



Texas Petrochemicals LP

The Leading Producer of C₄ Based Chemicals

Butene-1 Distillation Control Project

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**Texas Technology Showcase
December 6, 2006**



Summary

- Process description
- Old regulatory controls
- New regulatory controls
- Results & benefits
- Next steps

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Butene-1 Project

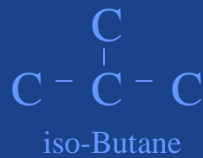
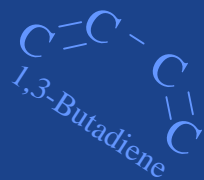
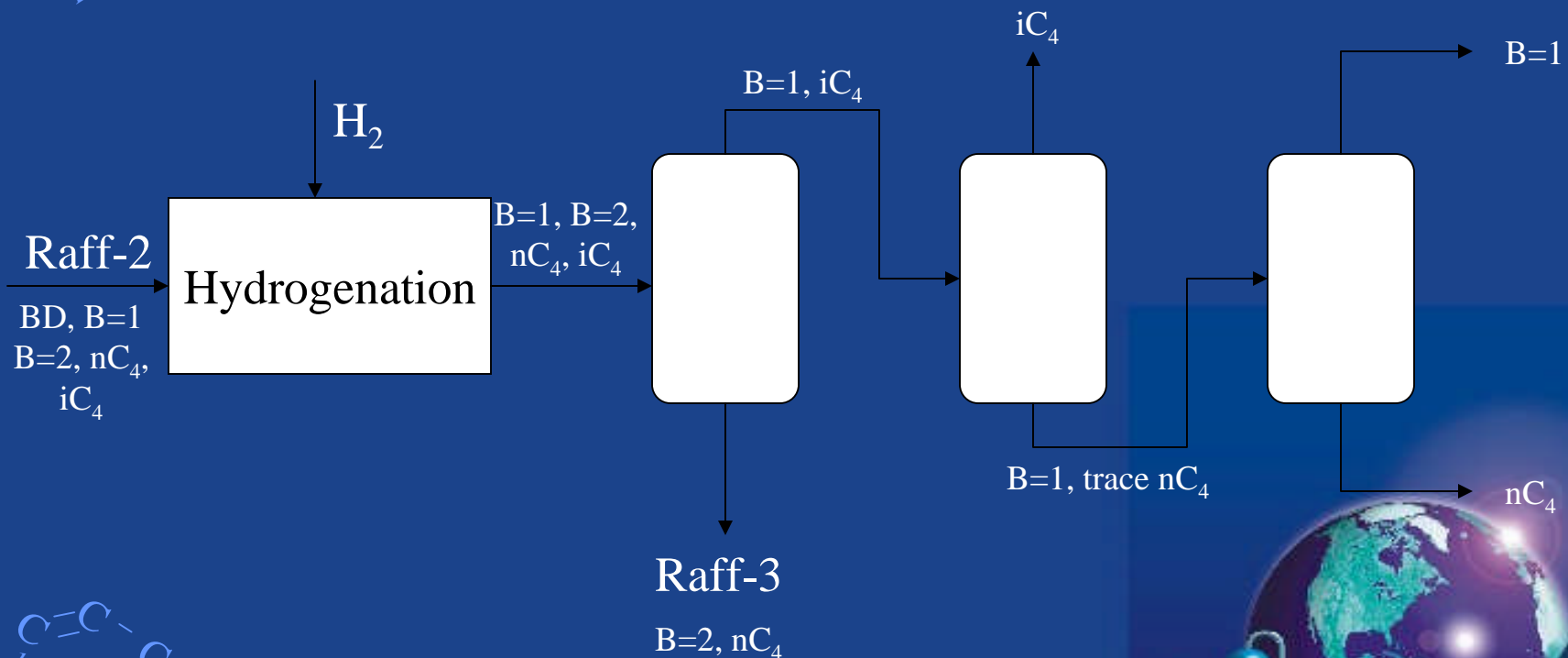
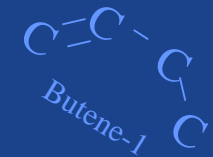
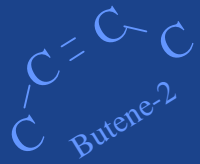
Objective

Debottleneck B1 train to meet the increasing demand for highly profitable B1 production

