

Recent Process Improvements for the AFEX Process and Resulting Processing Cost Reductions

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Overview

- History
- Reproducing Original Data
- Parameter Changes
- Results

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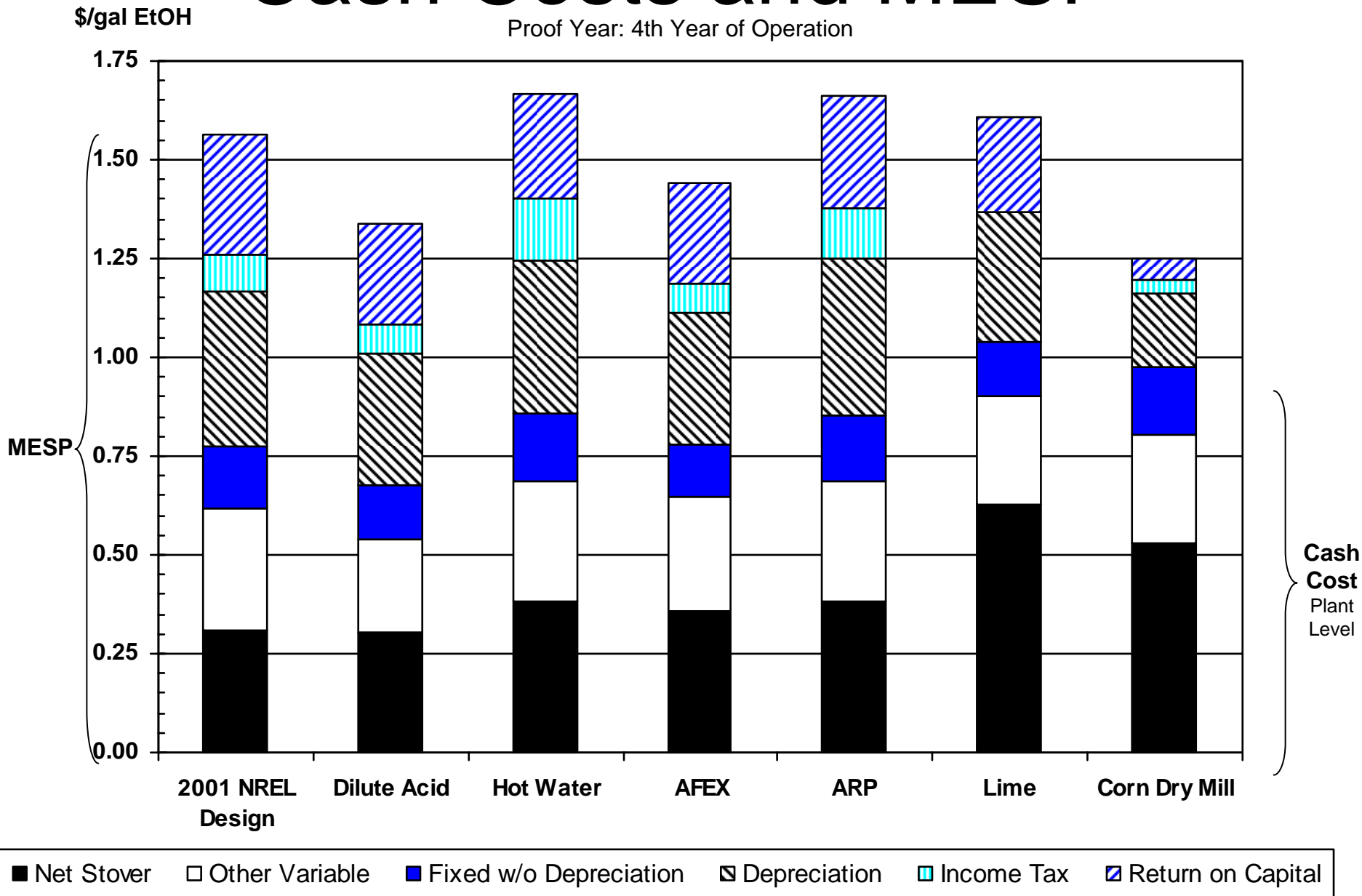
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History

