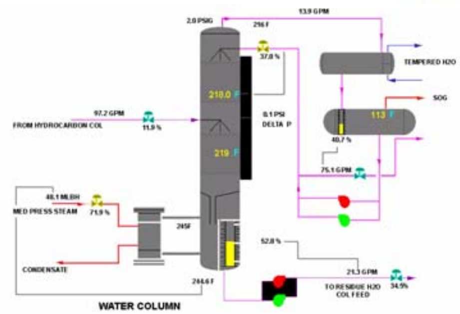


Energy Savings Through Automation – Target Areas

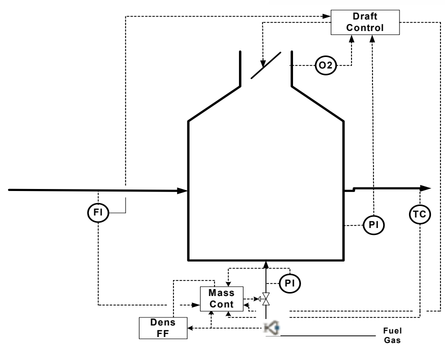
Site- Wide

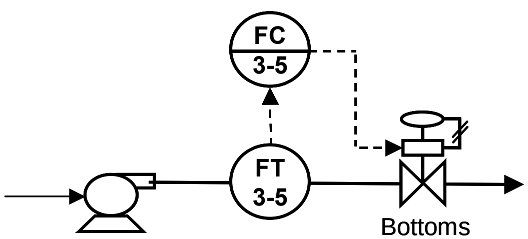


Process Unit



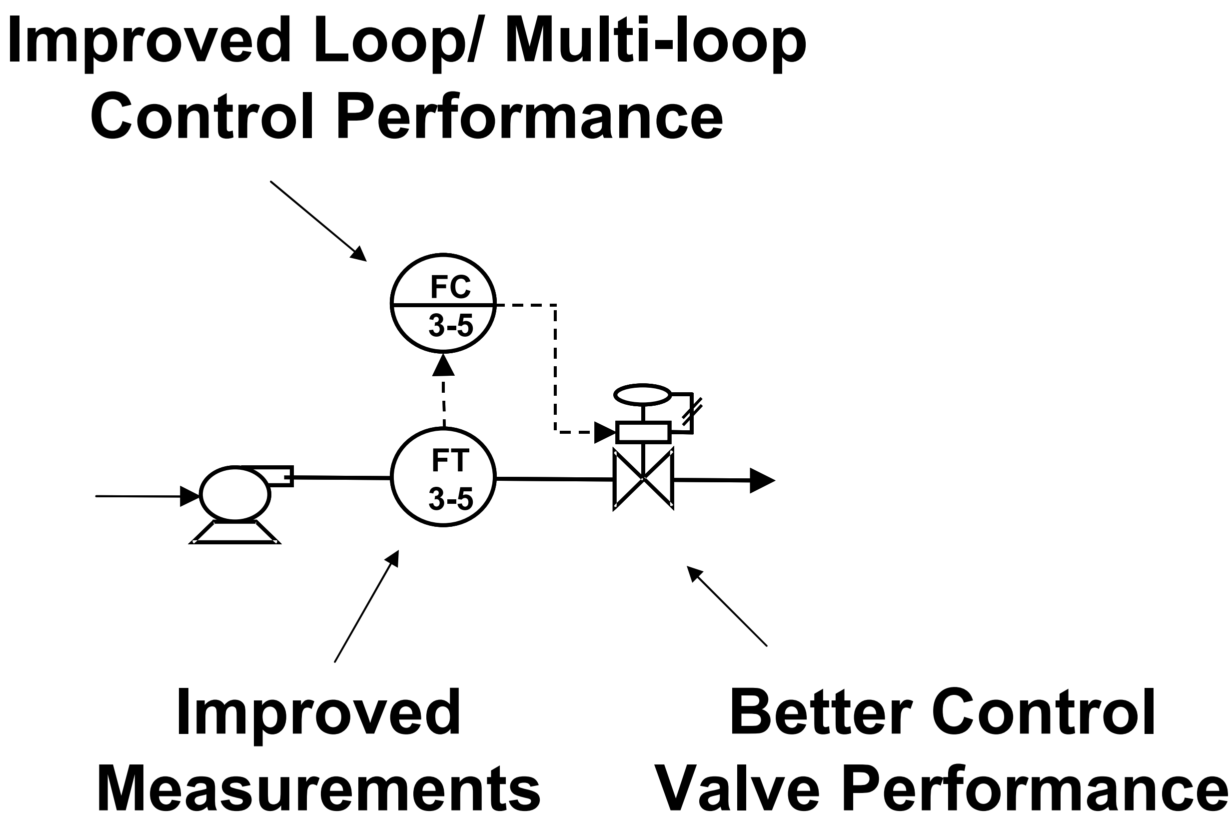
Equipment





Device, Loop

Saving Energy – Automation Examples

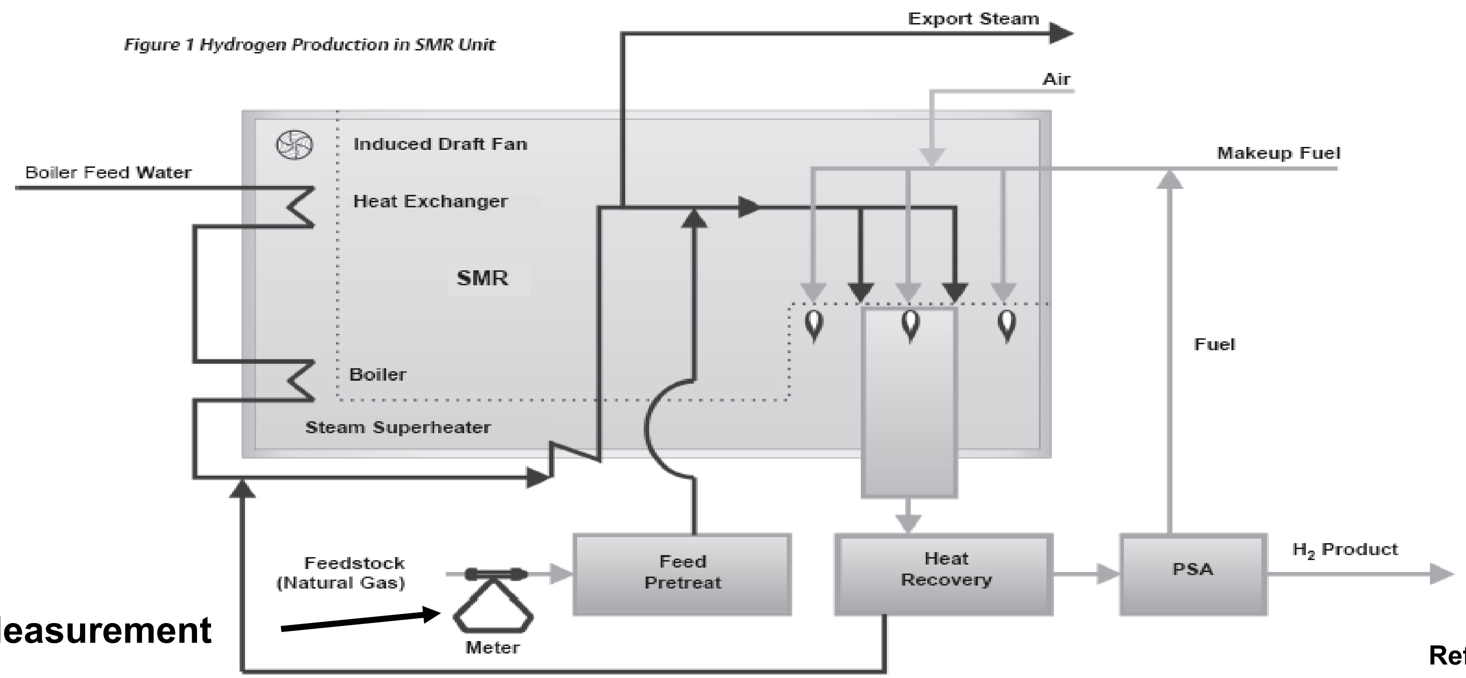


Component Heating Values

Fuel Gas Component Heating Value	
Component	Heat of Combustion kcal/ NM3 (gross)
Hydrogen	3020
Methane	9520
Ethane	16820
Propane	24320
Butane	32010

Control Fuel Flows By Mass Instead of Volume

Energy Savings From Improved Measurements – Hydrogen Plant



Mass Measurement

Ref: MMI WP_00724

Objective: Control S/C ratio as close to 3.2 as possible but avoid going below

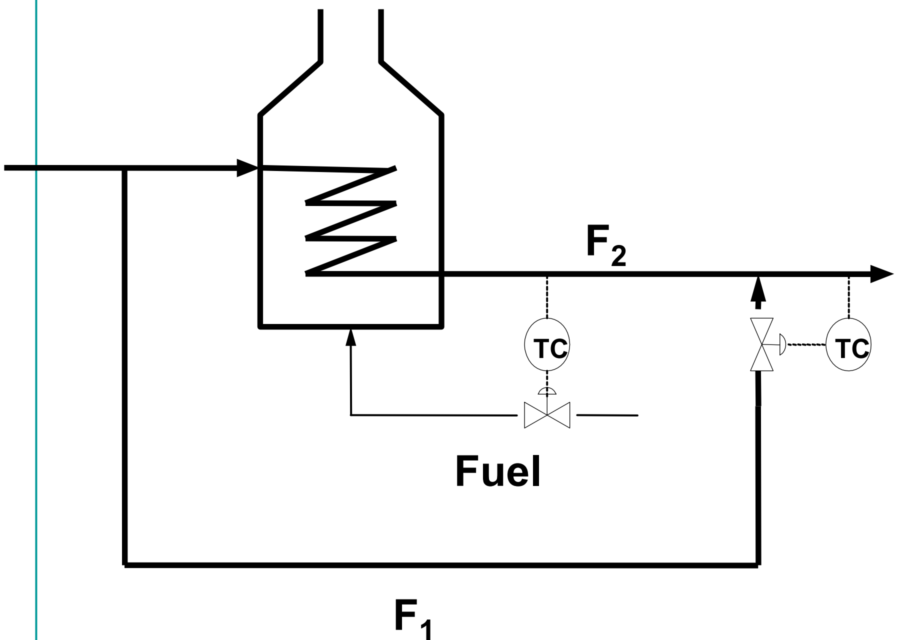
Disturbance: Fuel gas C1 77 – 85%; C2 6.8 – 15; N2, CO also fluctuate

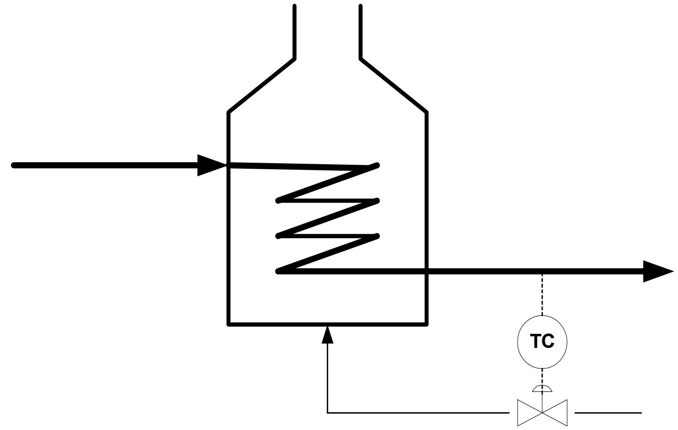
Test: Normal orifice plus GC – max error 0.2; MMI – max error – 0.02

Benefits: Moving 0.2 ratio closer to limit worth 8 BTU/SCF of H2;
80 MMSCFD plant; $7 MM BTU gas –

$1.6 MM per year

Energy Losses Through Bypassing



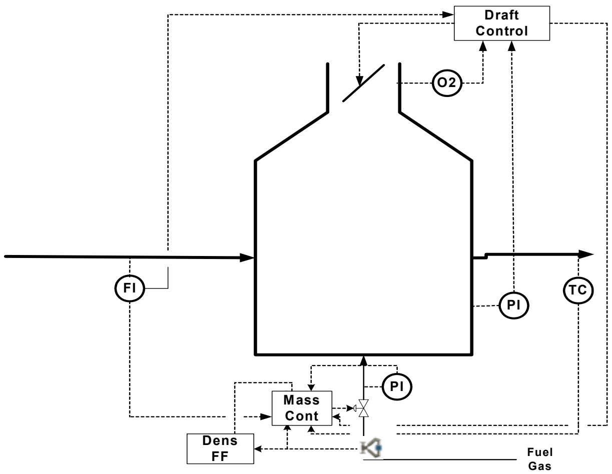


$F_1/(F_1 + F_2)$	Heat Loss Increase -%
0.14	3.2
0.25	6.8
0.4	14.3

Reference:
Shinskey;

