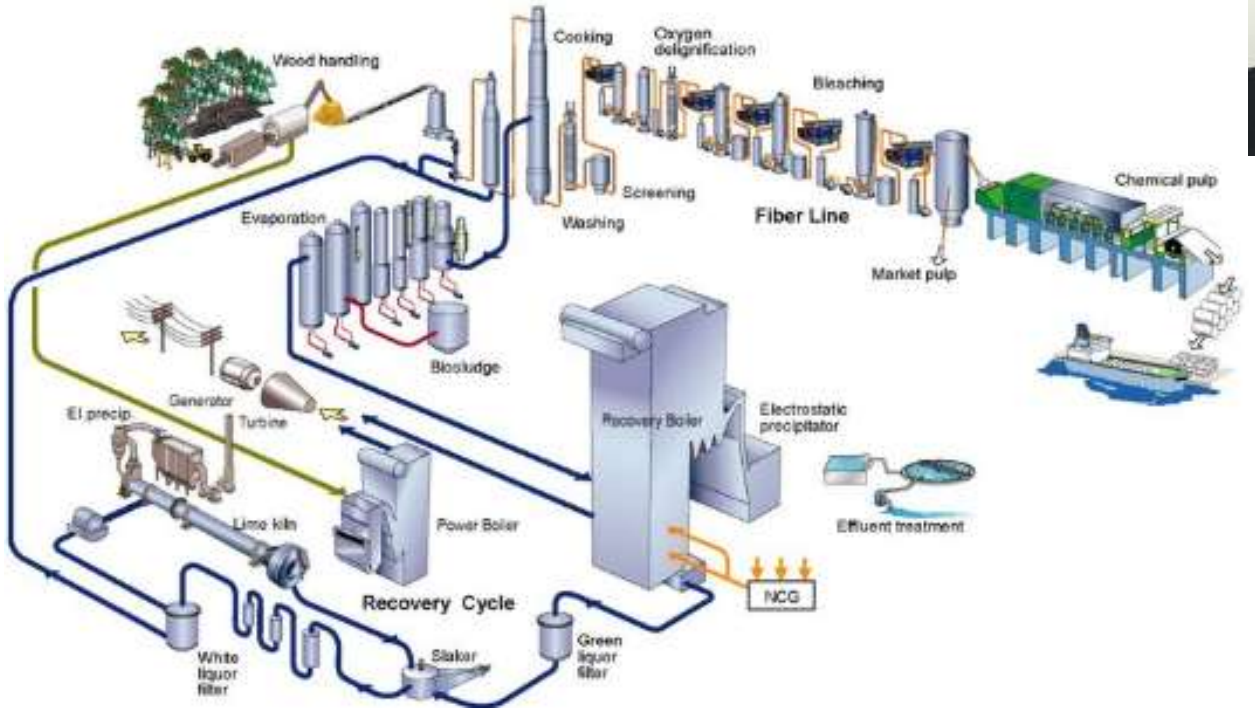
ENMAS ANDRITZ

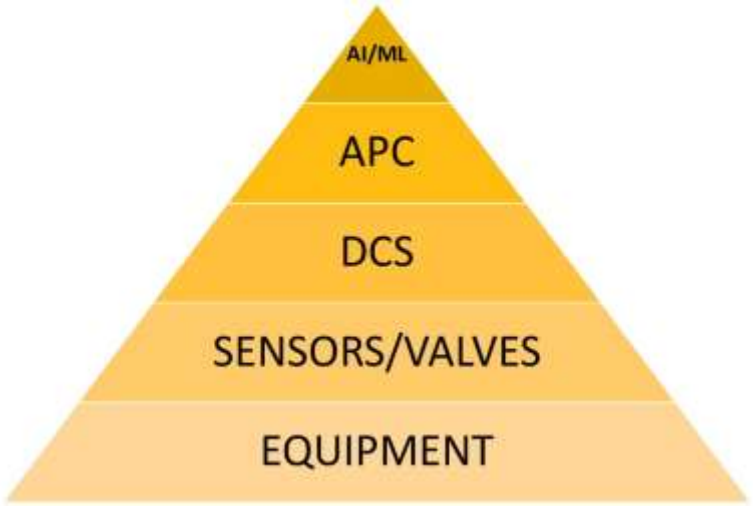
ADVANCE PROCESS CONTROL FOR CHEMICAL RECOVERY

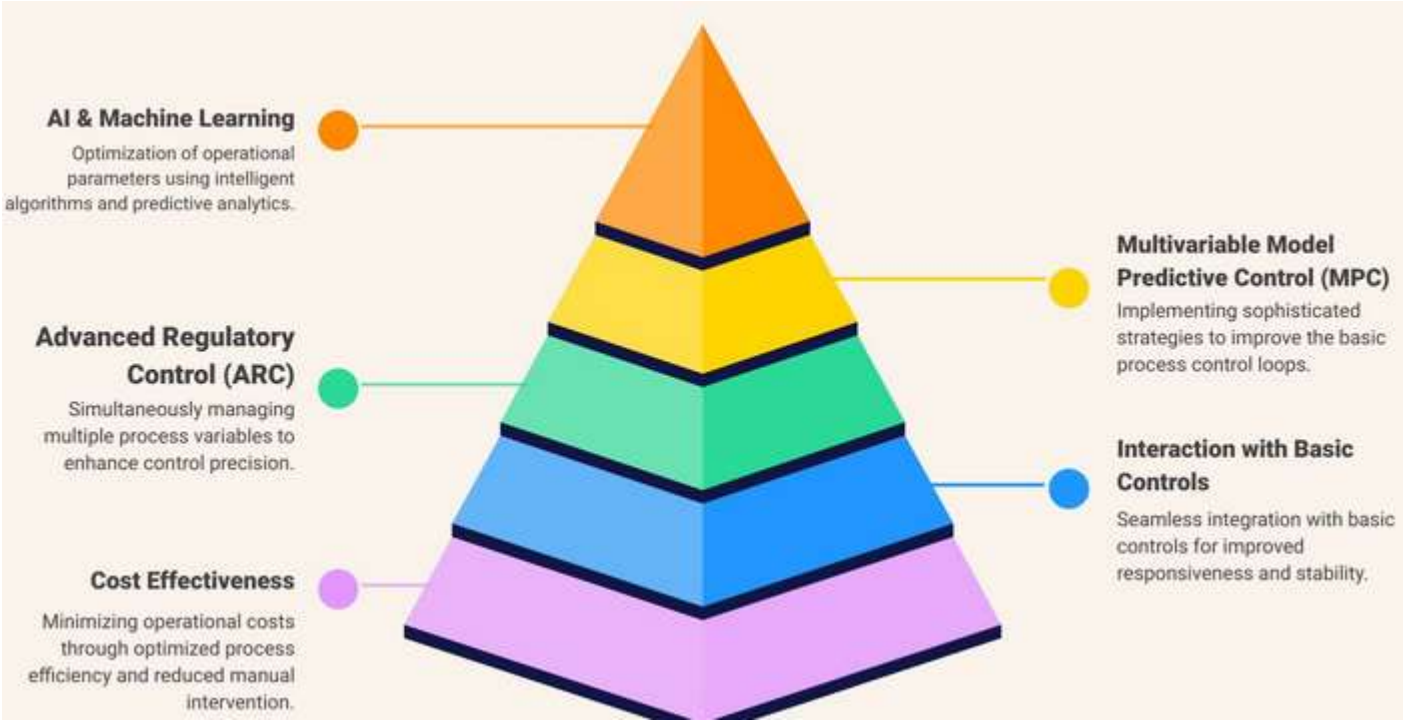
R Chandrasekaran 10.07.2026



Advance Process Control – What is that ?

- Advance Process Control (APC) is a layer of software technology added on top of basic control systems (like DCS or PLC) to optimize industrial processes