- 1.5 years ago Dr. Tim Eggeman studied the economic performance of various cellulosic biomass pretreatments
- Ammonia Fiber Explosion (AFEX)
Minimum Ethanol Selling Price (MESP)
~ \$1.40/gallon

Cash Costs and MESP

Proof Year: 4th Year of Operation



Opportunities

- Rapidly Maturing Technologies
- AFEX is not mature
- Neither is cellulosic ethanol production

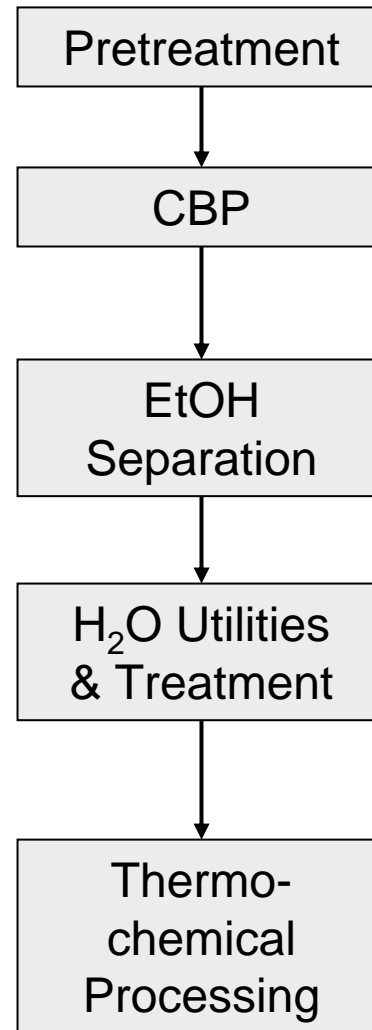
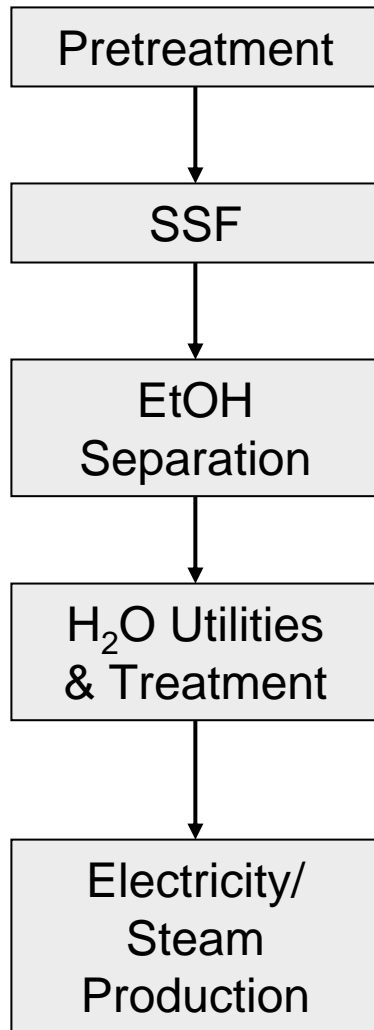
Process Improvements

- Report economic advances in
 - AFEX process parameters
 - AFEX process design
 - Context of advanced cellulose processing – namely CBP
- Details to come - IP