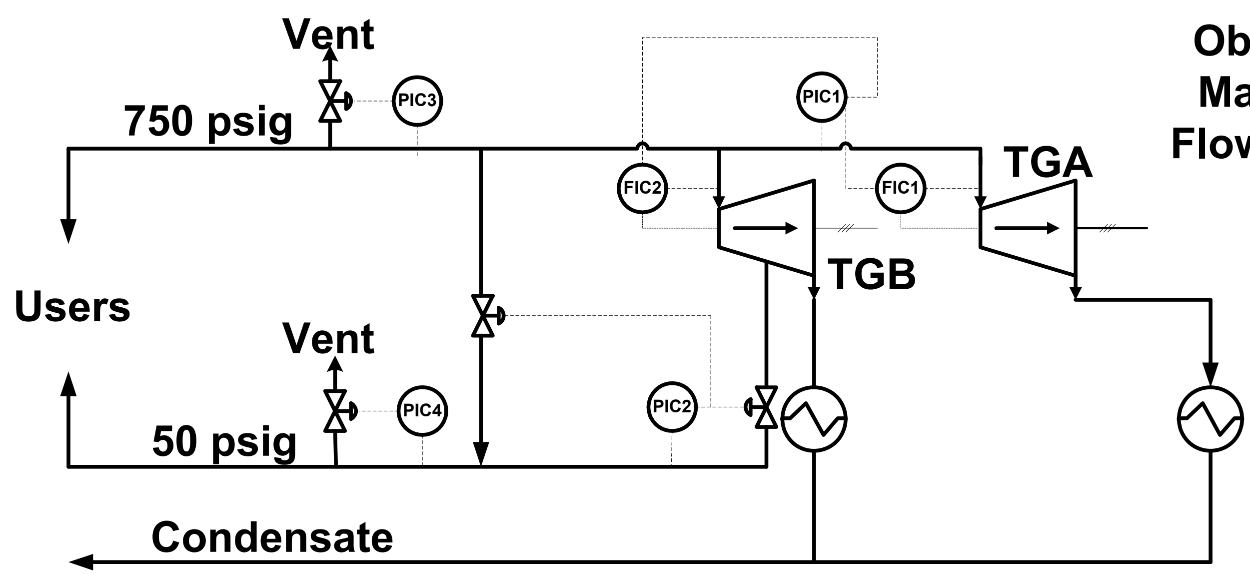
Energy Conservation Through Automation

Energy Savings – Equipment Level

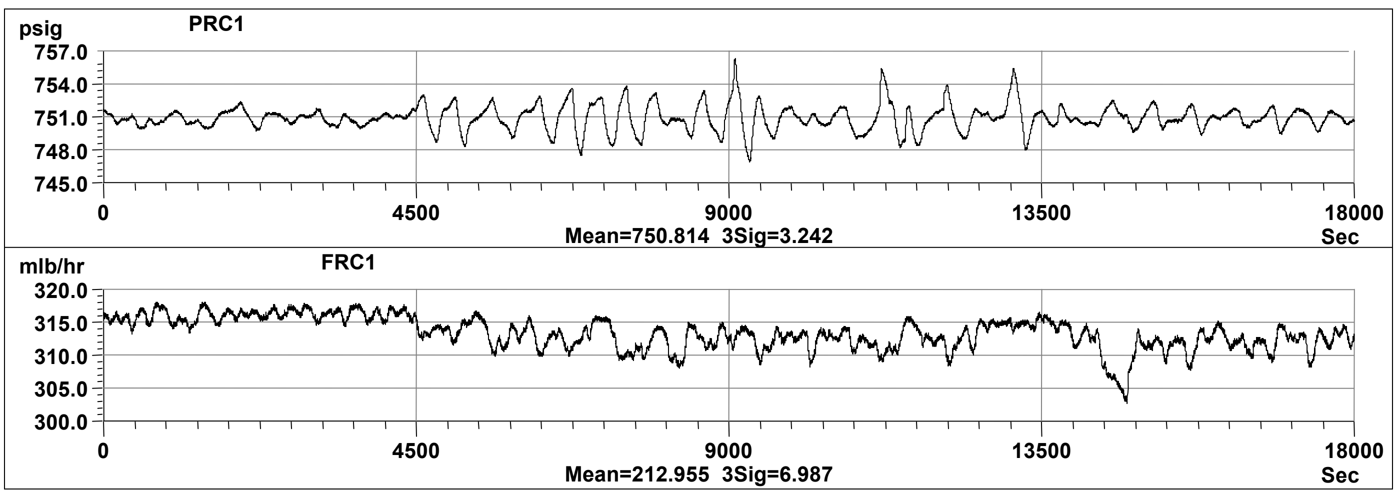


- Improved Multi-Loop Control – Advanced Control
- Improved Performance Monitoring
- Improved Diagnostics

Steam System Control Issues

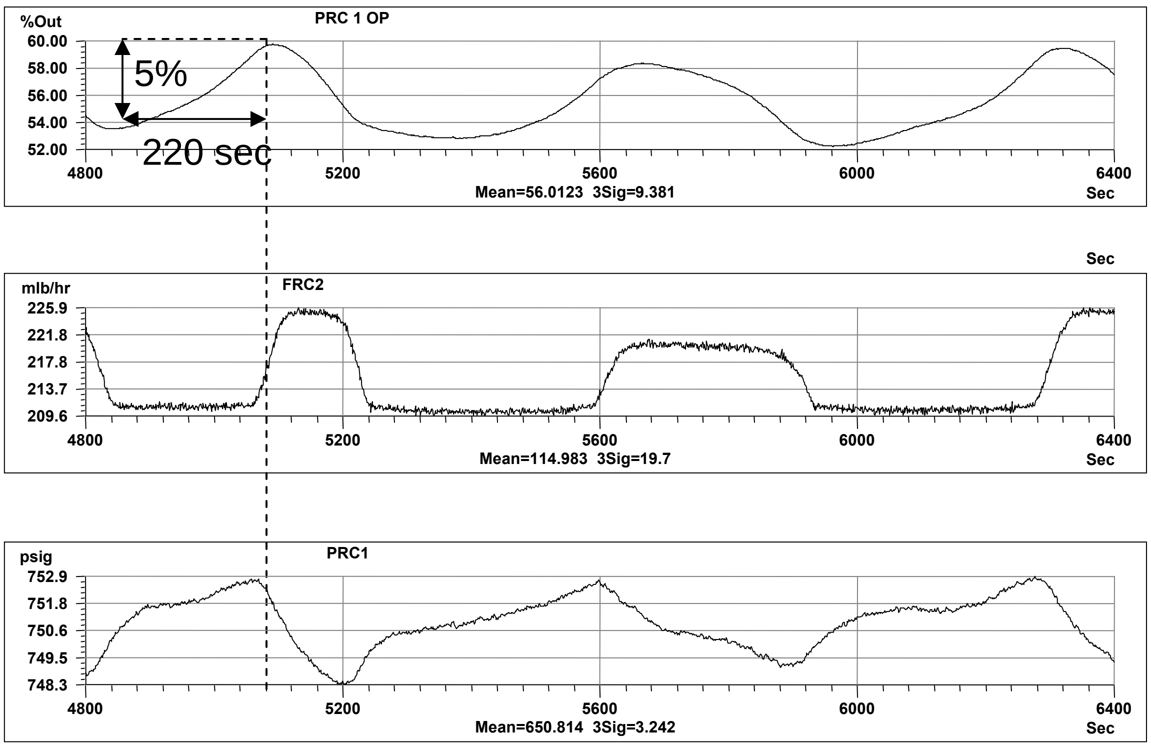


Objective: Maximum Flow to TGA



Problem: Pressure Instability in Header Limited Flow to TGA

Steam System Diagnosis – Valves and Tuning



Flow controller to TGB has 5% deadband; induces limit cycle in pressure

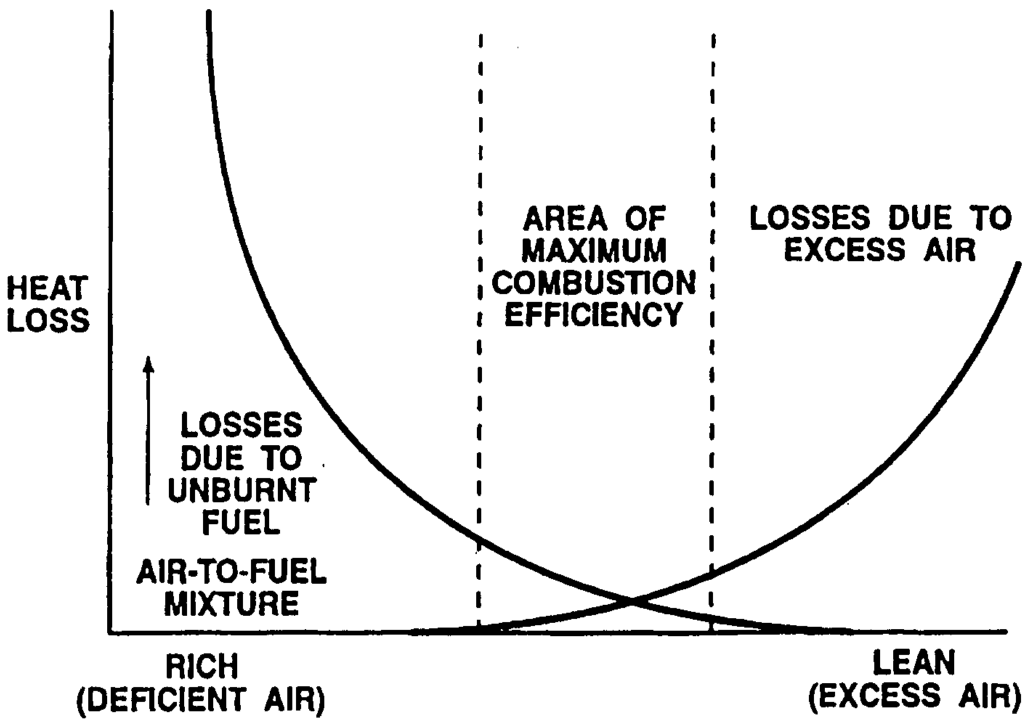
Correction:
Fix TGB turbine governor/ steam valve

Tune controllers as system – not individually

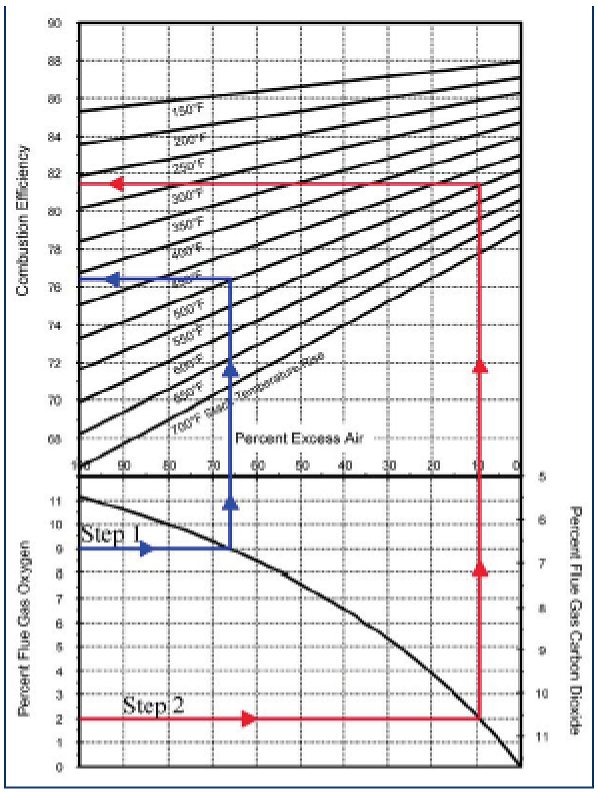
Estimated value of increased flow to TGA - $3000/ day