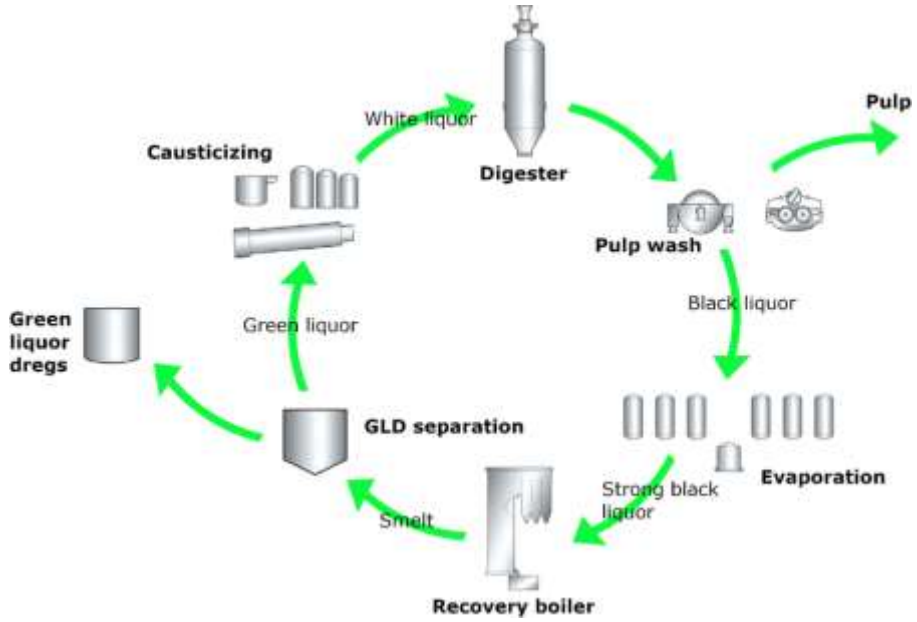




APC solutions – Key Benefits

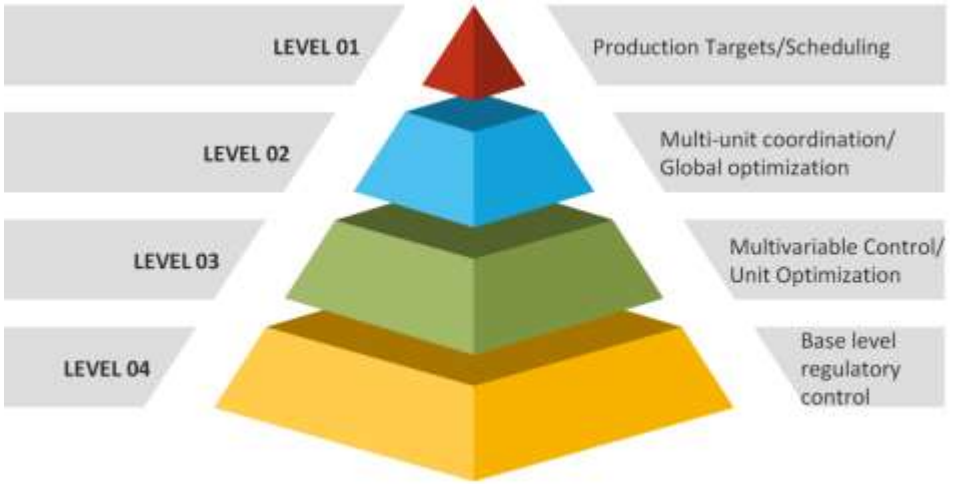
Key Benefits are:

- Better fuel and chemical management
- Improved quality of final product
- Less process variations and smooth operation of the process
- Less environmental chemical load and hence lower pollution
- Well utilization of installed assets and increased production and profitability



APC solutions – How

- utilizes mathematical algorithms and computer software
- Optimize production yield while minimizing energy consumption
- APC is the added value upgrade to a Process Automation System.
- The information gathered is then used to stabilize the process control without user interaction and adjust the set point closer to the limit



APC solutions – Tools and Technologies today

SINGLE LOOP APC	MULTI LOOP APC	
- Advanced Regulatory Control	Multi-loop Control (MLC)	Model Predictive control (MPC)
- Feed forward - Override - Adaptive Gain - Etc.	- Limited tools available - Tool gap	- Complex - Pros & Cons well known
- Close Single loops - Improve Single loop performance	- Close multivariable loops - Automate multi variable control	

APC solutions – Types

➢ MPC (Model Predictive Controllers)

- Rely on dynamic models of the process, most often linear empirical models obtained by system identification.
- The main advantages of MPC is that it allows the current timeslot to be optimized, while keeping future timeslots in account.

➢ Soft Sensor or (inferential analyzer)

- Is a common name for software where dozens of measurements are processed together. T
- he interaction of the signals can be used for estimating properties of material being processed

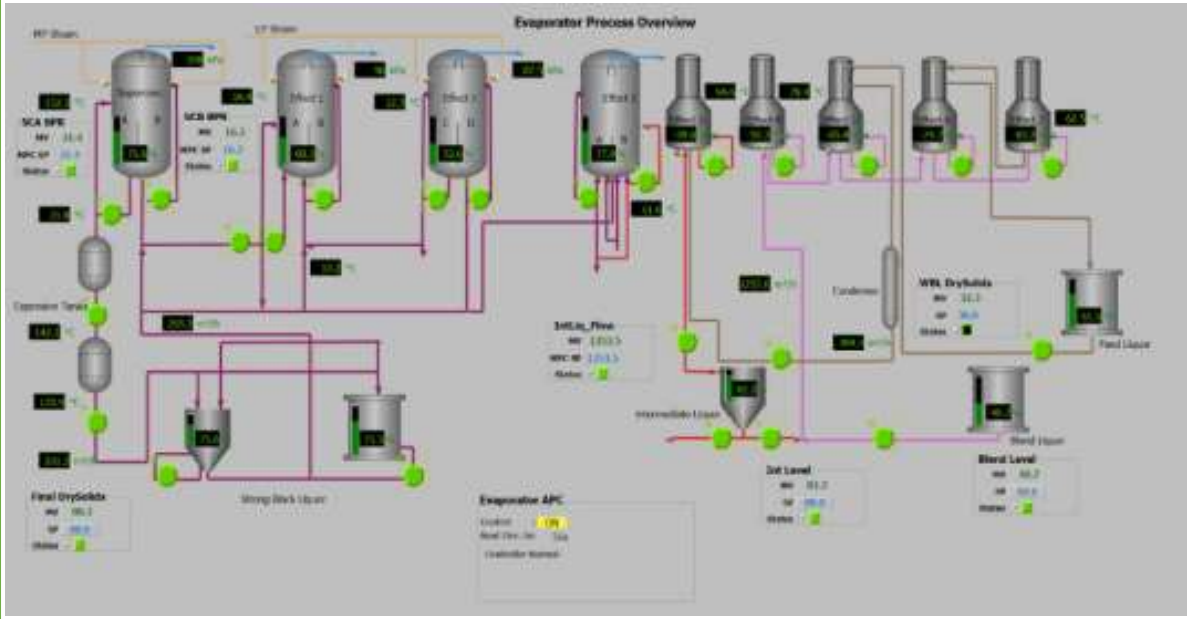
➢ Feed forward control :

- Anticipates disturbances (such as load changes) before they affect process stability.
- Enabling more advanced stability and control by utilizing the multivariate analysis and estimated product properties in real-time (such as Dew point, RVP, Density, etc.)

APC solutions – MULTIPLE EFFECT EVAPORATOR

:

- **Energy Efficiency:** Minimizes steam consumption by optimizing pressure and flow distribution across multiple effects
- Stabilizes dry solids content to maximize efficiency while ensuring the liquor does not exceed safety constraints before firing.
- Production rate controls
- Real-time adaptive modelling: Automatic adjustments based on process changes
- Higher-order model support: Captures process dynamics accurately
- Cost optimizer: Looks for ways to optimize operational costs within process constraints
- Evaporators performance monitoring
- KPI Dashboard and control usage reports by day/shift
- Performance monitoring, with both on-site and remote access for customers
- Task oriented and user friendly customizable operator displays

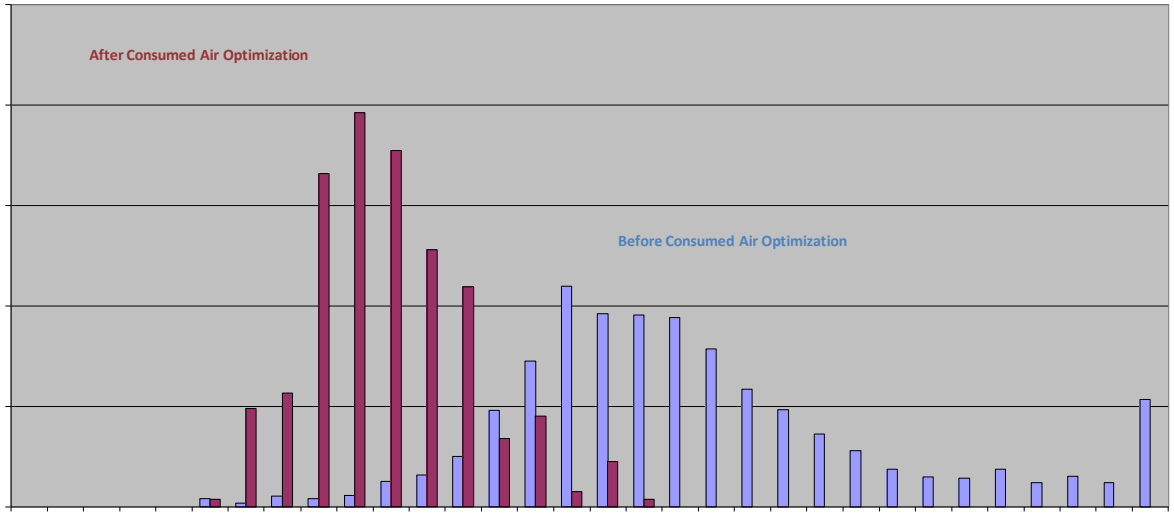


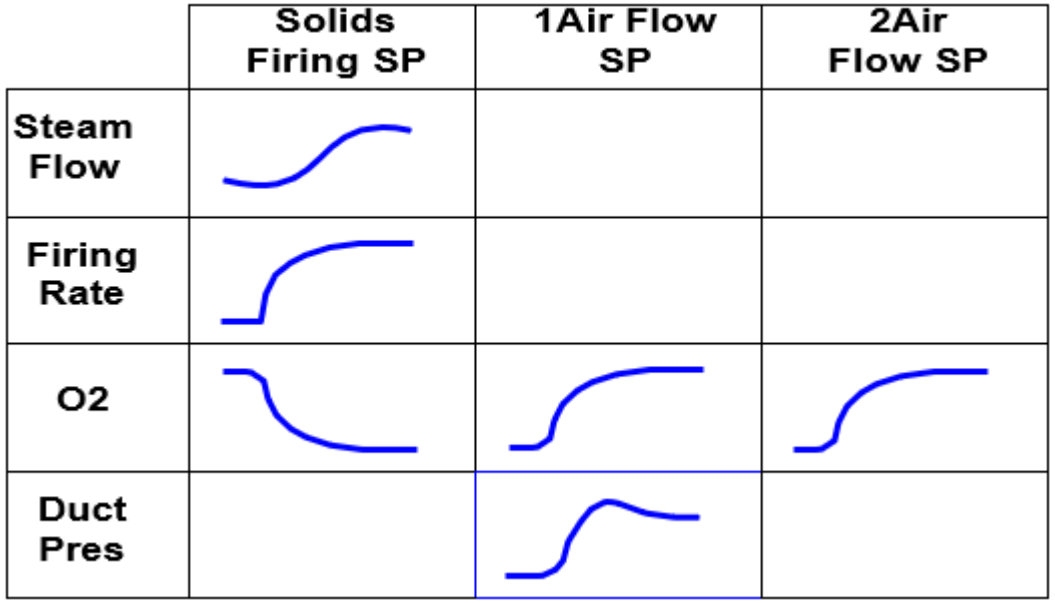
APC solutions – MULTIPLE EFFECT EVAPORATOR – STANDARD CONTROL STRATEGIES