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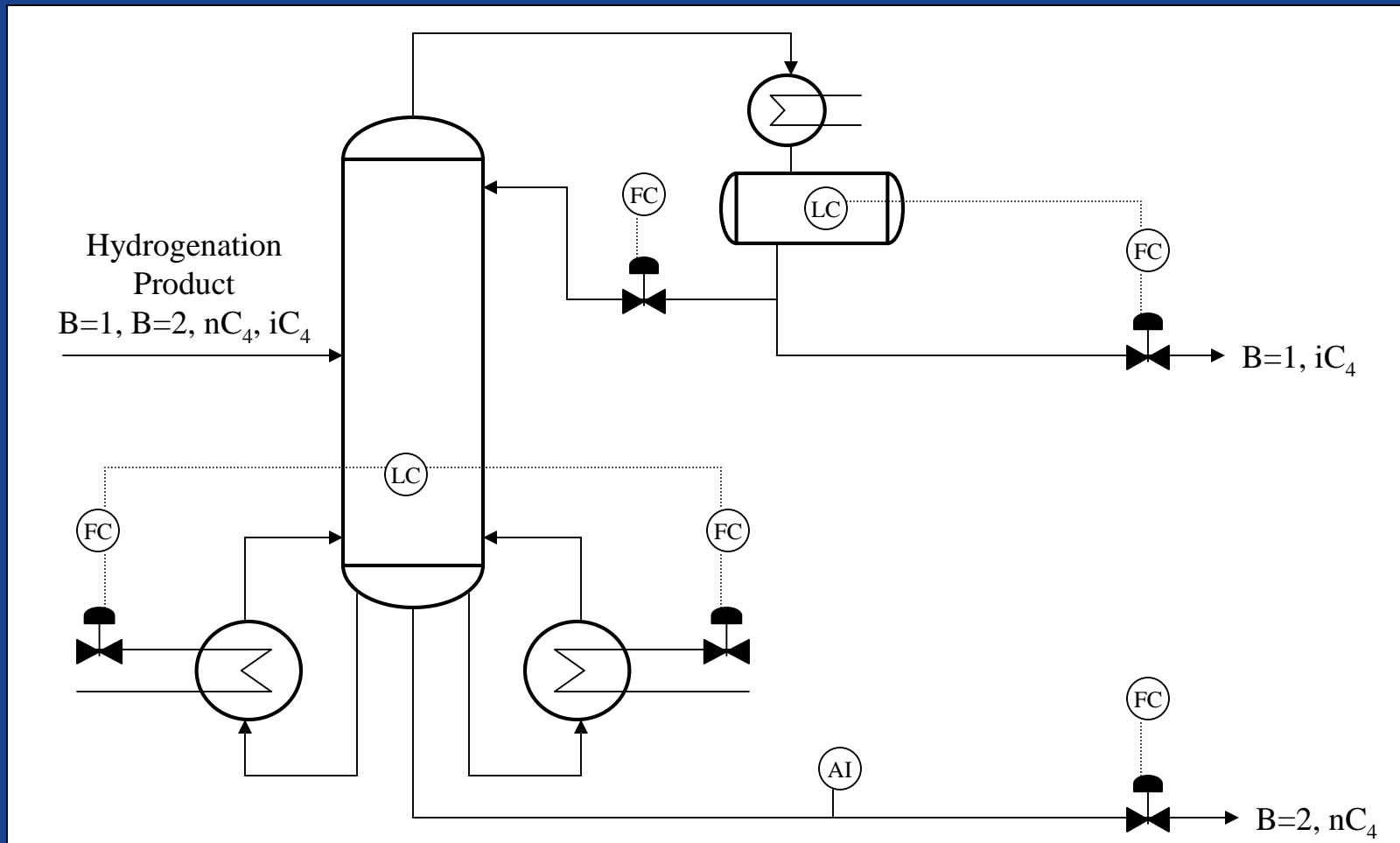


Process Description



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Old Regulatory Controls



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Old Regulatory Controls

- Large swings in product flows and composition
 - OH flow and composition (nC_4) affects downstream towers & performance
 - Bottoms composition impacts Raff-3 “total butylenes” ($C_4=$)
 - Variable B=1 losses in bottoms stream
- Unknown effect of B=1 losses vs. column energy efficiency (BTU/lb)



Objective Revisited

Debottleneck B1 train to meet the increasing demand for highly profitable B1 production

Goals

1. Reduce B1 losses
2. Reduce OH variability
3. Improve energy efficiency

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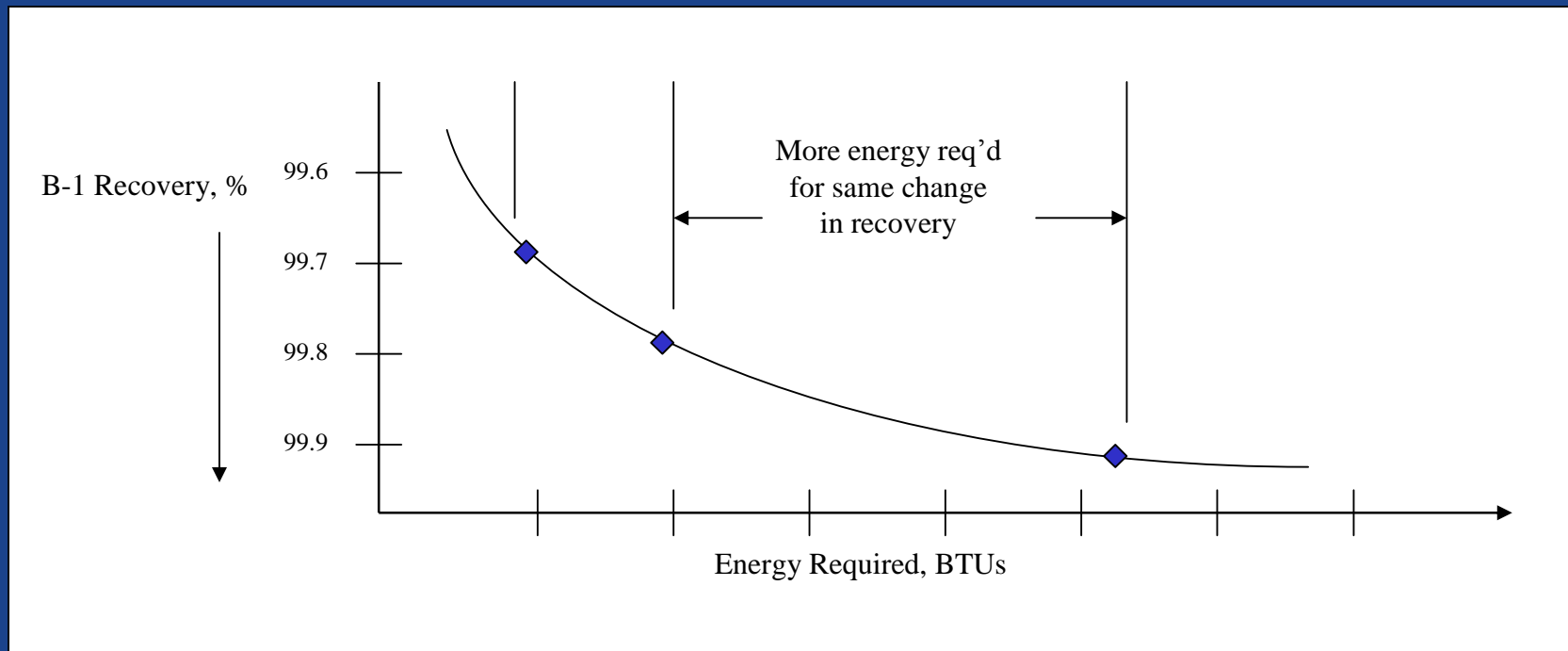
Variable Definition