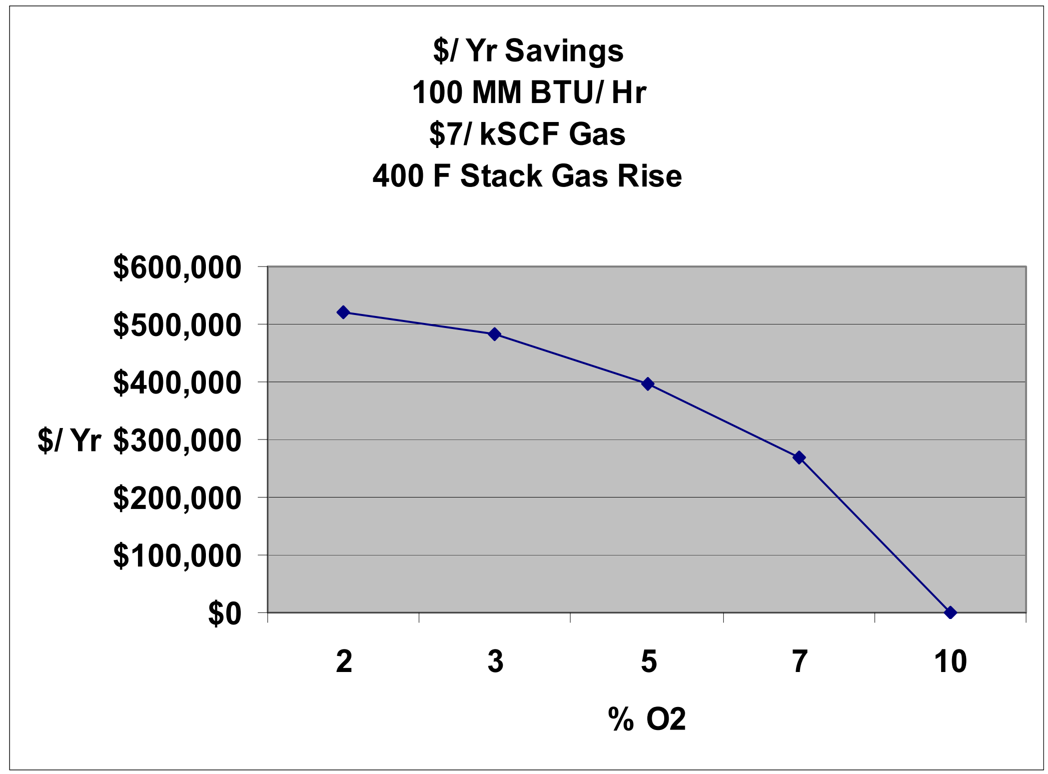
Fired Heater Controls

Combustion Control

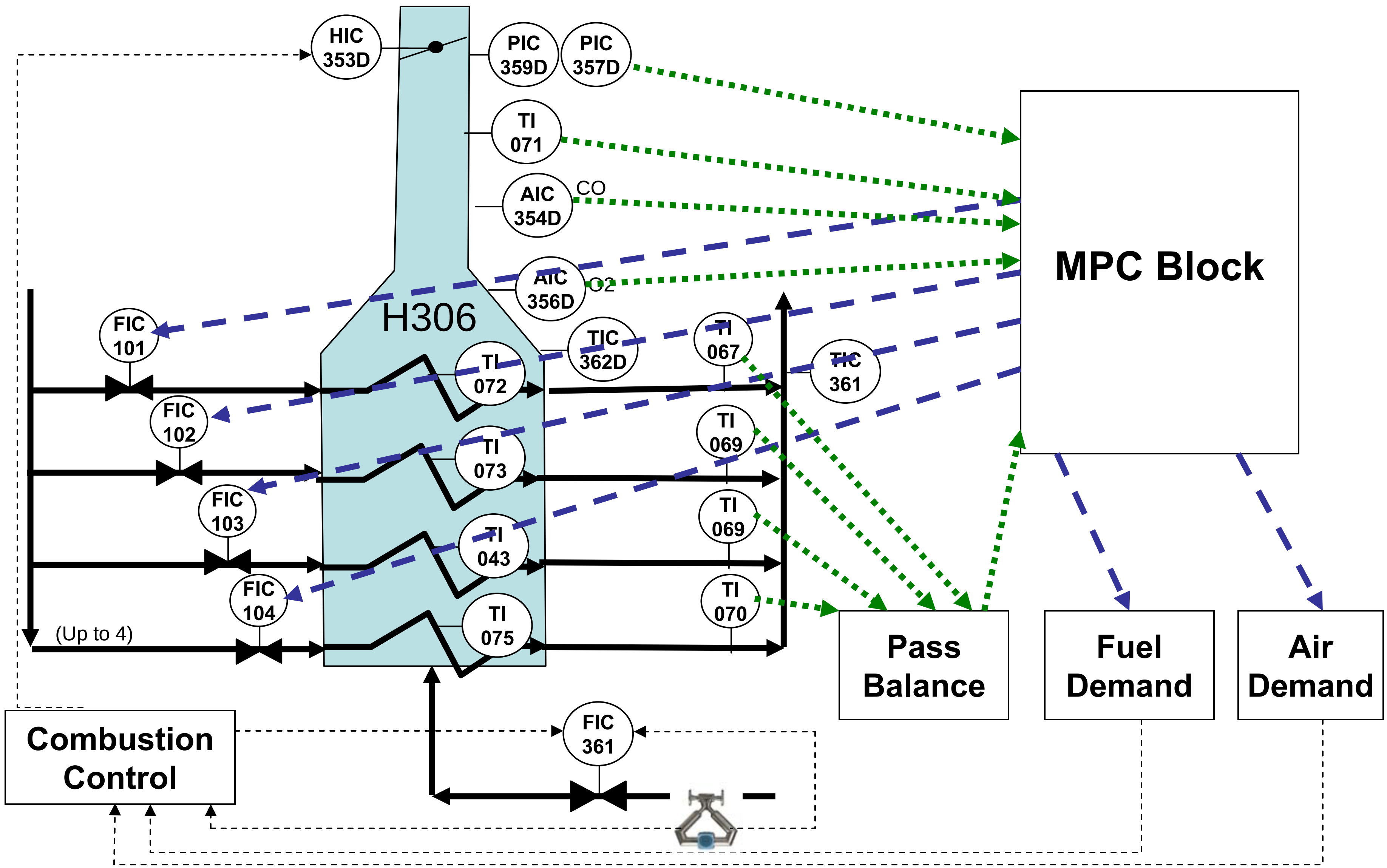


Heater/ Boiler Combustion Control Savings





Typical Heater APC Package

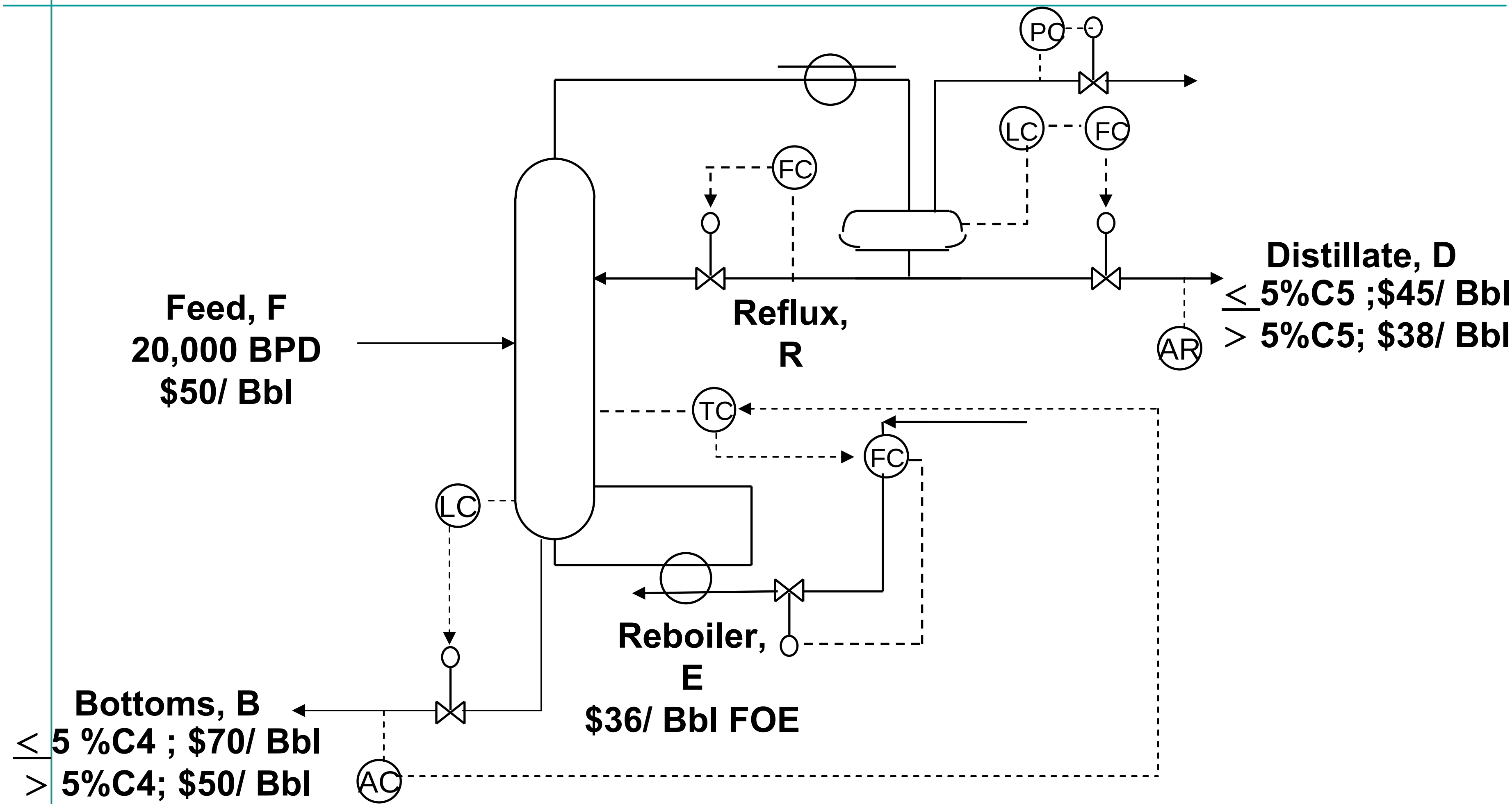


Excuses For Not Improving Heater Controls

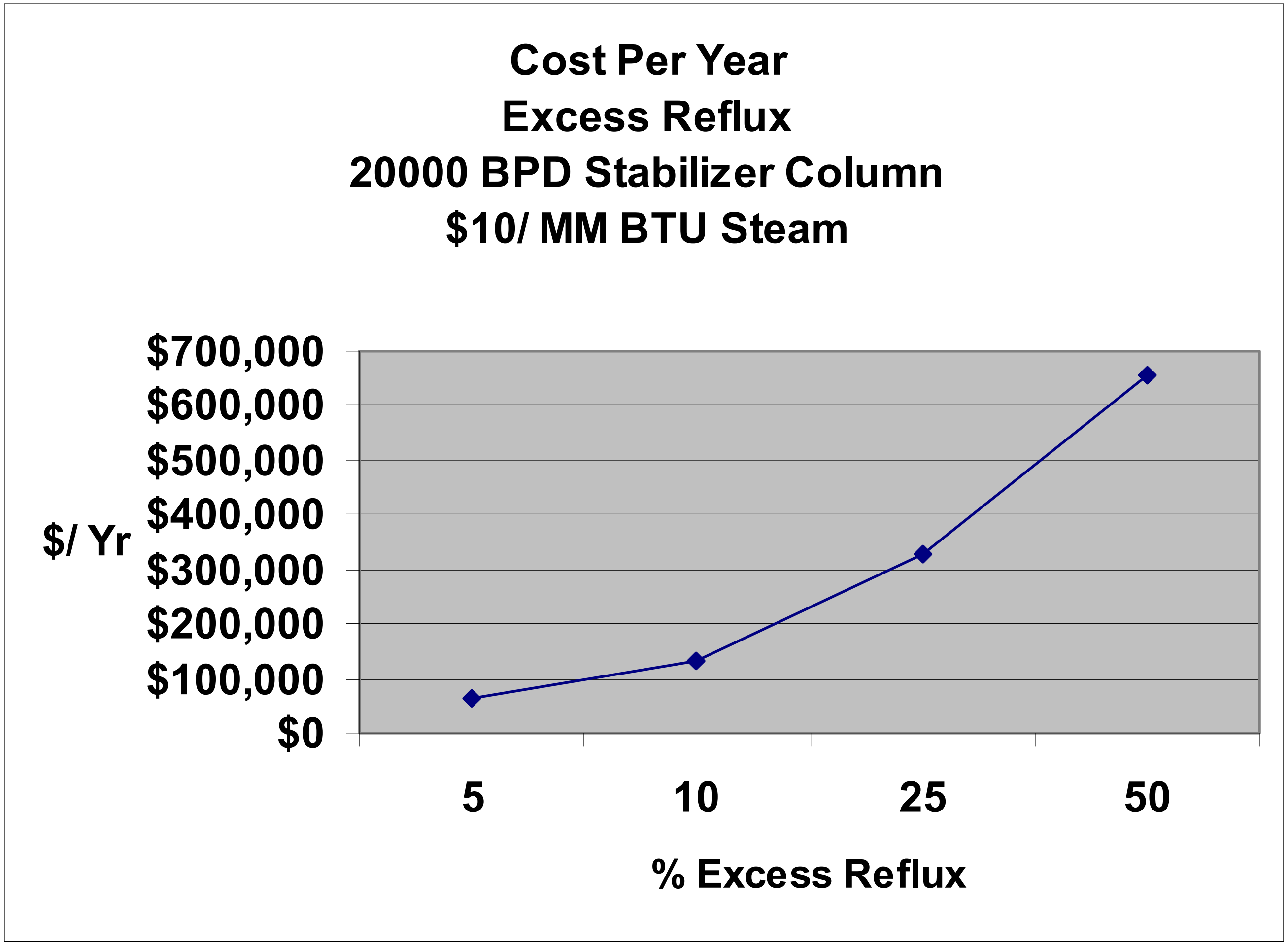
- **Damper/ Air controls are not reliable**
  - **Answer: Add positioners to dampers, with feedback to control system; Analyze and fix controller problems**
- **Don’t have online analyzer/ can’t maintain them**
  - **Answer: Analyzers are cheaper and more reliable – particularly mass flow meters. With higher fuel costs, they are well justified.**