Control Strategy	Function & Benefits
Model Predictive Control (MPC)	Uses dynamic process models to predict how changes in feed flow or steam pressure will affect all evaporator effects, coordinating manipulated variables simultaneously to respect physical limits.
Boiling Point Rise (BPR) Compensation	Dynamically adjusts setpoints for density and temperature, accounting for the elevated boiling point of concentrated black liquor to avoid erratic boiling.
Fouling & Scaling Management	Uses Soft Sensors to estimate fouling resistance and automatically sequences switching/washing without interrupting production.
Feed-Forward Control	Anticipates disturbances in weak black liquor feed flow or temperature, adjusting steam flow proactively to maintain stable product density.

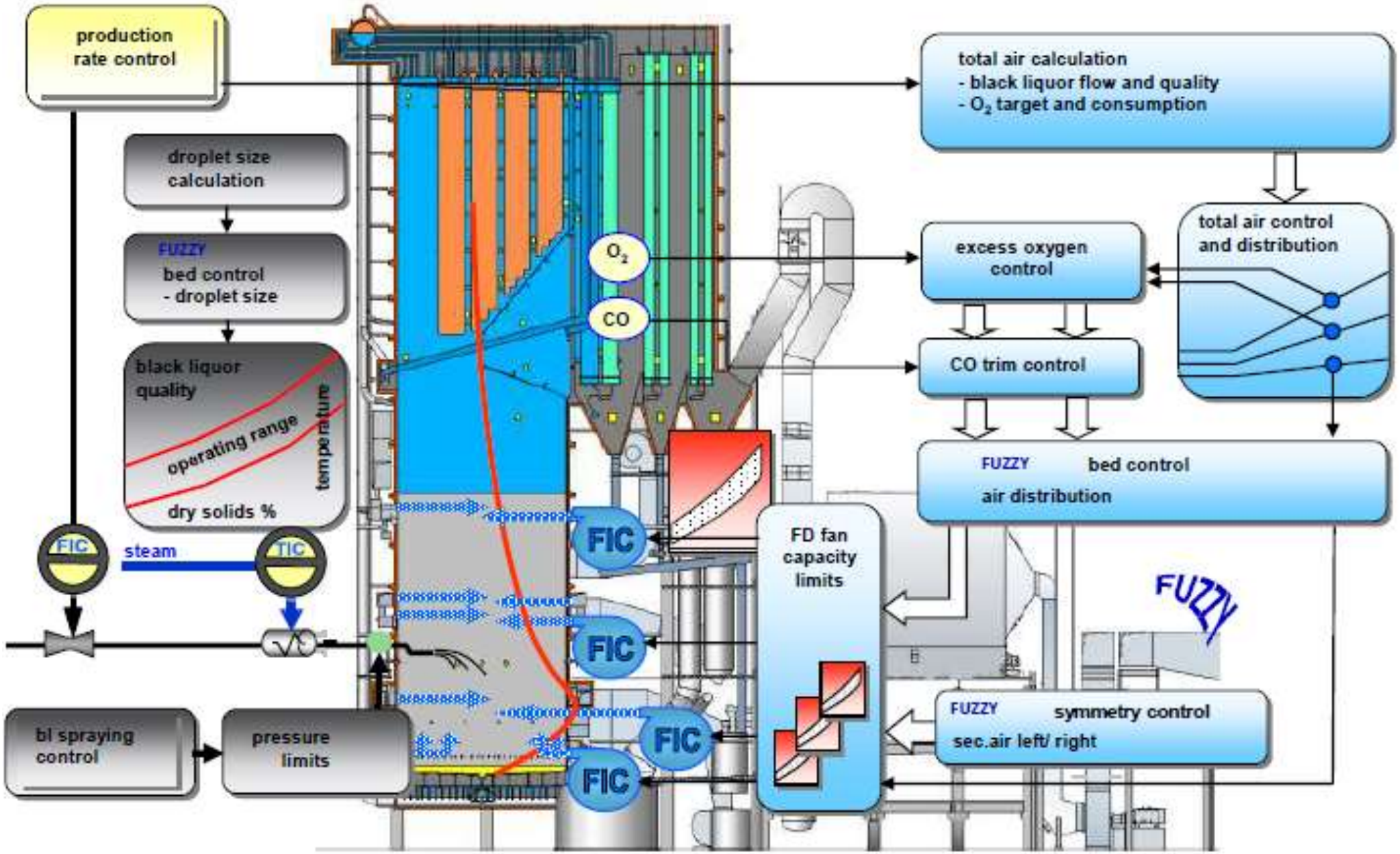
APC solutions – RECOVERY BOILER

- Combustion air control has several potential benefits including better stability, improved efficiency and increased throughput.
- Multivariable, model predictive control technology has proven very effective at optimizing consumed air.
- With this technology, minimum excess air can be achieved while all other process constraints are honored.
- Each one percent (1%) decrease in boiler excess oxygen yields a 0.5 – 1.0% increase in efficiency.