- Evaluate controlled variables
 - Relationship between B=1 purity and heat duty
 - Non-linear

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Heat Duty vs. B=1 Purity



Significant incremental energy required to meet precise specifications



Variable Definition

- Evaluate controlled variables
 - Relationship between B=1 purity and heat duty
 - Non-linear
 - Total C₄= spec in Raff-3 product
 - Bottoms blended with other stream to form Raff-3
 - Kept B=1 bottoms concentration between 1 – 15%
- Challenge existing targets
 - Tower operated on basic level control
 - Level cascaded to steam reboiler flow
 - Manual composition adjustments
 - Varying feed from Hydrogenation unit
 - Varying Hydrogenation product composition (B=1, nC₄)

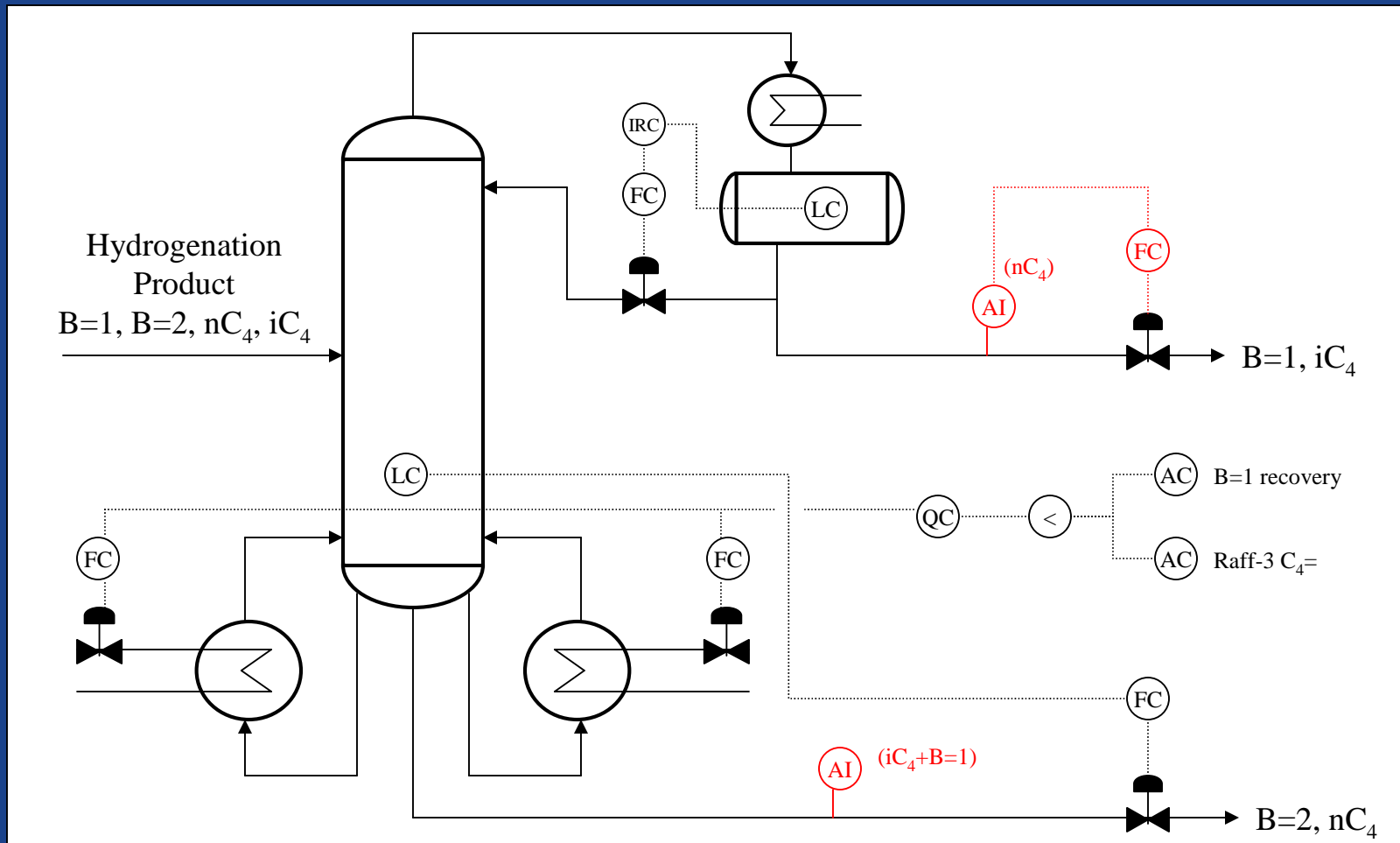


New Regulatory Controls (Primary)

- Analyzer modifications
 - Added OH analyzer to measure nC_4
 - nC_4 composition controls OH flow
 - Bottoms $C_4=$ analyzer used for control
 - Calculate blended $C_4=$ in Raff-3