Distillation Controls

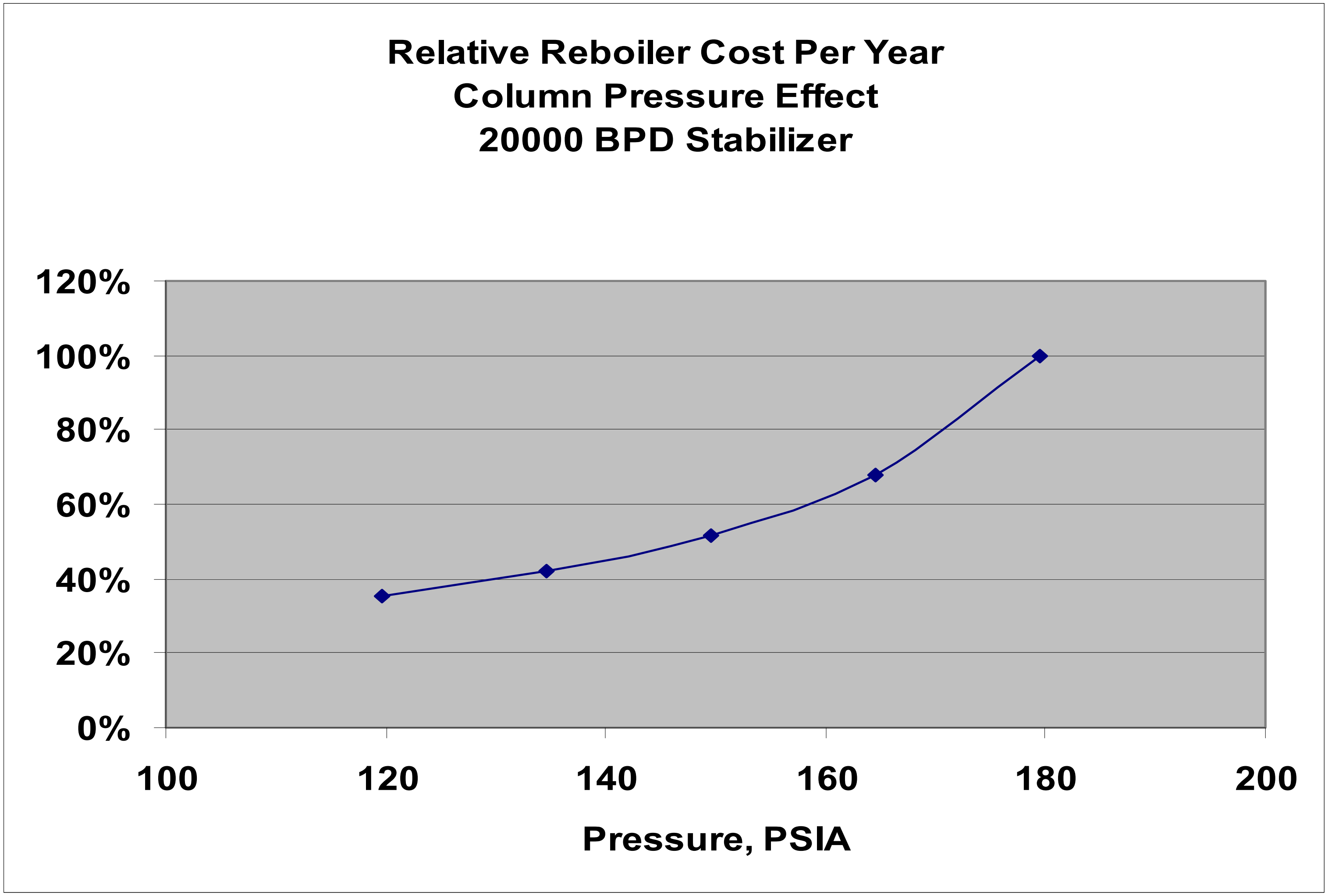
Typical Distillation Column



Distillation Column Control Savings

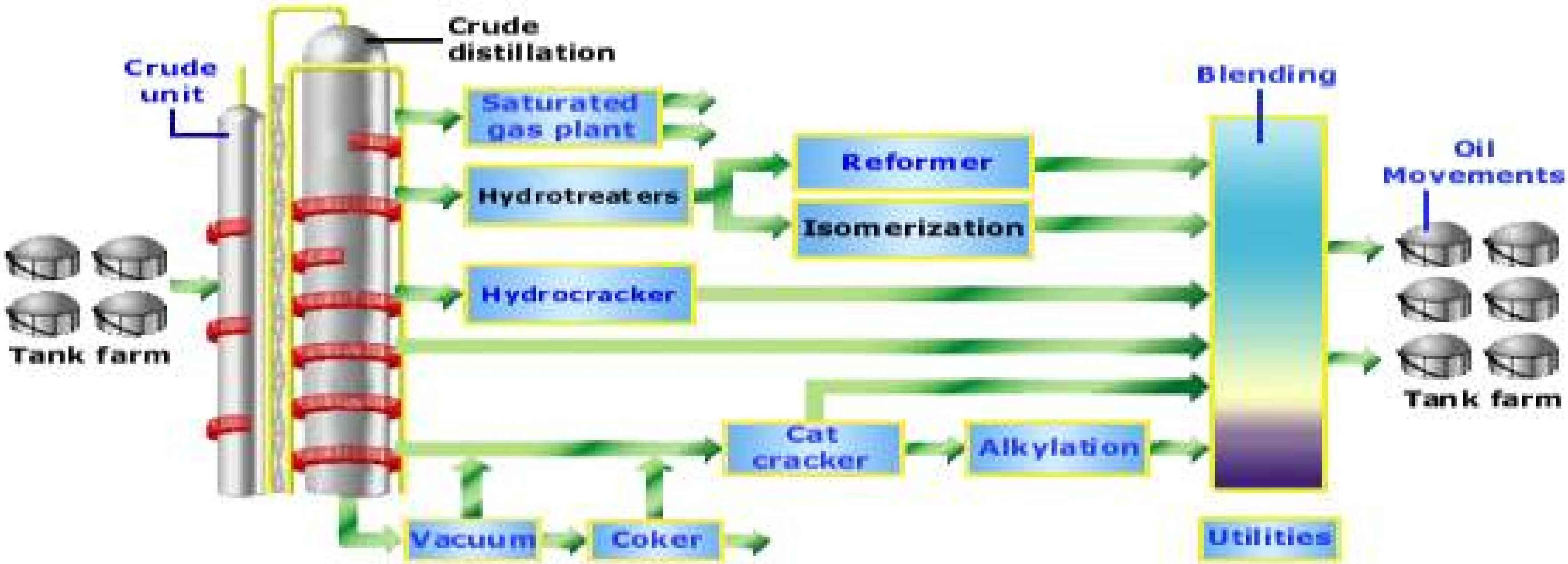


Column Pressure Effect



Basis: Constant Separation
Modeled With ChemSep
Peng Robinson Equation of State

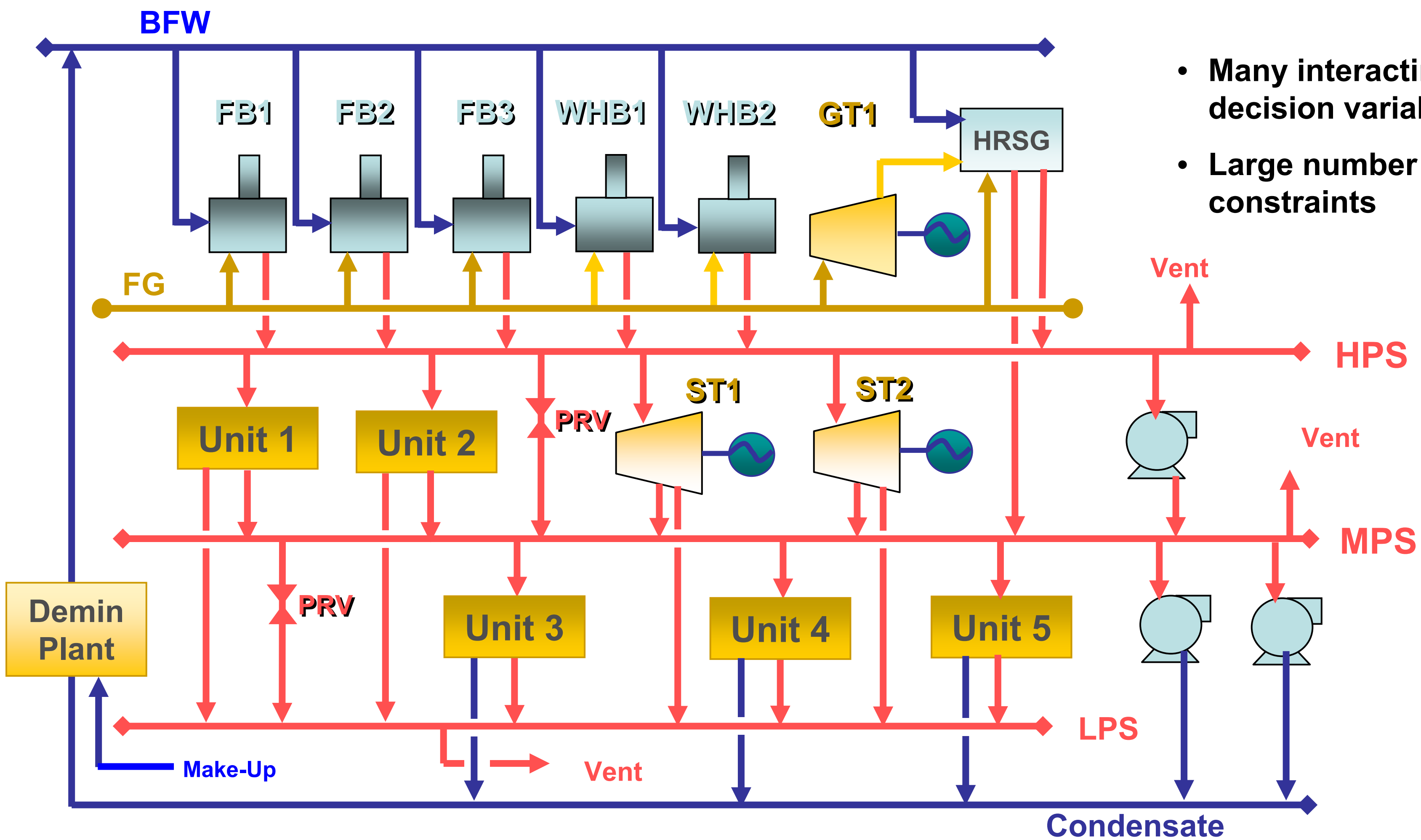
Energy Savings – Site Wide



- Site Energy/ Utility Management
- Steam System Control
- Fuel System Control

Energy Management and Optimization System

Plant Utility Systems – Many Opportunities for Savings

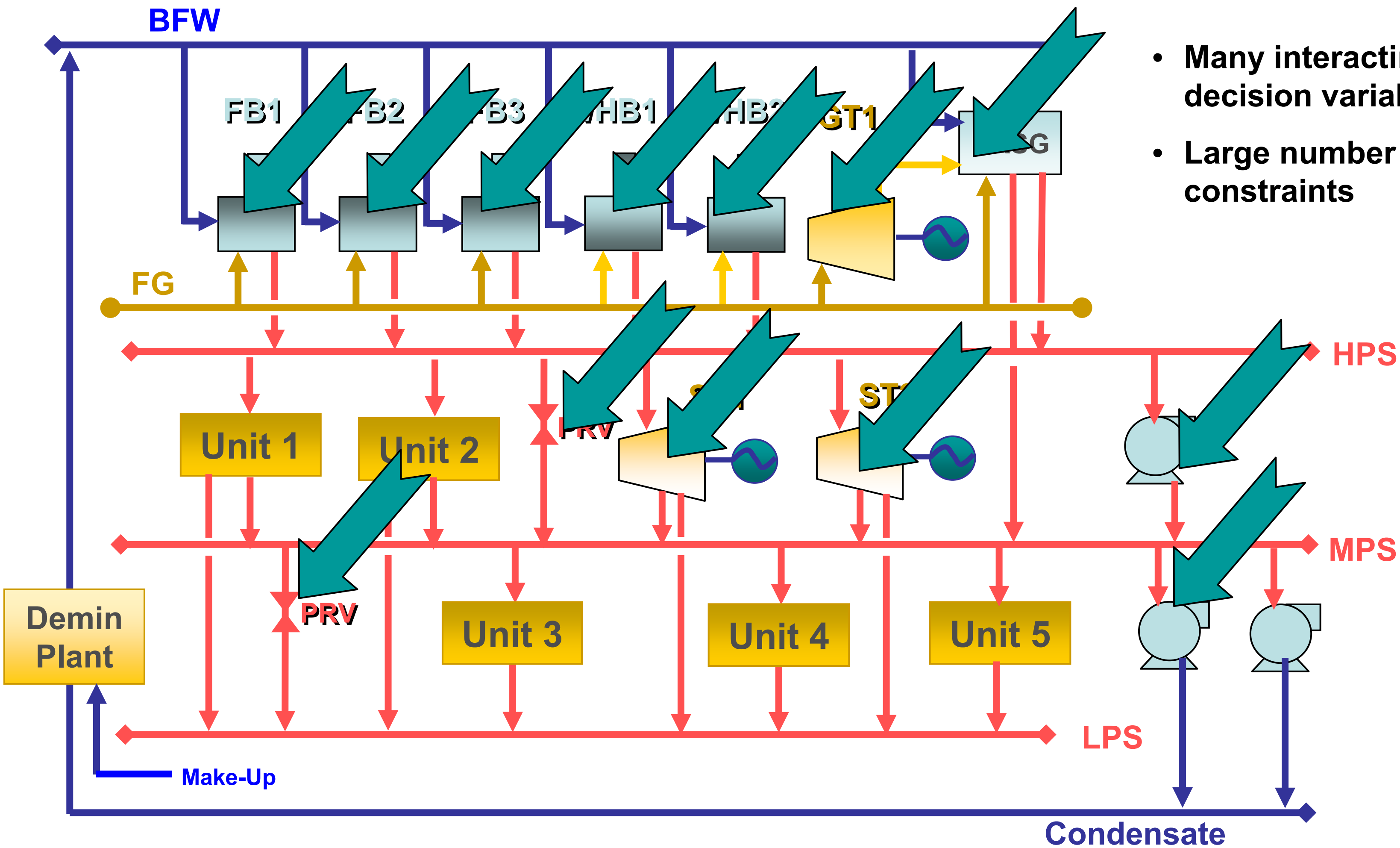


- Many interacting decision variables
- Large number of constraints

Optimizer Decisions

- **Which boiler(s) should I run? What load?**
- **How much electricity should I produce? Buy? Sell? Is it economic to run the steam turbine?**
- **Which fuel should I buy? How much?**
- **Should I be using more steam drives or more electric drives?**
- **When will efficiency gain from maintenance balance the cost of shut down for this equipment?**
- **How does my actual compare with plan corrected to standard conditions?**