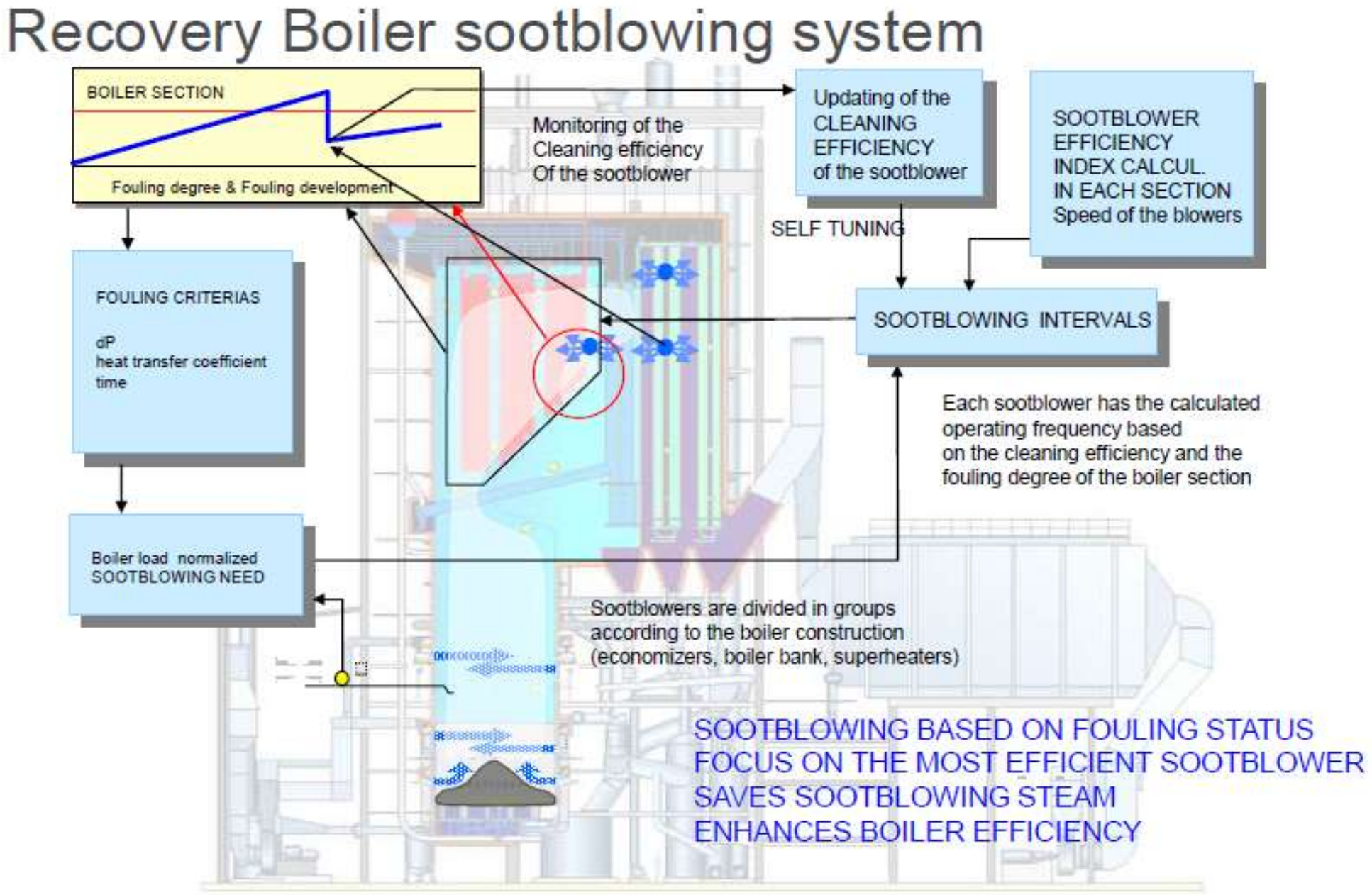




APC solutions – RECOVERY BOILER



APC solutions – RECOVERY BOILER

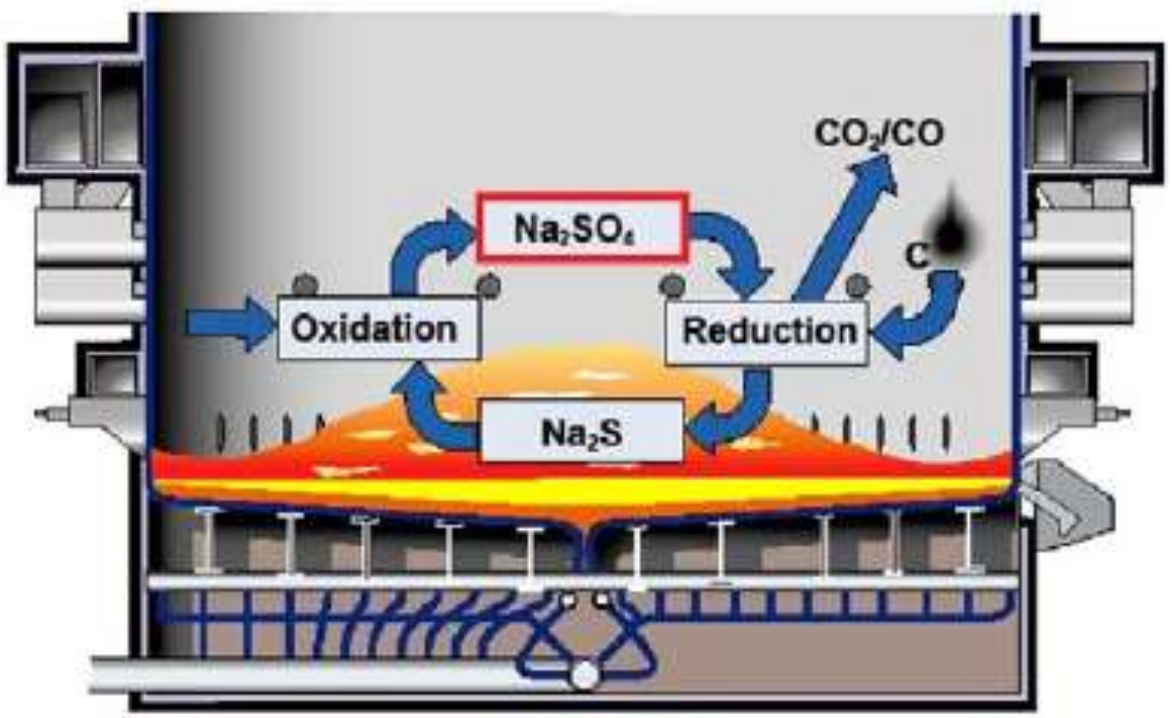


APC solutions – RECOVERY BOILER

- Reduction rate control : Reduction reaction strongly depends on the bed temperature
- High enough temperature keeps the reaction on the Na2S side with minor reoxidation.
- Targets to :

  - Air distribution optimization

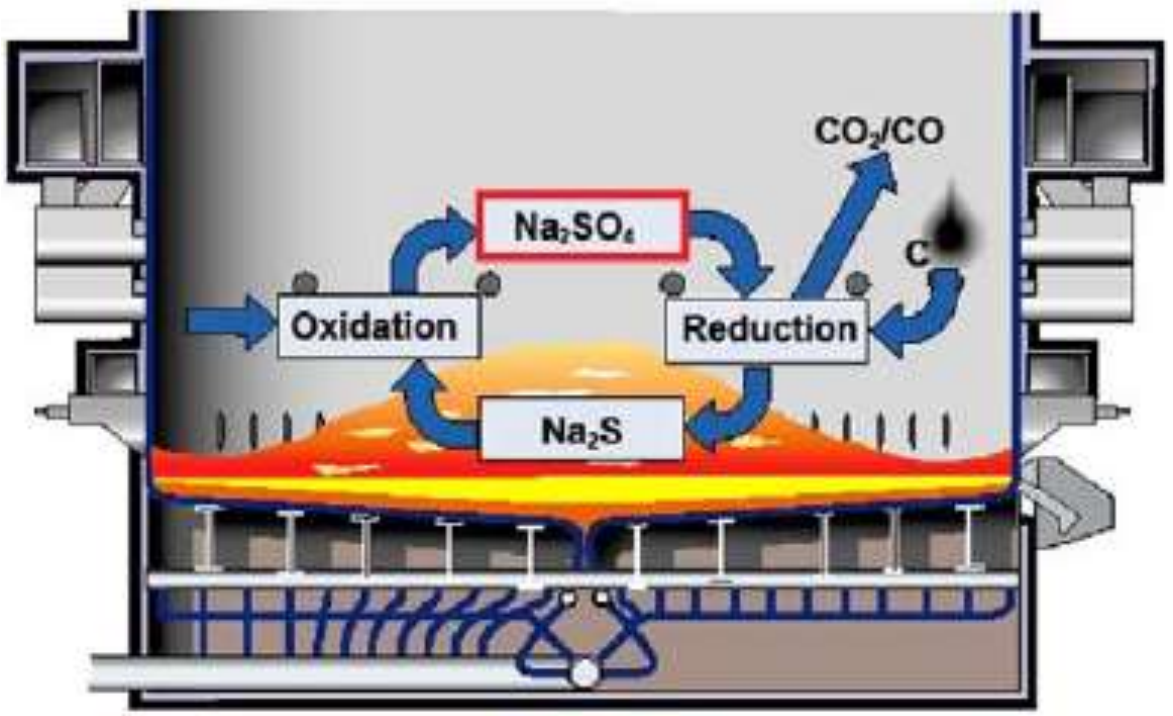
  - Liquor droplet size optimization



APC solutions – RECOVERY BOILER

Reduction rate Optimization benefits:

- Maximized reduction efficiency :
  - Minimizes Na2SO4 Chemical Load
  - Maximizes active Na2S in cooking liquor
- Higher concentration of active chemical in white liquor means less white liquor flow to digester:
  - Less heating of WL in digester
  - Less Black liquor to evaporators
  - More heat output from recovery boiler
  - Reduced load on Recausticizing/ Kiln