New Analyzers

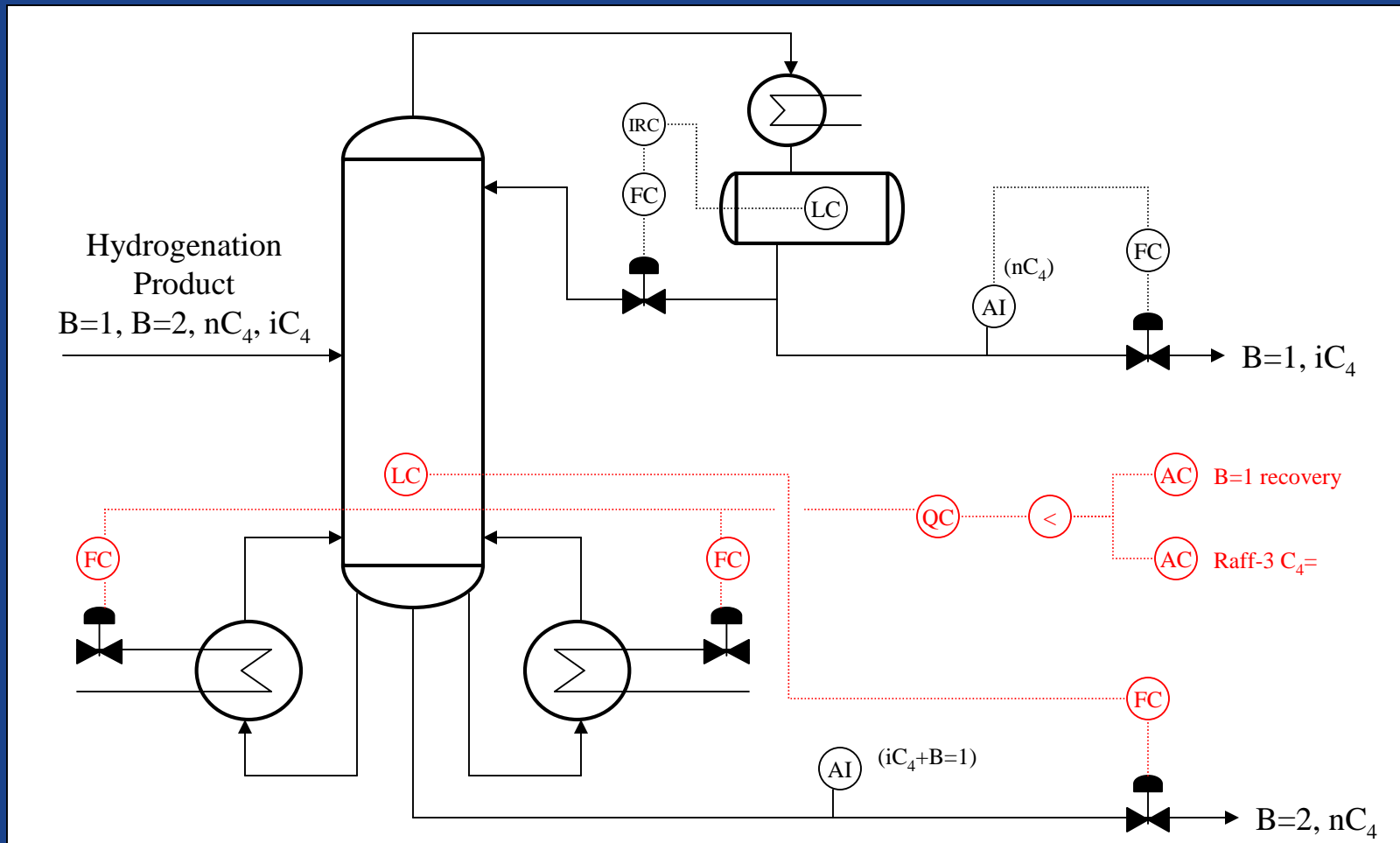


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- Control scheme changes
 - Column heat duty controlled by either Raff-3 $C_4=$ or B=1 OH recovery
 - Column level controlled by bottoms flow



New Composition Controls

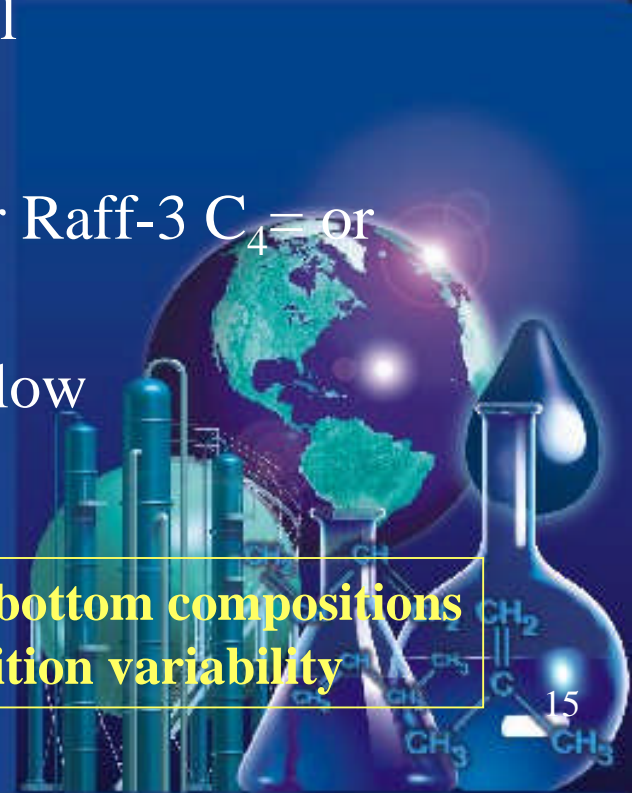


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Minimized interaction between top and bottom compositions
Reduced product flow and composition variability