Full Utility Optimization

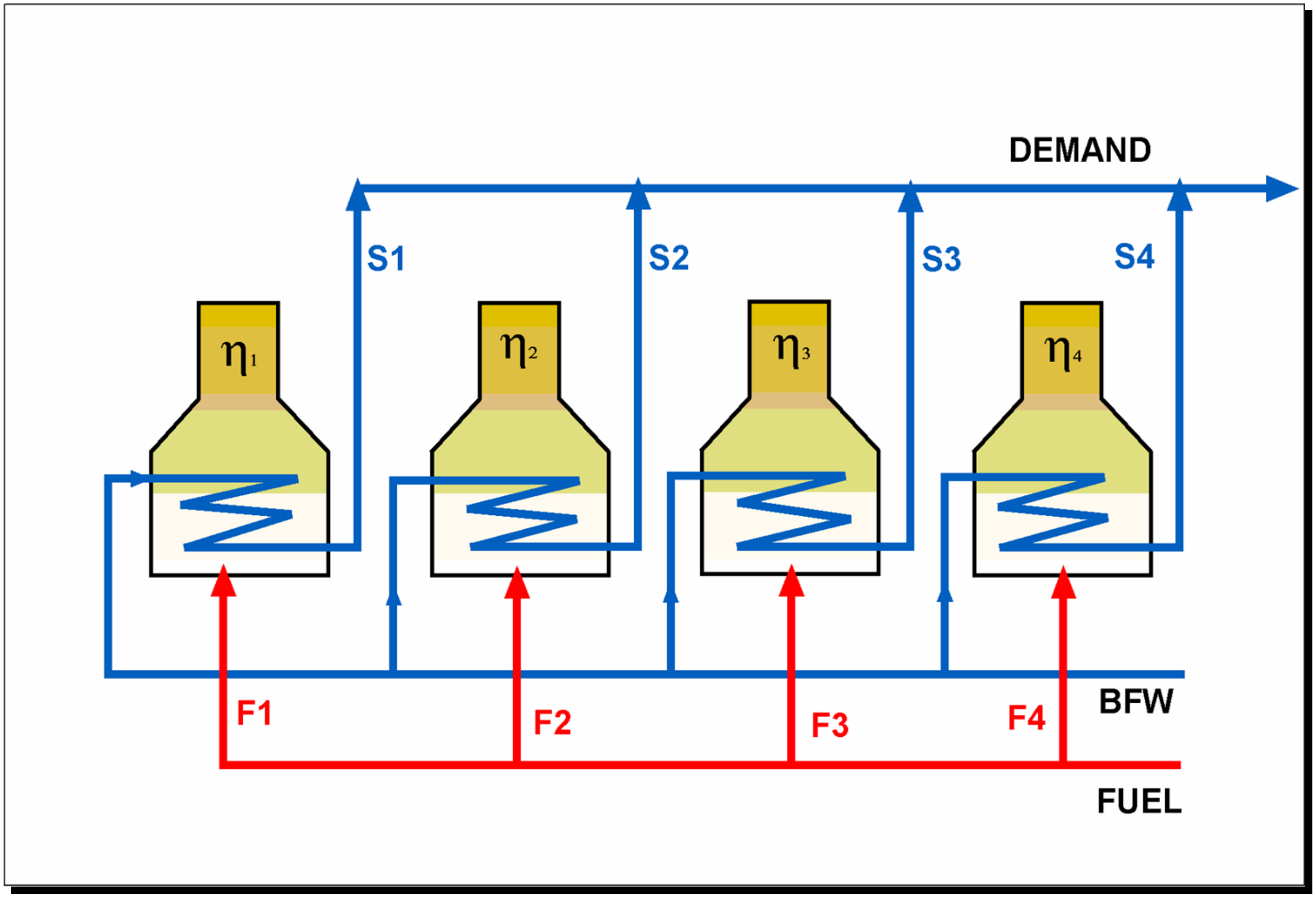


- Many interacting decision variables
- Large number of constraints

Overall Energy Optimization Strategy

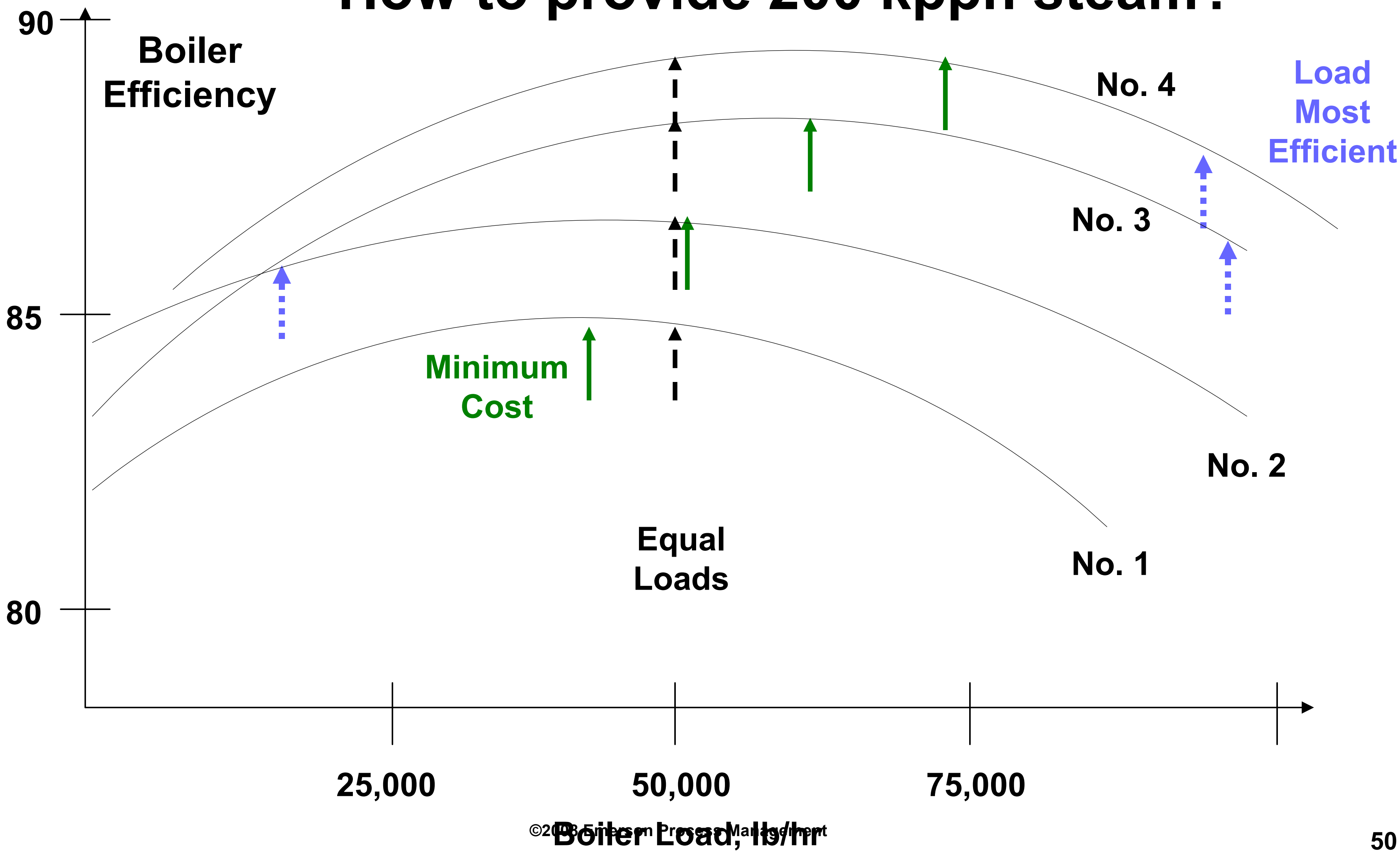
- Continuously Calculate Production Costs Over Load Range with Current Fuel Mix
- Incorporate Constraints on All Equipment
- Decisions Made Through Rule Based Logic
- Boiler Load Allocation
  - Distribute Steam Production Based on Cost and Constraints
- Turbine Load Allocation
  - Distribute Steam for Minimum Cost with Constraints
- Tie-Line Control
  - Control Electrical Purchase Based on Economic Decision and Constraints

Boiler Load Allocation

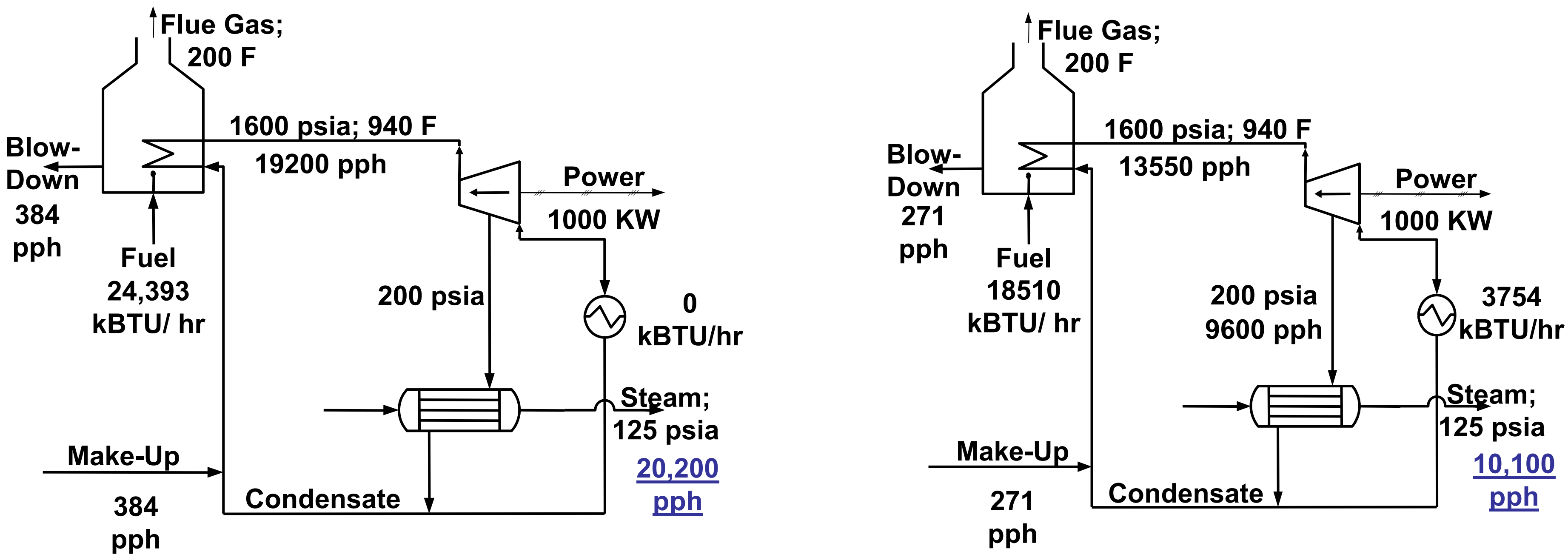


Load Allocation

How to provide 200 kpph steam?