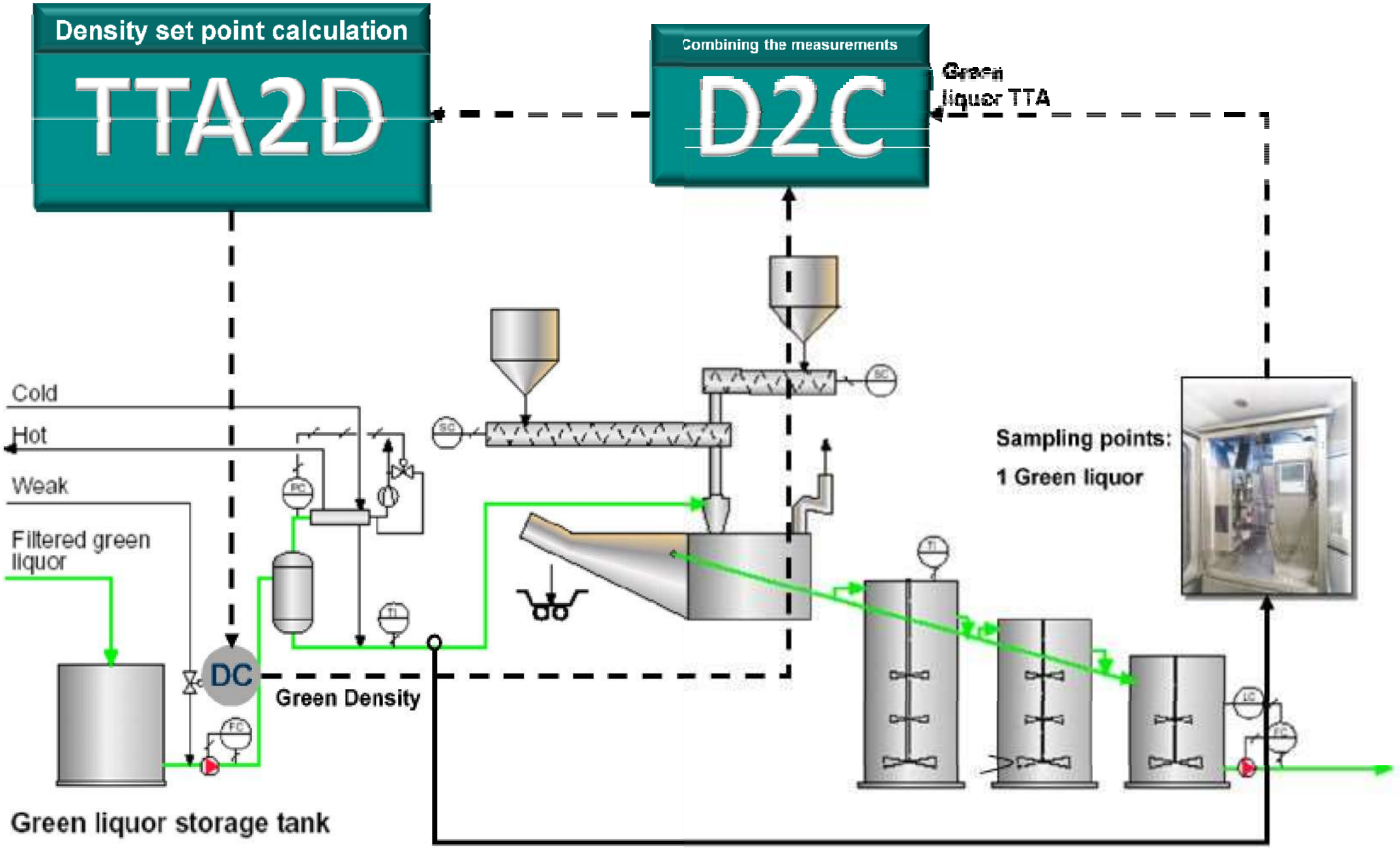


APC solutions – Recausticizing

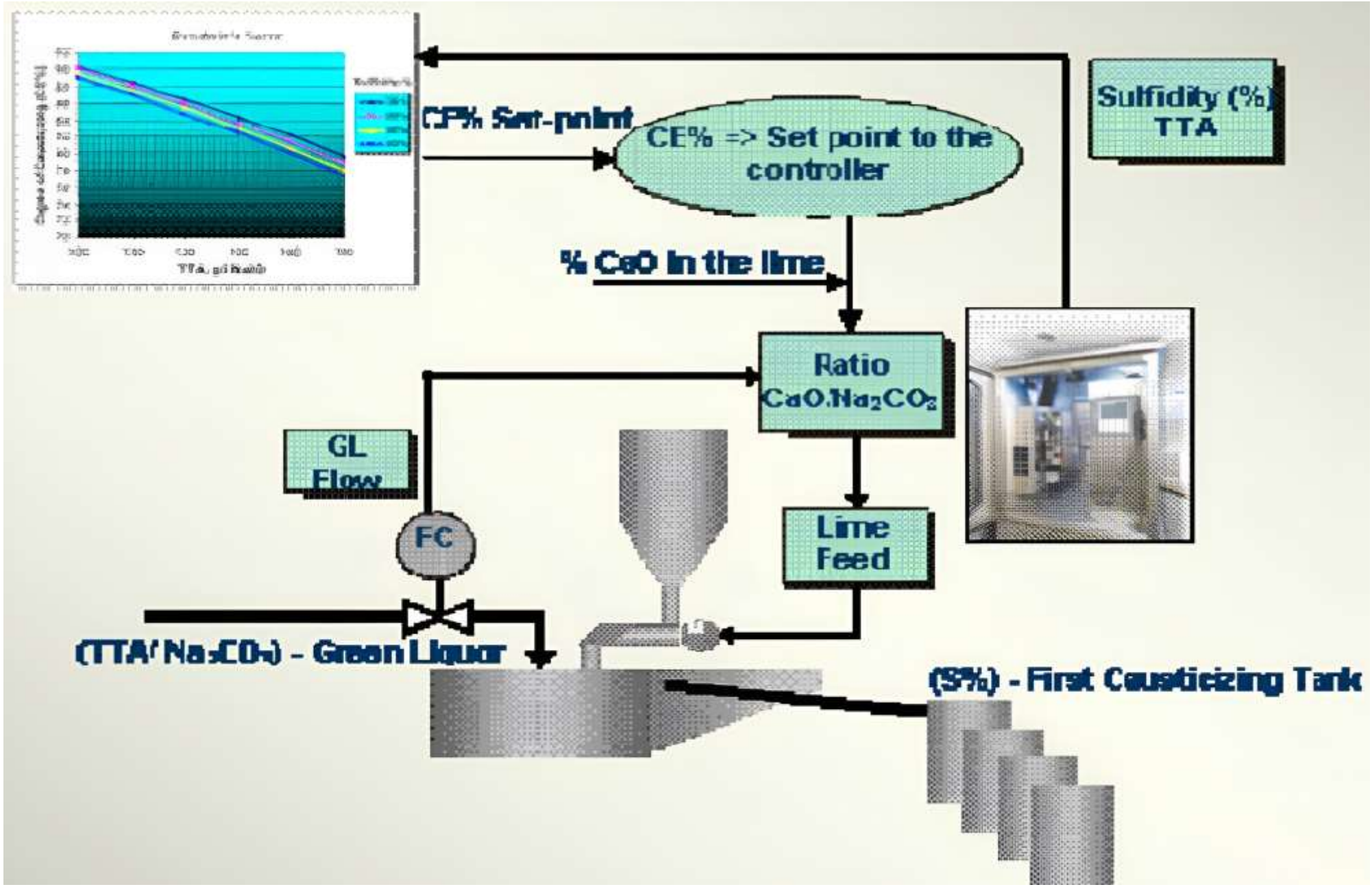
- In the causticizing area, there are two key variables to control – incoming green liquor total titratable alkali (TTA) and the causticizing efficiency (%CE) of the lime mud slurry and white liquor. It is proposed to have a different adaptive model-based control strategy for each variable.
- Green liquor TTA control starts at the dissolving tank. At least one control point is required between the dissolving tank and the slaker. The control model is based on comparing an in-line density measurement with an on-line titrator measurement such as a Kajani ALKALI analyzer.

- ❑ incoming green liquor and slaker bowl is used as a quick feedback for the lime reactivity and is modeled to the %CE measurements from 'on line titrator'. This model is once again dynamic and updated in real-time.
- ❑ The temperature of the incoming green liquor can also be controlled to maximize heat of reaction (dT) in the slaker while preventing boil over. The heat of reaction is also used to ensure proper lime addition to achieve % CE without overliming