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New Regulatory Controls

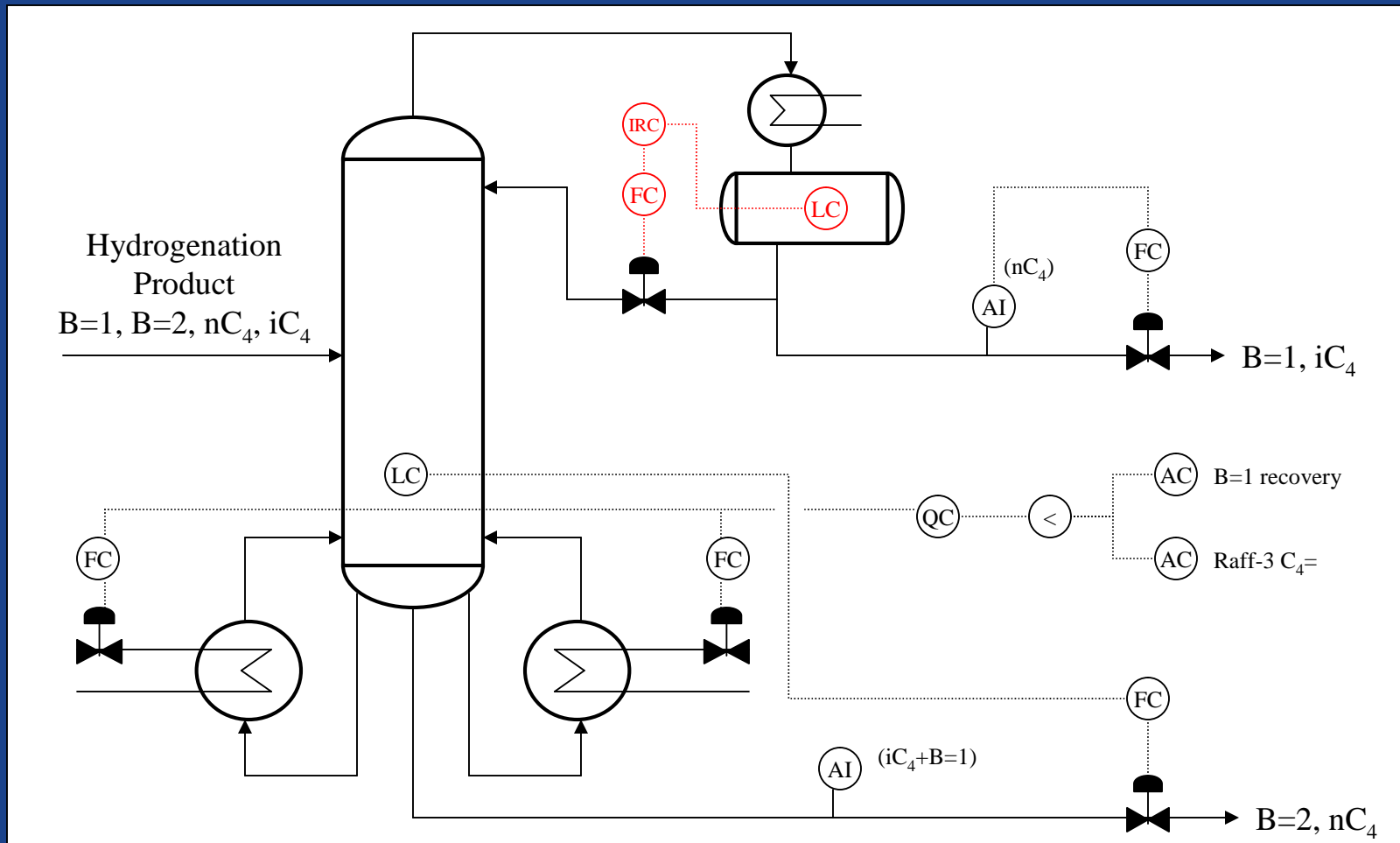
(Secondary)

- Internal reflux control
 - Temperature-compensated flow
 - Controlled by OH accumulator level