Energy Savings via Site Energy Balance



Naïve calculation, value 125 psia steam reduction =
1000 x (1031 Btu/ lb (ΔH_v) ÷ 0.7(eff))x \$7/MMBtu (Fuel) =
\$10.31 per klb

Reference: Kinney; Energy Conservation in Process Industries

Actual site value 125 psia steam reduction =
\$4.08 per klb

Typical Energy Management System Benefits

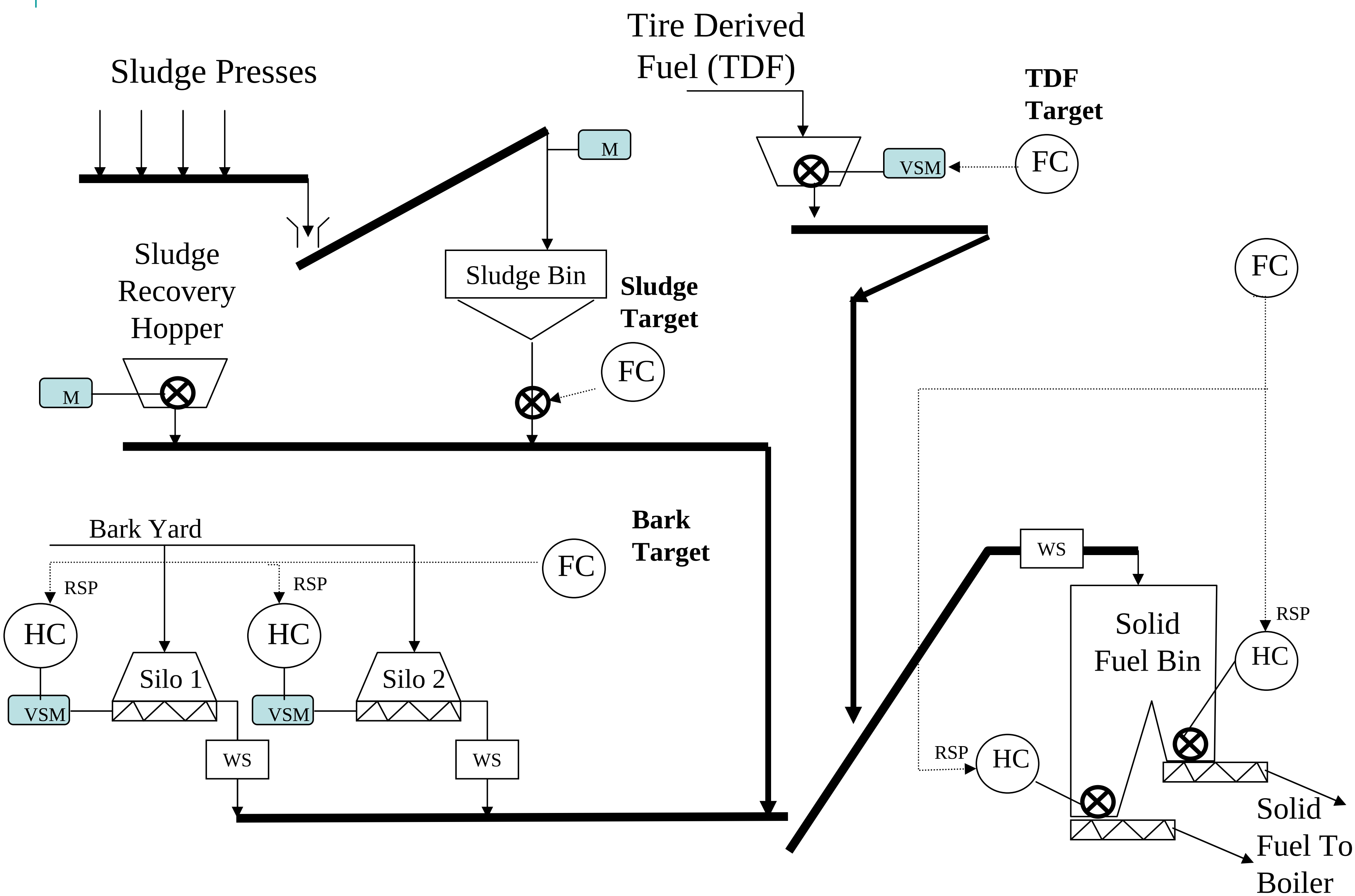
1 – 3 % Overall site utility cost savings!

Example

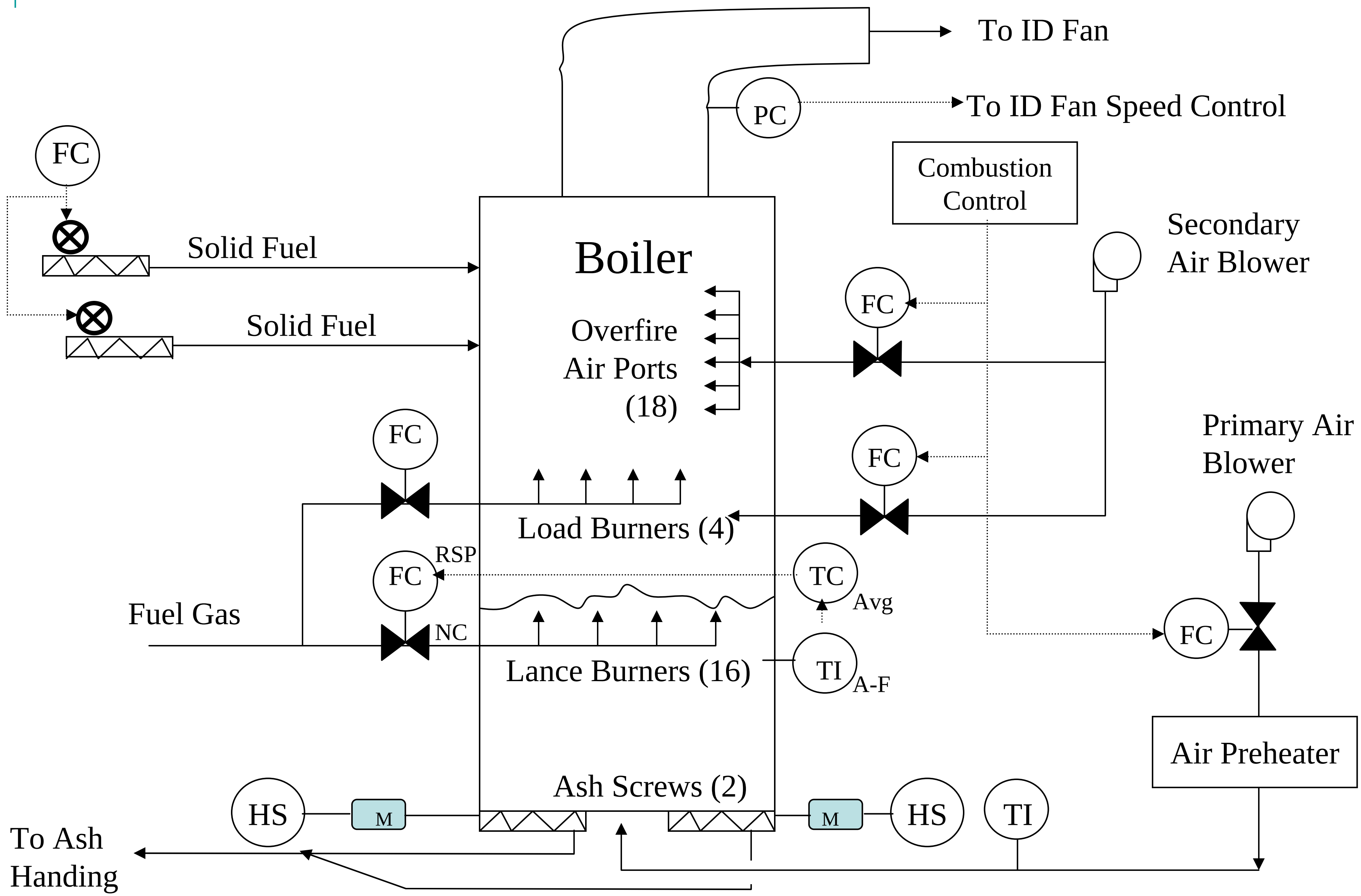
Utilities Example – Biomass Power Boiler

- Paper mill
- 160k PPH Fluidized-bed Boiler
- Fuels:
  - Sludge
  - Wood waste
  - Tires
  - Fuel gas
- Incentives:
  - Maximize use of cheap fuels (Tires & Wood)
  - Burn all the sludge to minimize land fill
  - Maximize steam production

Solid Fuel Composition Control



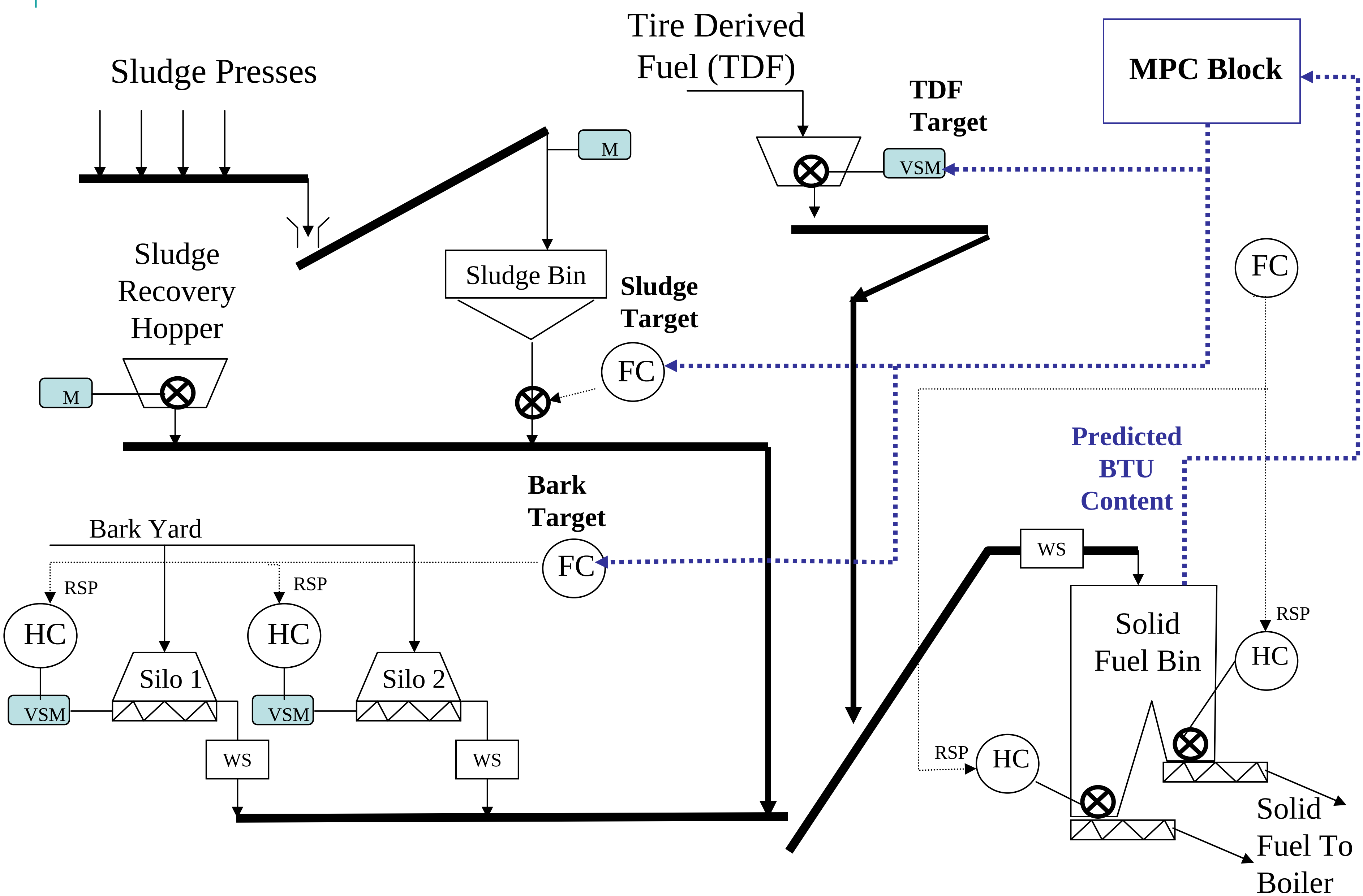
Boiler Control



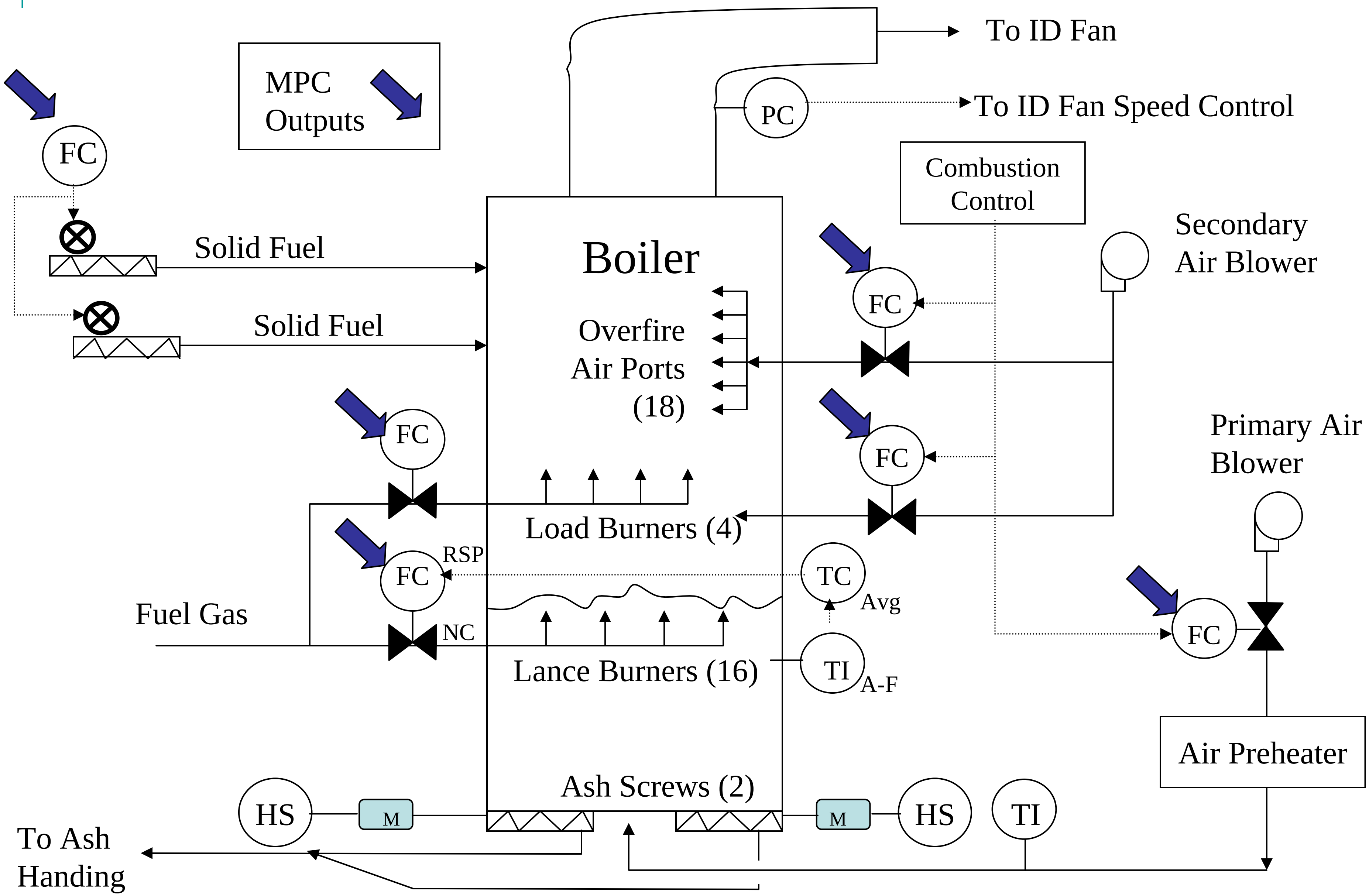
Boiler Process Control Issues

- Varying water in sludge
- Long delay & lag times (20 – 60 minutes) to change fuel composition
- Fuel composition time constants are a function of fuel bin level
- Solid fuel composition in fuel bin is unknown
- Bed temperature constraints (max & min)
- Multiple operators controlling same unit
- Different operating philosophy used by each shift