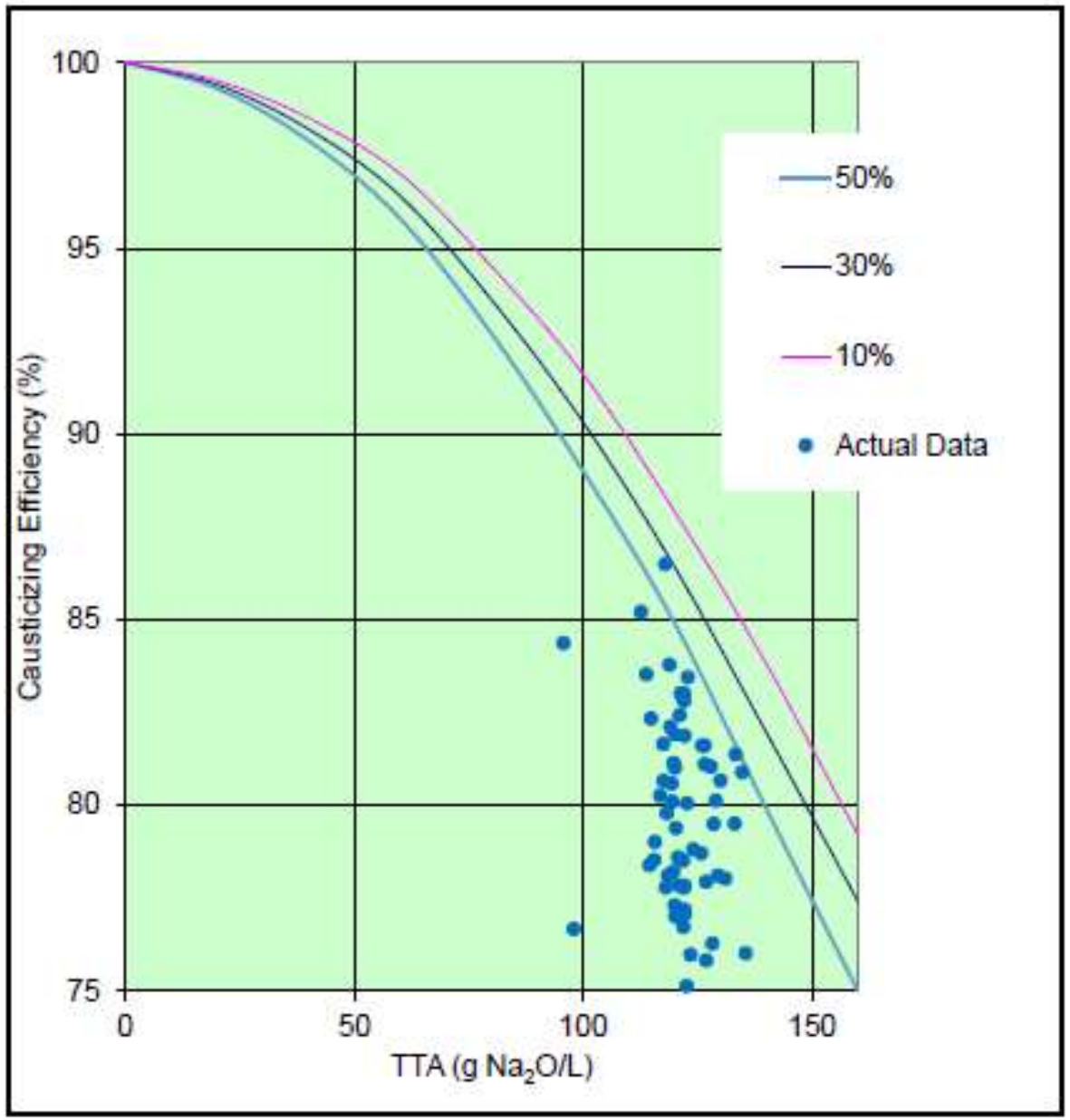
APC solutions – Recausticizing

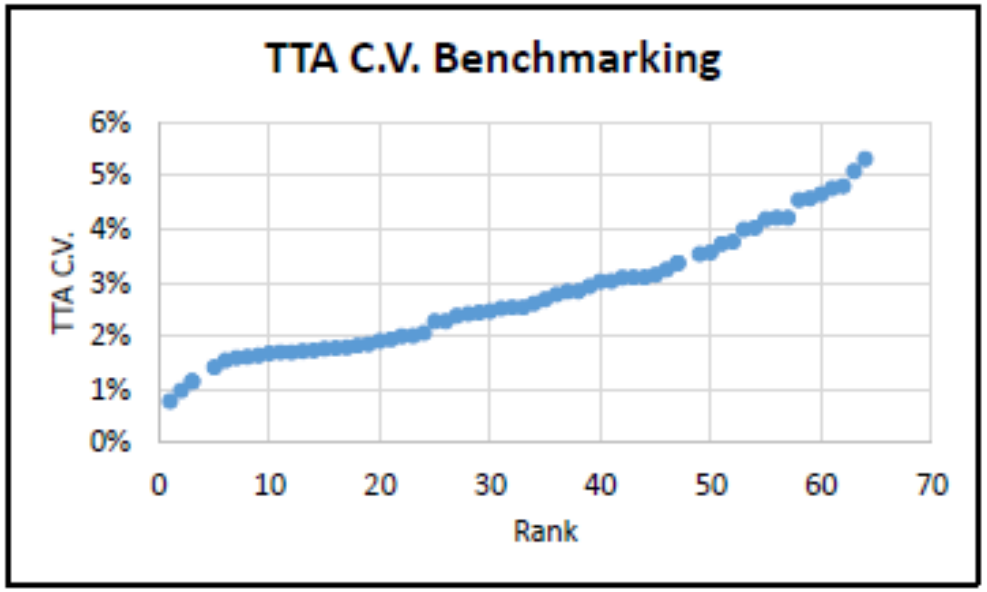


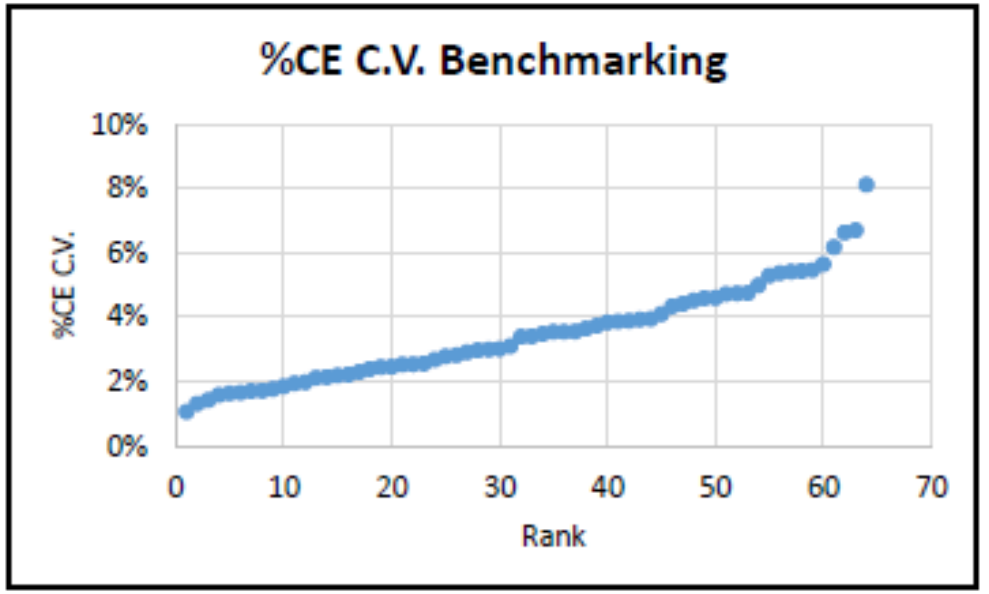
APC solutions – Recausticizing



APC solutions – Recausticizing



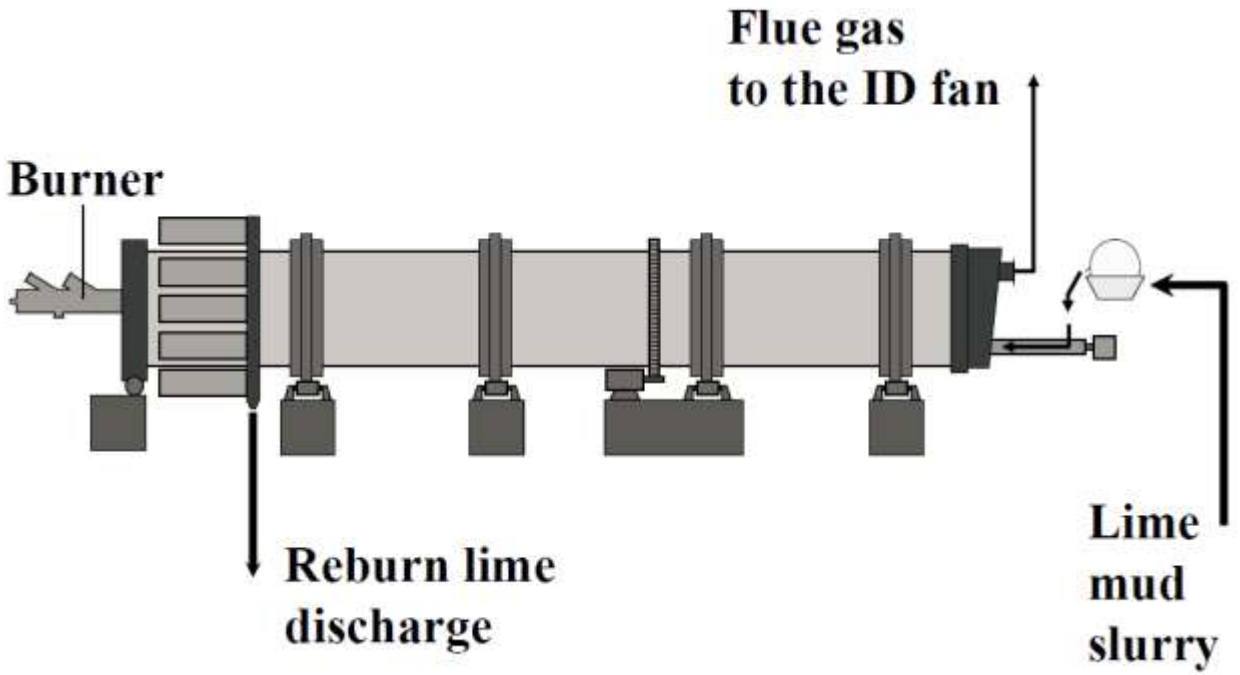




APC solutions – Rotary Lime kiln

Objectives:

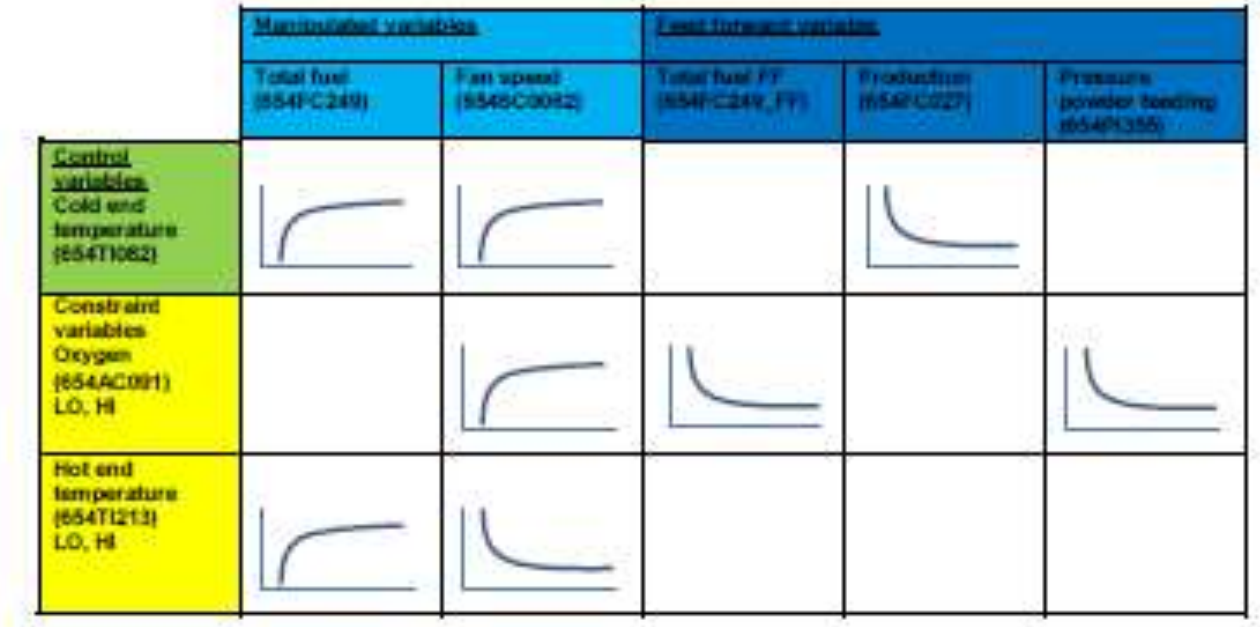
- Produce High Quality Lime
- Maintain Stable Hot End Temperature
- Maintain Stable Cold End Temperature
- Maintain Oxygen within Limits
- Prevent CO Formation
- Achieve Production Targets
- Minimize Energy Requirements