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New Internal Reflux Control

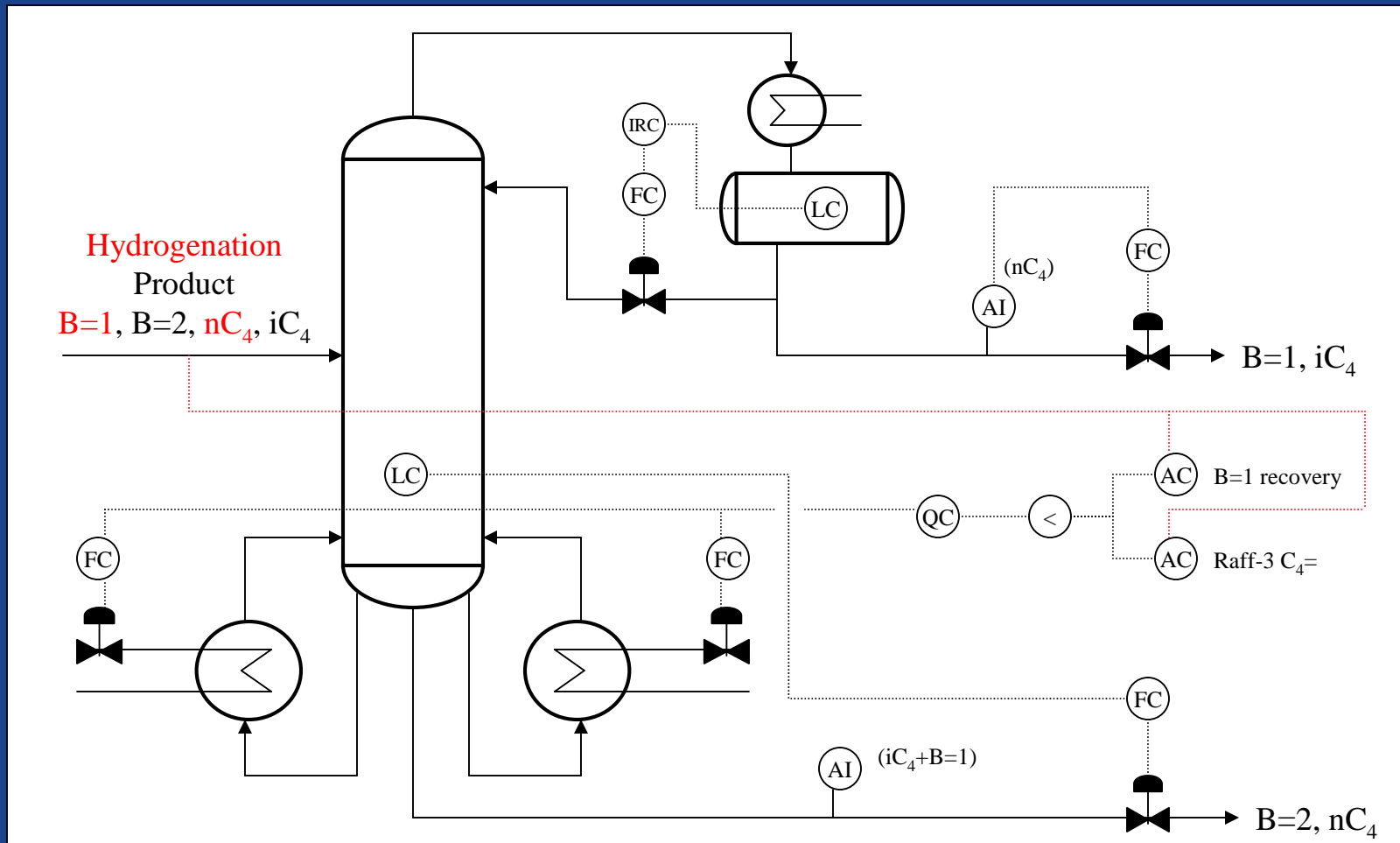


New Regulatory Controls (Secondary)

- Internal reflux control
 - Temperature-compensated flow
 - Controlled by OH accumulator level
- Hydrogenation feed forward signal
 - Changes sent to heat duty controllers
 - Hydrogenation feed flow
 - Hydrogenation product B=1 %
 - Hydrogenation product nC₄ %