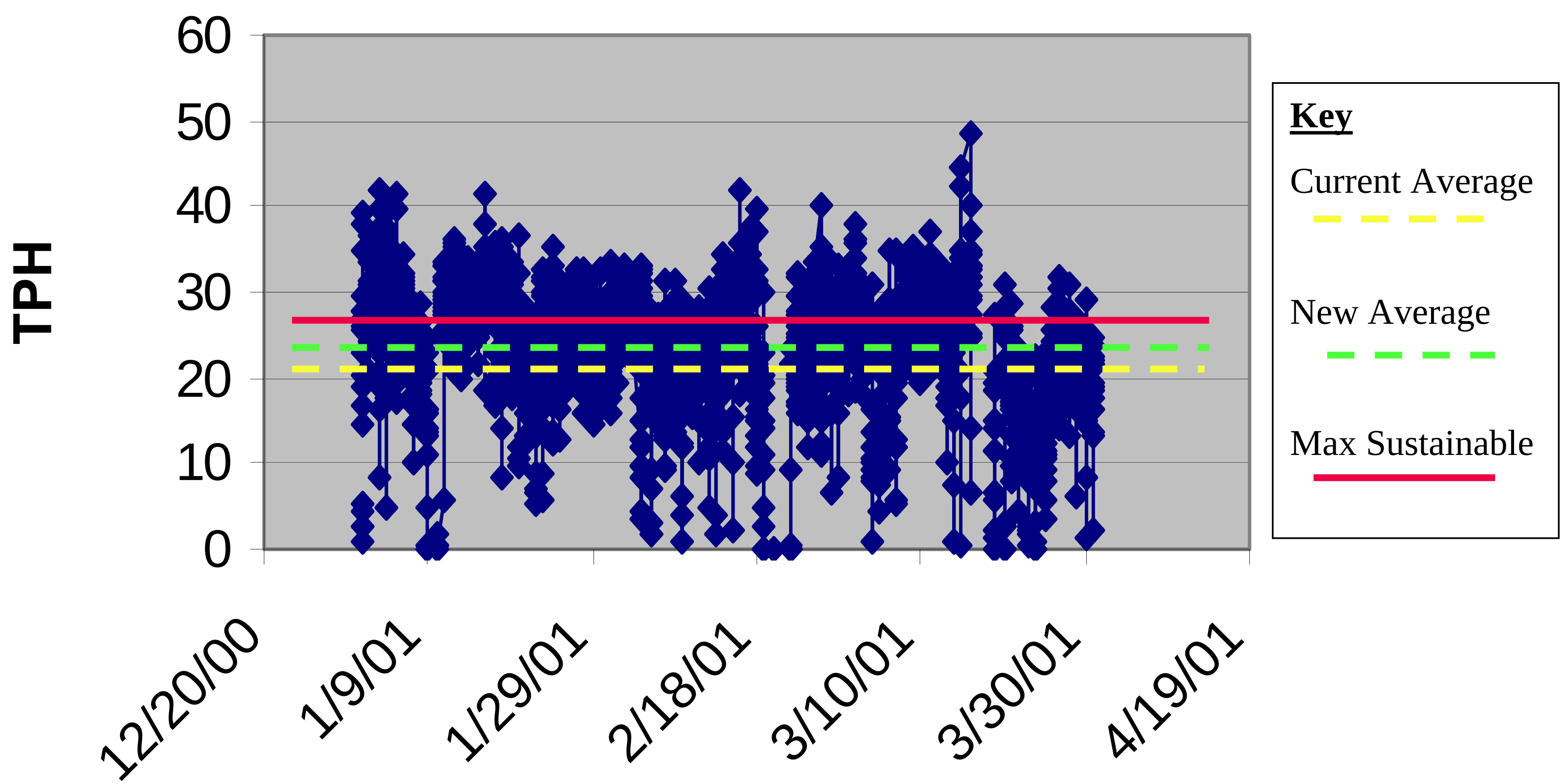
Solid Fuel Composition Control

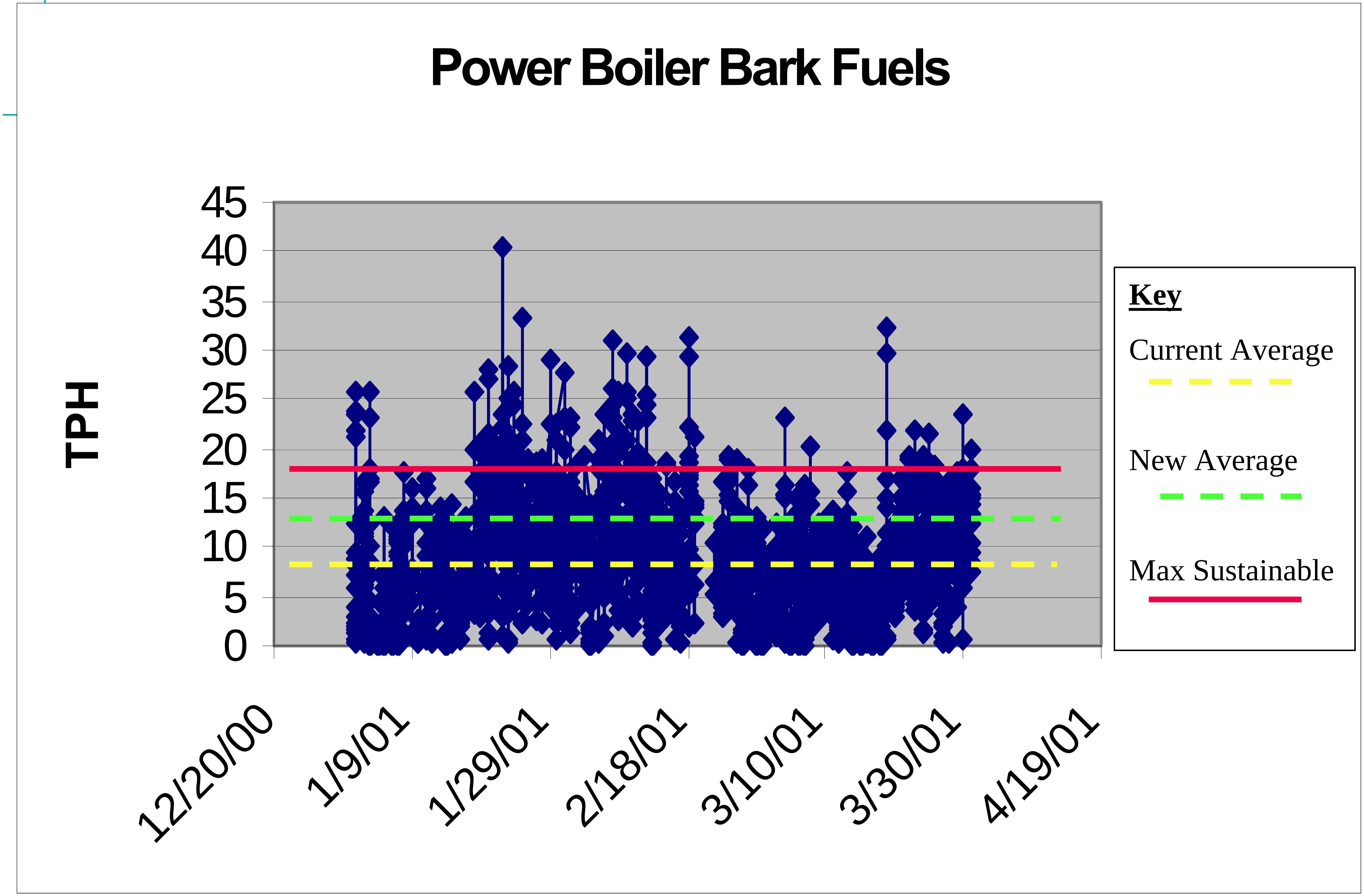


Boiler Control



Power Boiler Sludge




Power Boiler Bark Fuels
TPH
45
40
35
30
25
20
15
10
5
0
12/20/00
1/9/01
1/29/01
2/18/01
3/10/01
3/30/01
4/19/01
Key
Current Average
New Average
Max Sustainable

Power Boiler APC Benefits

Power Boiler	Difference in Hourly Costs & (Savings)
Natural Gas	$2.22
Sludge Disposal	($23.04)
Sludge Ash Disposal	$9.18
TDF	$0.46
TDF Ash Disposal	$0.00
Waste Wood	$26.91
W Wood Ash Disposal	$0.77
Total	$16.50
Package Boilers	
Displaced Natural Gas	($98.42)
Net Savings, $/Hr	($81.92)

Total Savings

$56k / mo

$672k / yr

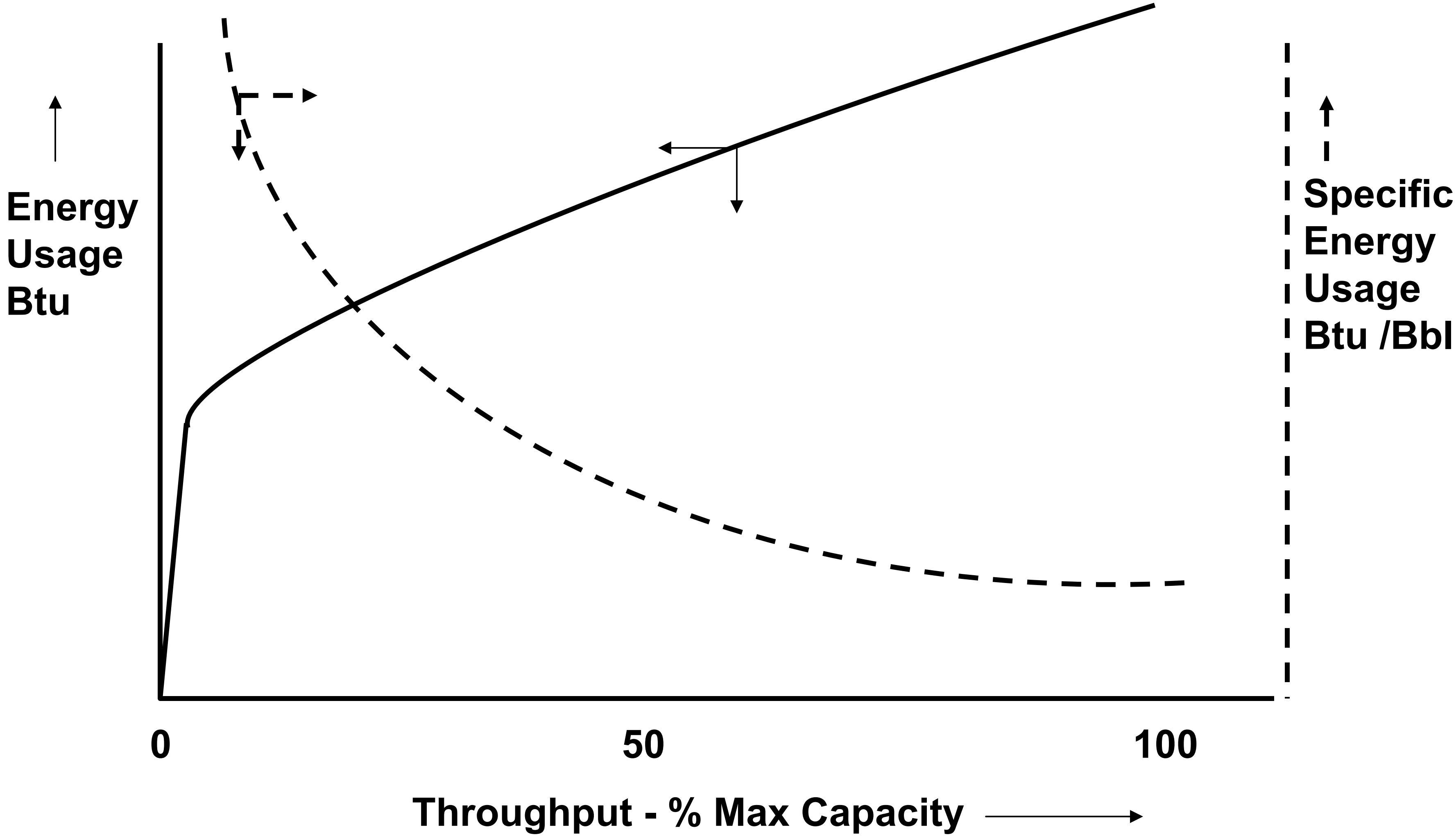
Project Justified:

- Replacement of required pneumatic instruments
- DCS Hardware / Software
- APC Tools
- Turnkey Engineering Services

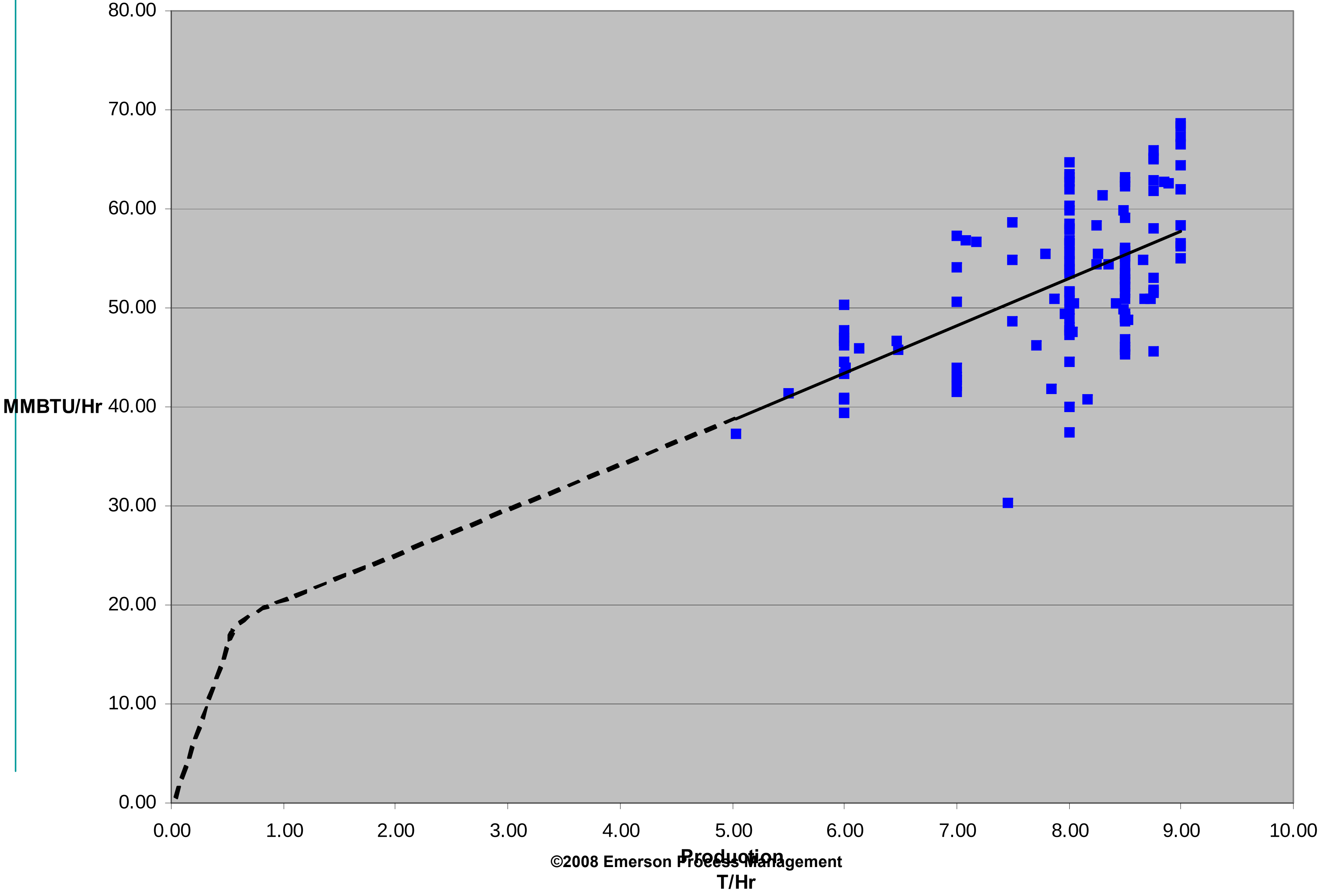
Issues in Evaluating Plant Energy Usage

- **Unit energy usage depends on production rate**
- **Unit energy usage variance dependent on production rate**
- **Need to correct to standard unit conditions**

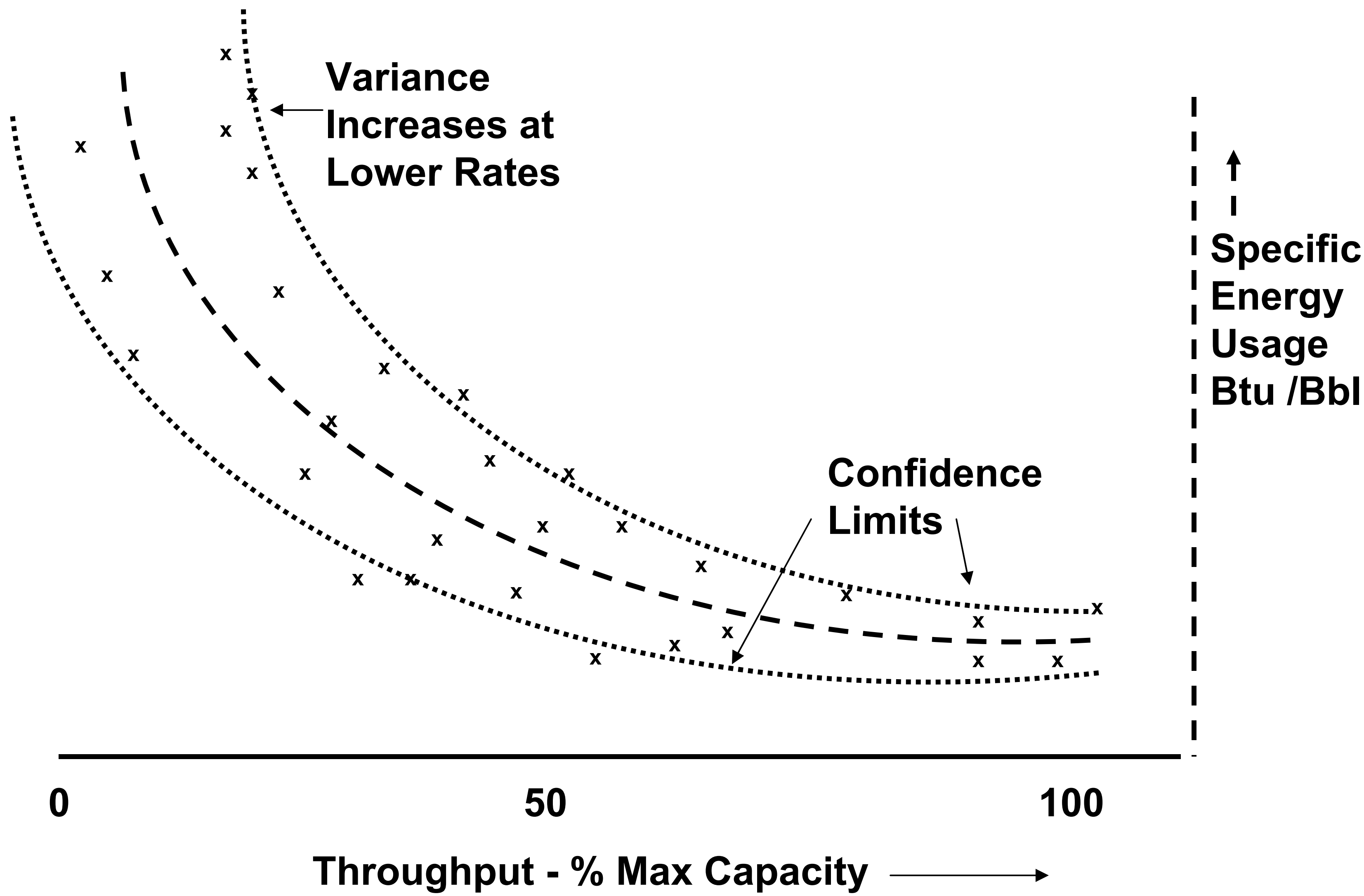
Unit Energy Usage



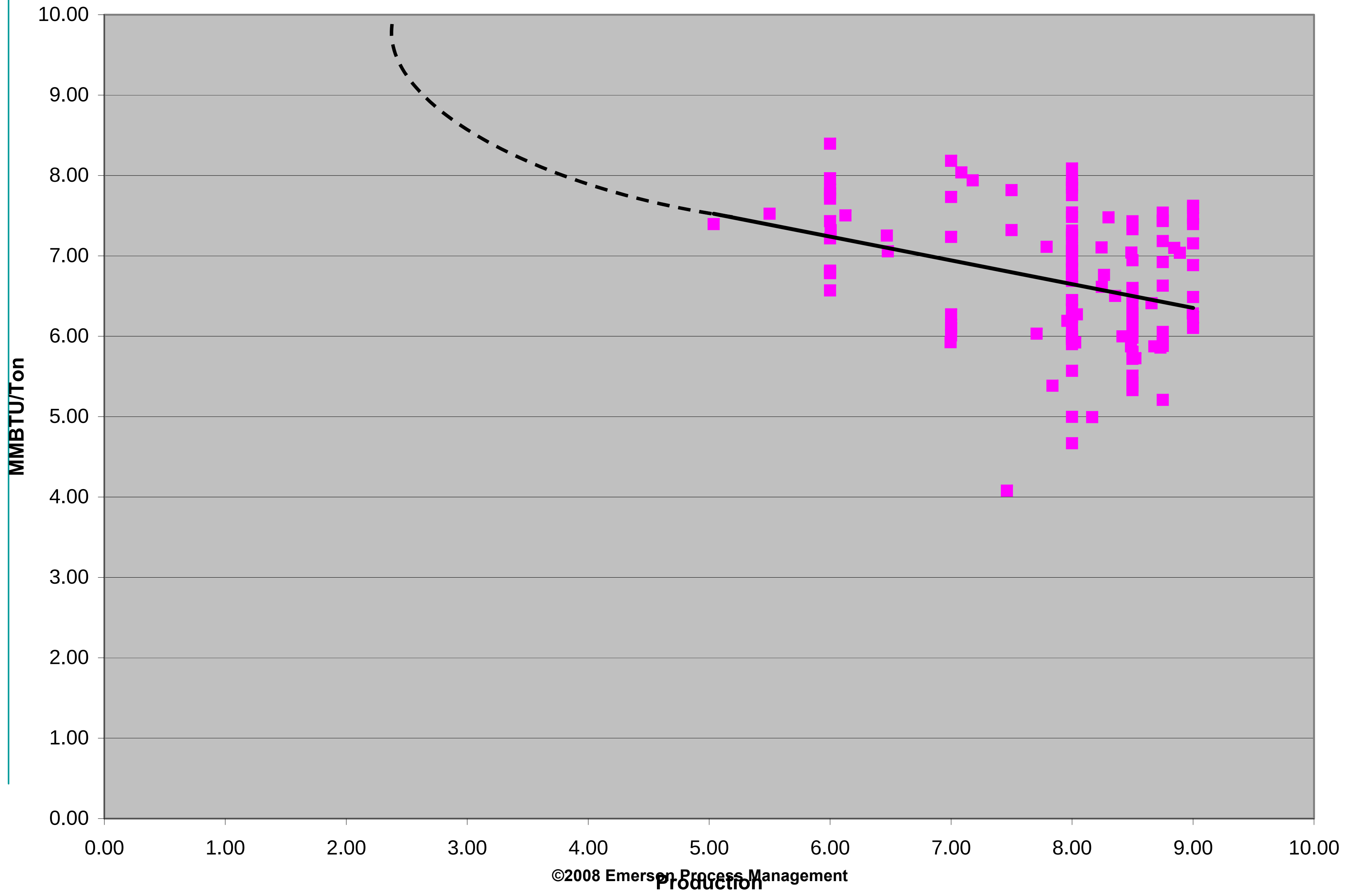
Energy Usage - Example



Unit Energy Usage



Unit Energy Usage - Example



Excuses for Doing Nothing

- **Not enough manpower - Too busy doing other things**
- **Our plant is special – analysis based on other sites doesn't apply**
- **We run our plant well already, there won't be any big savings found**
- **Ostrich - (If we find something obvious, management will ask why we didn't find it before)**

Summary

- Energy is the largest controllable cost in process operation – it's efficient production and use are keys to plant profitability
- Automation and Advanced Automation are keys to effective use and management of energy in the plant
- Implementation of a program to save energy requires a disciplined approach to evaluation and analysis

Questions? Comments?

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More material on subject:
http://www.emersonprocess.com/solutions/services/aat