APC solutions – Rotary Lime kiln

Approach:

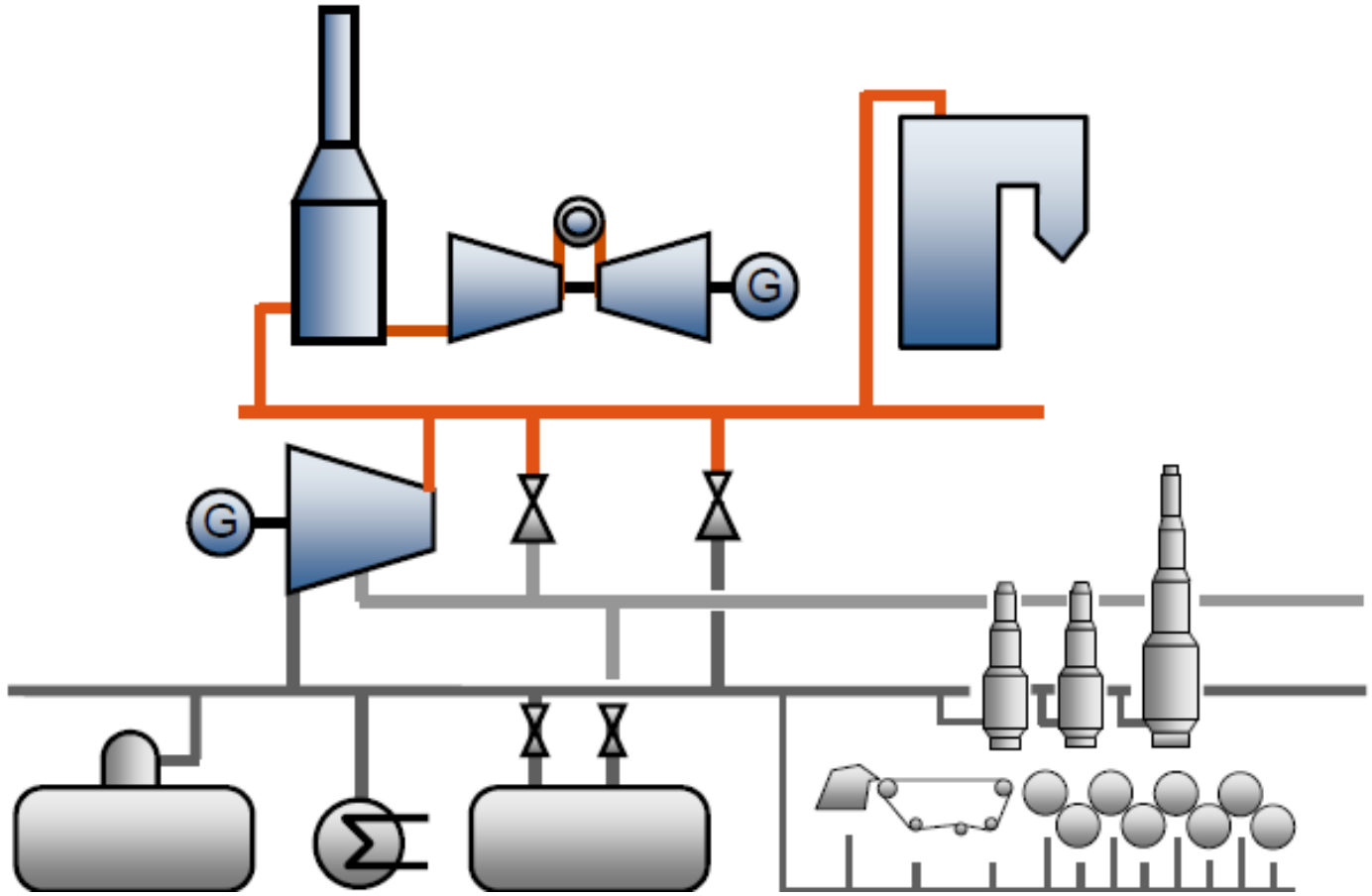
- Cold End Temperature is controlled to setpoint
- Hot End Temperature & Oxygen are controlled within limits
- Fuel Flow & ID Fan Speed are manipulated.
- Oxygen Safety Logics Included
- Production Rate Control Included



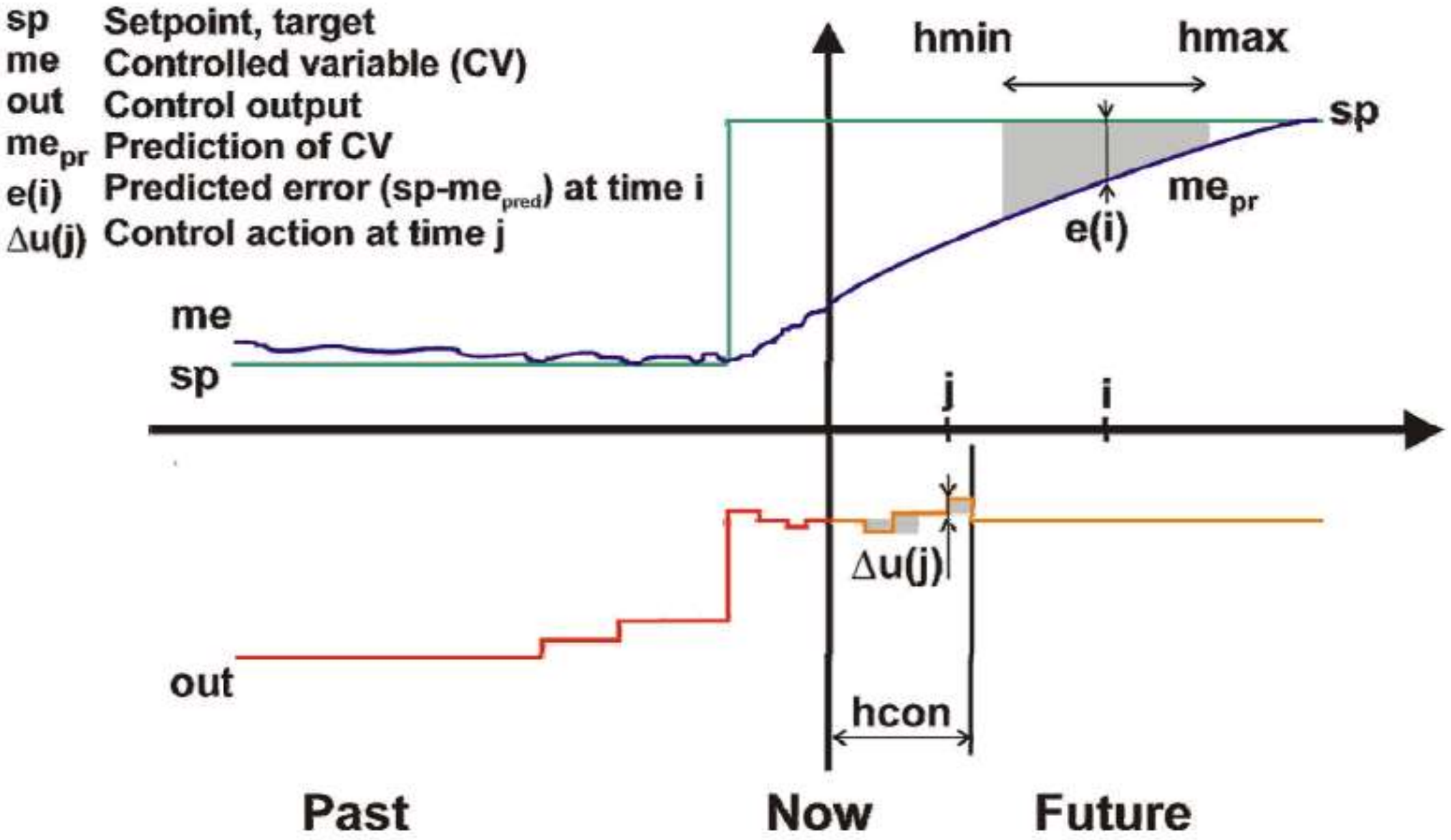
APC solutions – Steam network optimization

Approach:

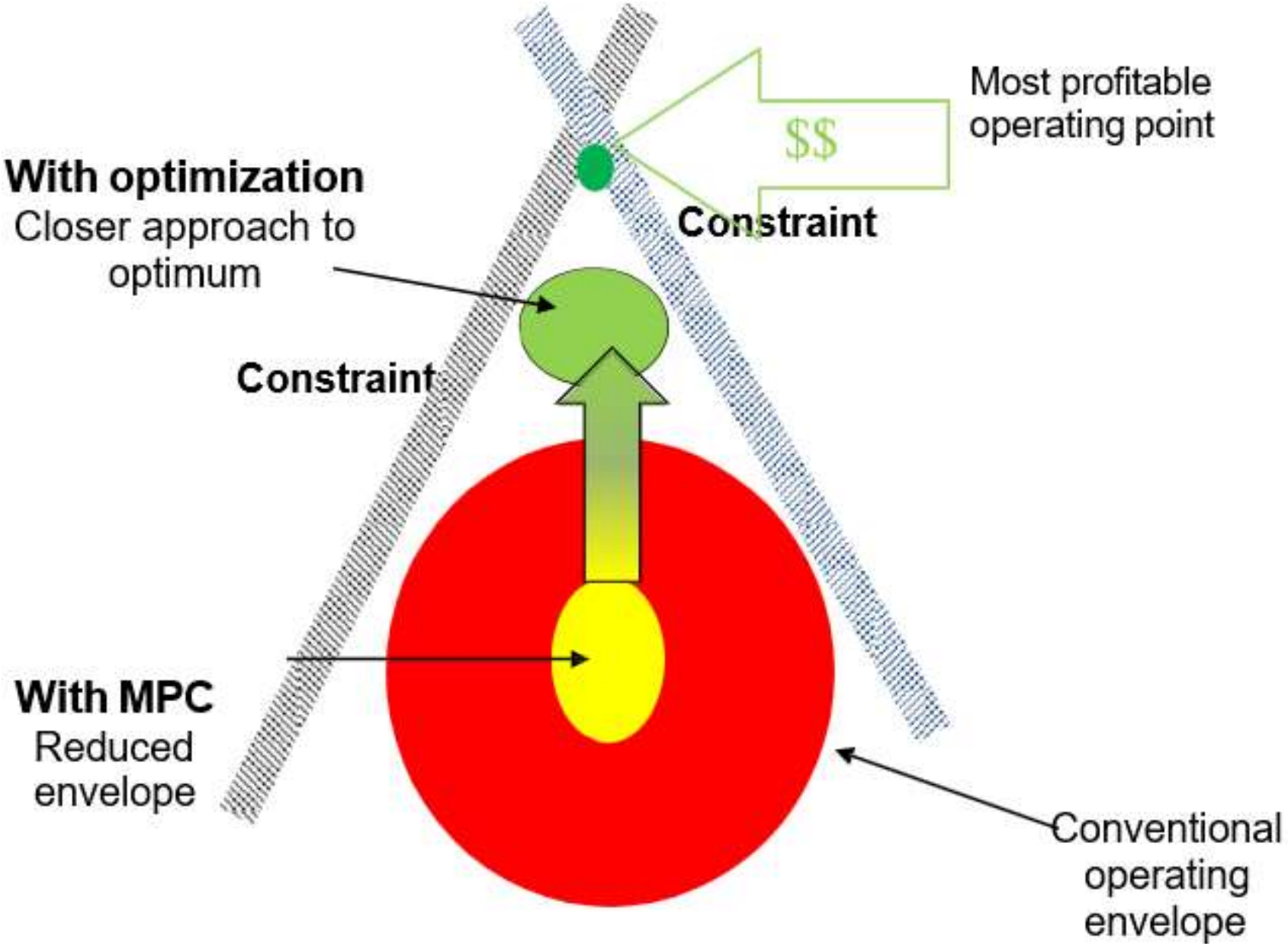
- Secures Process steam supply and quality
- Compensates Load changes economically
- Optimizes electricity generation



APC solutions – Model Predictive control



APC solutions – The Optimization approach



AI driven APC solutions

Unlike conventional PID and single-input-single-output controls, AI systems use a multi-tiered approach that views the entire Multiple-Effect Evaporator (MEE) train as a single interconnected plant

Data Ingestion: High-frequency sensor and Distributed Control System (DCS) data is fed into an Edge/Cloud computing environment.

Machine Learning Models: Deep learning and empirical algorithms (such as Neural Networks) compute complex non-linear parameters, including Boiling Point Elevation (BPE) and scaling/fouling rates.

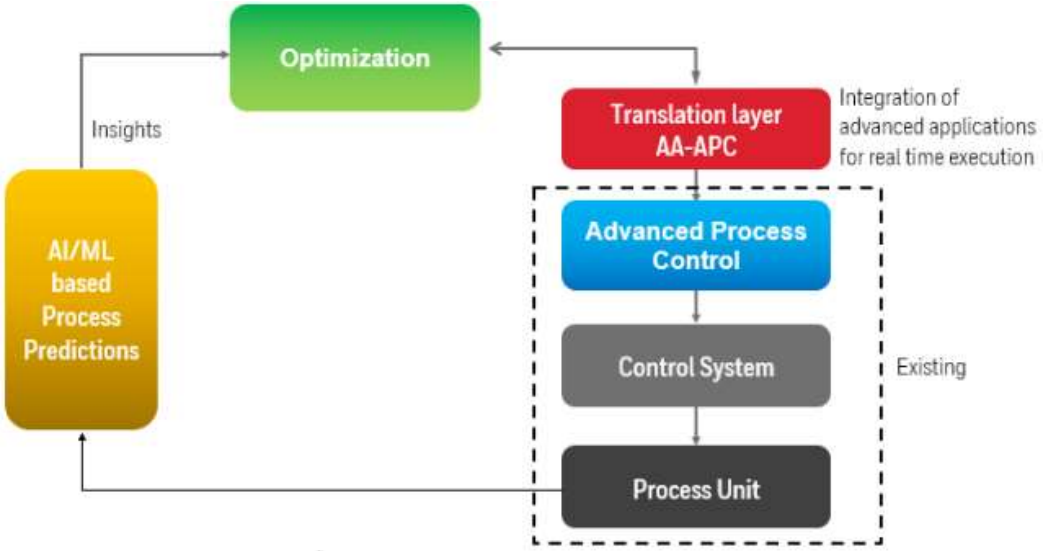
Closed-Loop Optimization: The AI optimizes variables (such as live steam ratio, flashing strategies, and liquor split) and automatically writes optimal setpoints back to the base DCS

Core Optimization Goals

Steam Economy Maximization: AI minimizes fresh steam consumption by finding the absolute optimal temperature and flowrate distribution across the effect train.

Dry Solids Consistency: It limits variability in final dry solids content, allowing mills to shift target values higher for better boiler efficiency.

Fouling & Scaling Mitigation: By predicting when and where sodium scaling will occur based on heat transfer coefficients and concentration gradients, the AI can adjust boiling parameters to slow down fouling



Key Benefits

Reduced Energy Costs: Substantial reduction in purchased steam and increased latent heat recovery.

Maximized Uptime: Minimized downtime for routine boil-outs and chemical wash sequences.

Predictive Stabilization: Quick, automated adjustments to handle variable incoming feed flow and weak black liquor densities without operator guesswork

APC solutions – RESULTS & DISCUSSION

1. Evaporator Train Optimization

Stability: Implementing Model Predictive Control (MPC) reduces the variability of dry solids in heavy black liquor . Exact percentage by which disturbances in the final solids content were reduced will depend on the mill base value and potential. available for improvement.

Energy Efficiency: Similarly the reduction in specific steam consumption (kg of steam per kg of evaporated water) across the multiple-effect evaporators. Can be 3 to 5 % depending on the potential available

2. Recovery Boiler Stabilization & Throughput

Bed & Furnace Management: implementing multivariable control, balances combustion air and black liquor spraying to maintain optimal char bed temperatures.

Steam Generation: Implementing APC optimizes steam generation finally based on heat input into furnace and optimization of combustion air. This could be typically 3 to 5 % increase depending on base value before optimization and varies from mill to mill.

APC solutions – RESULTS & DISCUSSION- Contnd…

3. Causticizing and Lime Kiln Efficiency

White Liquor Quality: Implementing APC improves the causticizing efficiency by optimizing control in slaking and causticizing tanks.

Lime Kiln Fuel Savings: Implementing PC gives the opportunity for reduction in fuel consumption (e.g., reduced natural gas/oil usage per ton of reburned lime) and reduction of total reduced sulfur (TRS) emissions.

4. Overall Economic and Environmental Impact

Variability Reduction: APC gives the opportunity for closing critical control loops which in turn allows the operation to run closer to safety and operational limits without operator intervention .

ROI & Emissions: Implementing APC could result in economic benefits typically could be 12 to 24 months (ROI) depending on the base value prior to implementation and could result in CO and Sox/ Nox or Totally reduced sulphur emission reduction.

APC solutions – CONCLUSION

What can be done to sustain APC performance long-term?

- Establish an APC Champion at Plant, with Authority / Budget
- Involve Operators as early as possible
- Verify Performance Suitability of underlying Conventional Controls

  before APC Installation
- Proper Training for all Personnel involved (initial and refreshers)
- Be as transparent as possible about the real-time APC Value to all Personnel involved, especially Operators
- Secure long-term Support of key APC Components from Suppliers

Optimize Chemical recovery through APC !!