New Feed Forward Control



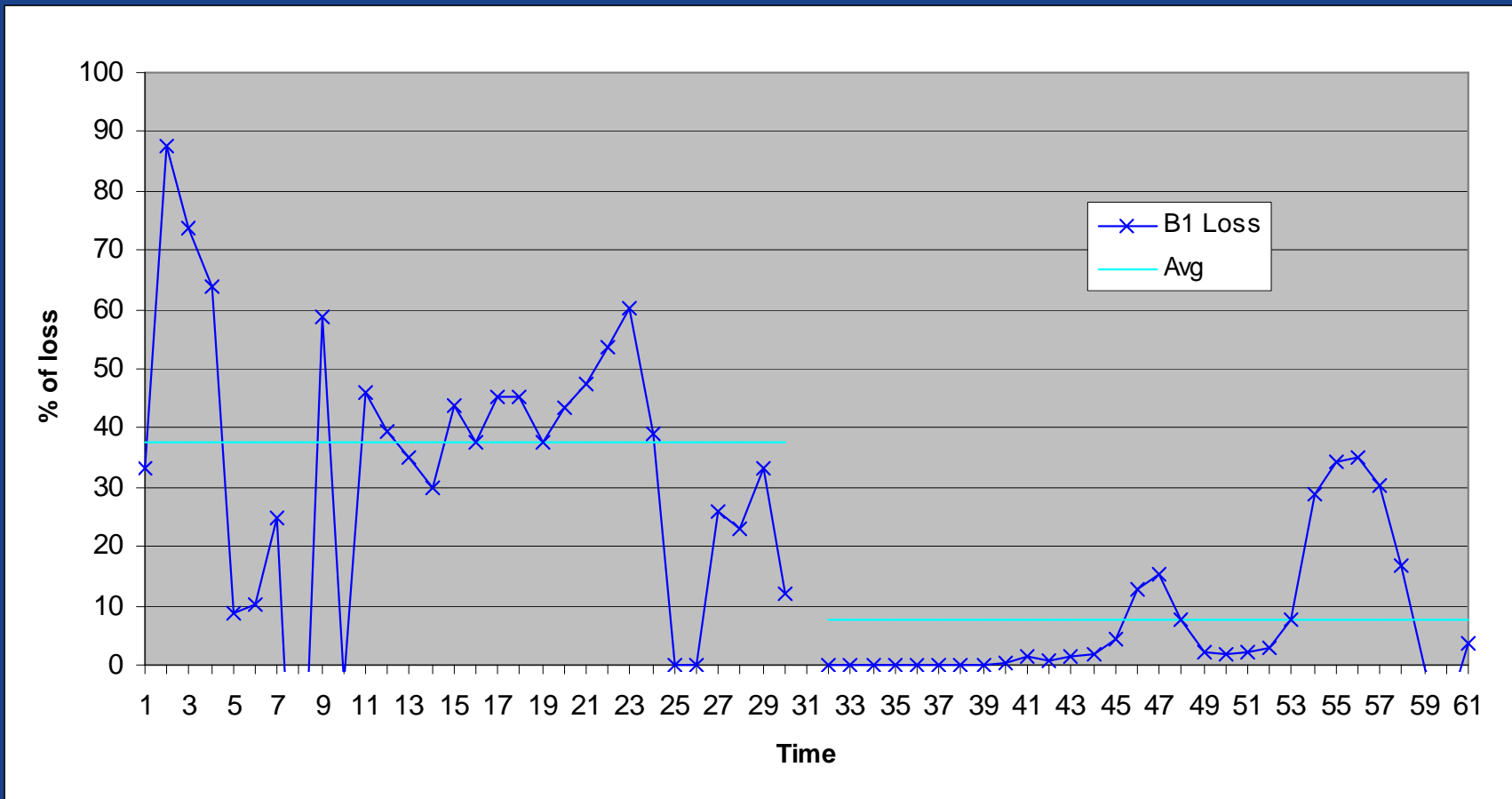
Project Results & Benefits

1. Reduce B1 losses
2. Reduce OH variability
3. Improve energy efficiency

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B=1 Loss Reduction



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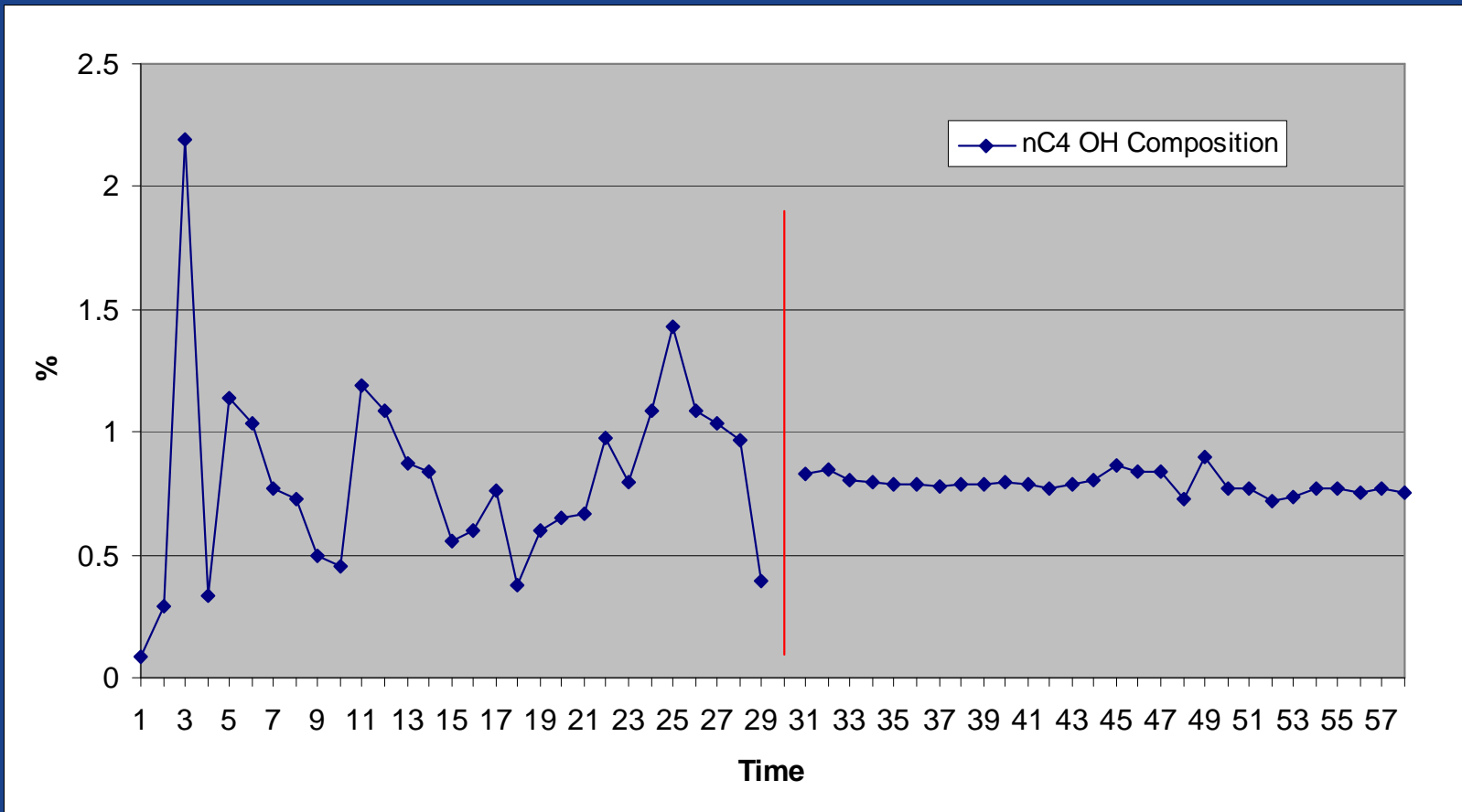
80% Reduction in B=1 Losses
57% Reduction in B=1 Variability

Project Results & Benefits

1. Reduce B1 losses
 - \$2.1 MM annual productivity improvement
2. Reduce OH variability
3. Improve energy efficiency

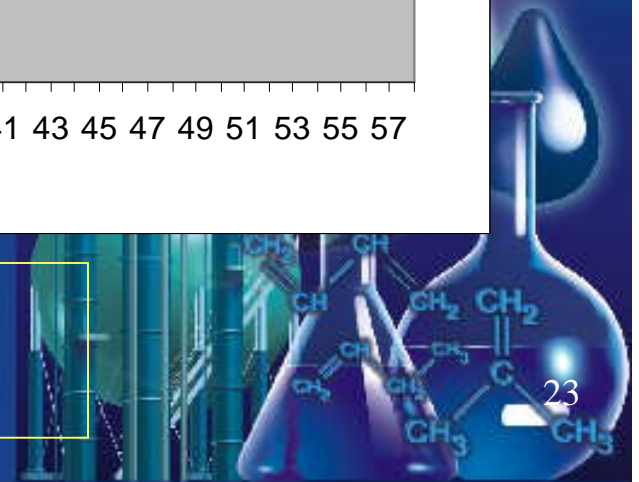


OH Composition Control



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$\sigma = 0.41$ before controls
 $\sigma = 0.04$ after controls

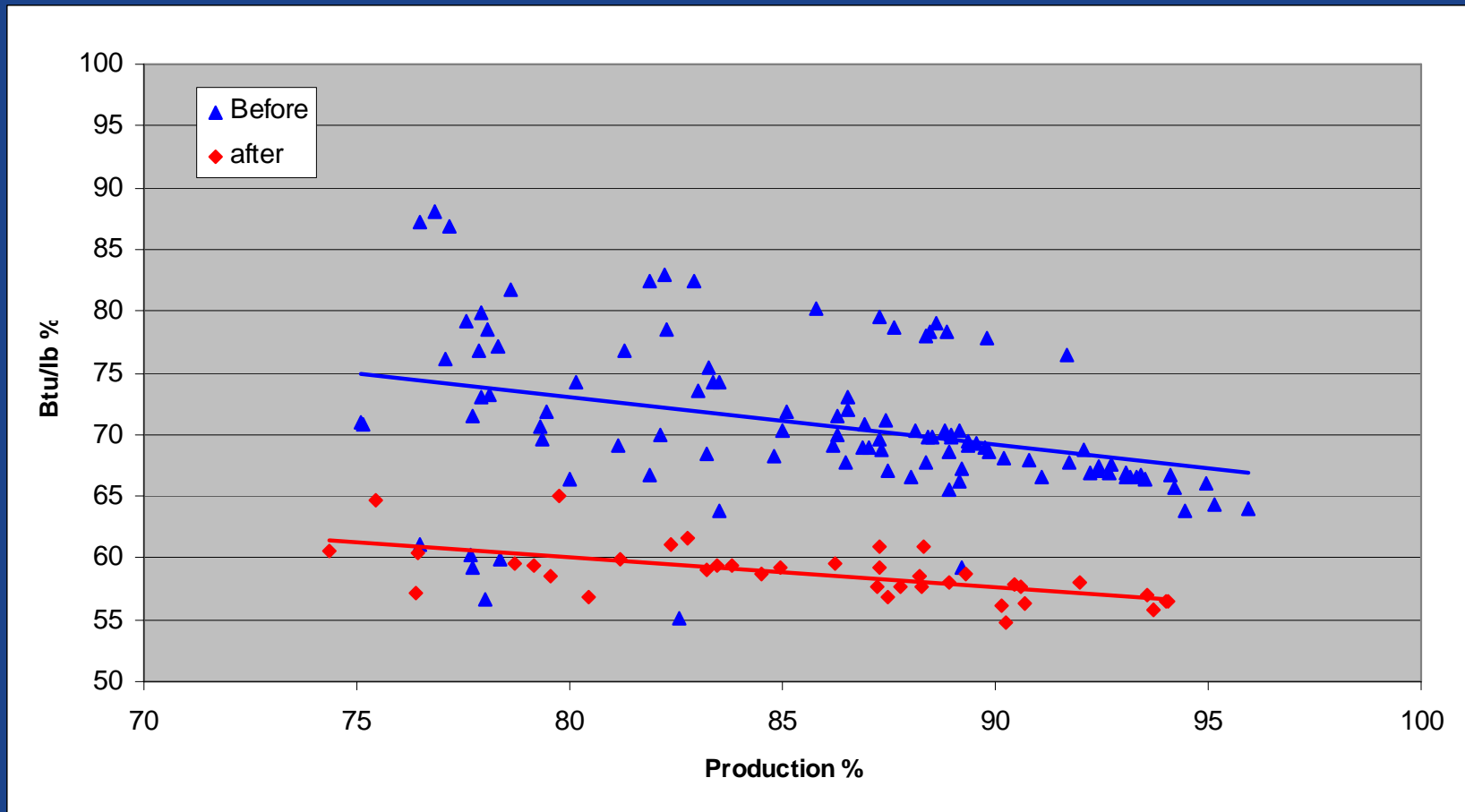


Project Results & Benefits

1. Reduce B1 losses
 - \$2.1 MM annual productivity improvement
2. Reduce OH variability
 - St.Dev. = 0.41 → 0.04
3. Improve energy efficiency



Energy Efficiency Improvement

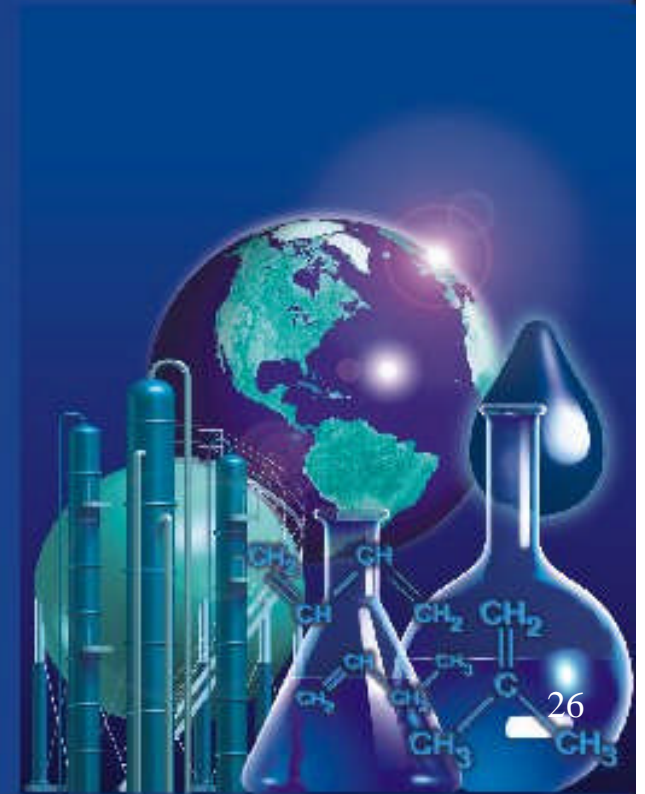


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**24% Reduction in Energy (Btu/lb)
65% Reduction in Energy Variability**

Project Results & Benefits

1. Reduce B1 losses
 - \$2.1 MM annual productivity improvement
2. Reduce OH variability
 - St.Dev. = 0.41 \rightarrow 0.04
3. Improve energy efficiency
 - \$950 M annual energy savings



Next Steps

- Develop energy vs. B=1 recovery model at varying energy prices
- Extend composition controls to downstream columns
- Develop B=1 train economic model
 - Energy prices
 - B=1 and Raff-3 prices
- Improve inventory control
 - Minimize Hydrogenation feed flow changes



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