Context

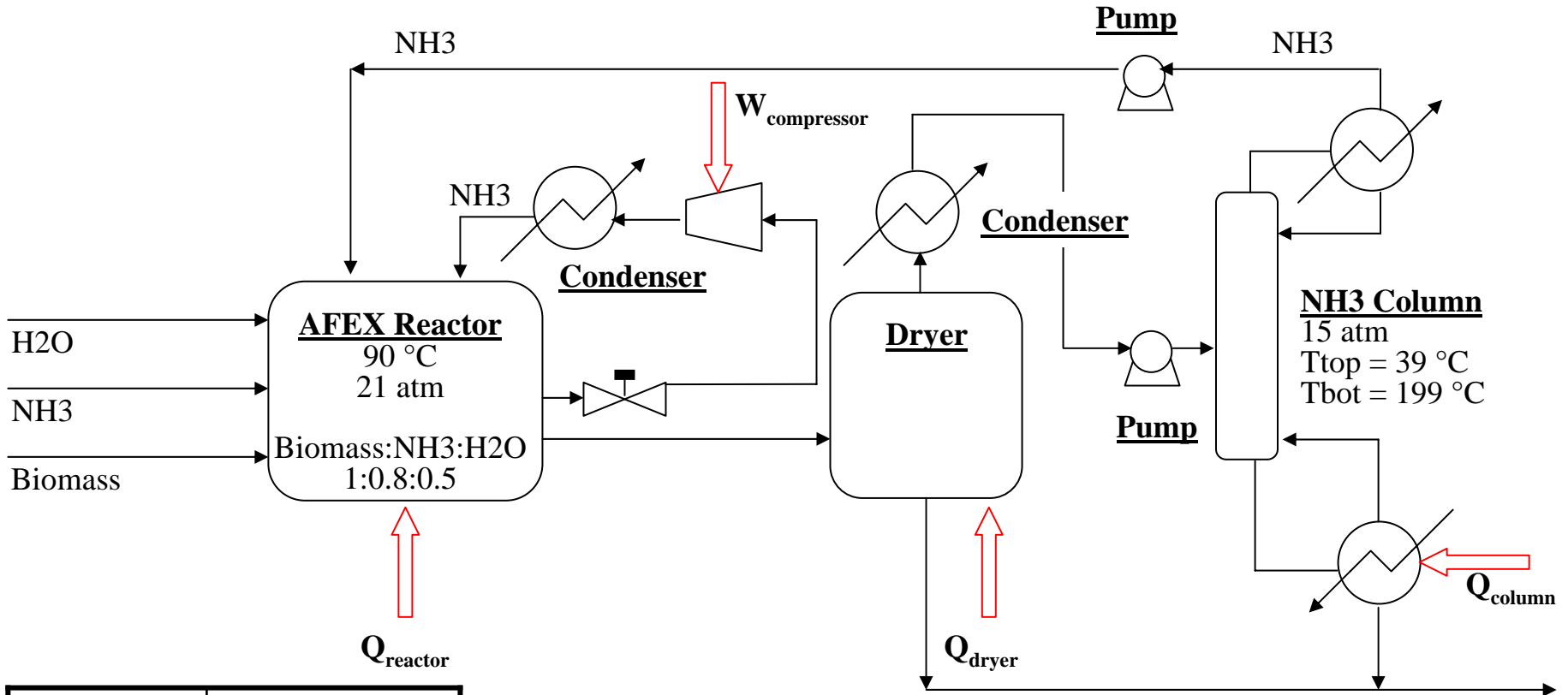
- SSF
 - NREL
 - 2,000 dry ton/day
 - Feedstock washing
 - AFEX pretreatment
 - Ammonia recompression recovery
- CBP
 - Dartmouth
 - 5,000 dry ton/day
 - Eliminated feedstock washing
 - AFEX pretreatment
 - New ammonia recovery approach

Overall Process



AFEX Pretreatment (Recompression)

Flash + Distillation NH3 Recovery



| Energy Flow | (% feed LHV) |
|-------------------------|--------------|
| Q_{reactor} | 0% |
| Q_{dryer} | 8.4% |
| Q_{column} | 3.7% |
| $W_{\text{compressor}}$ | 0.5% |
| TOTAL | 12.6% |

Innovation on AFEX Process

- Reduced Ammonia Usage (MSU)
- Reduced Ammonia Recycle Concentration (MSU)
- Improved Ammonia Recovery (Dartmouth)



Pretreatment & CBP

- CBP assumes 95% conversion of all sugars
- AFEX meets this test for SSF
- Not yet demonstrated AFEX for CBP at this level

Process Comparison

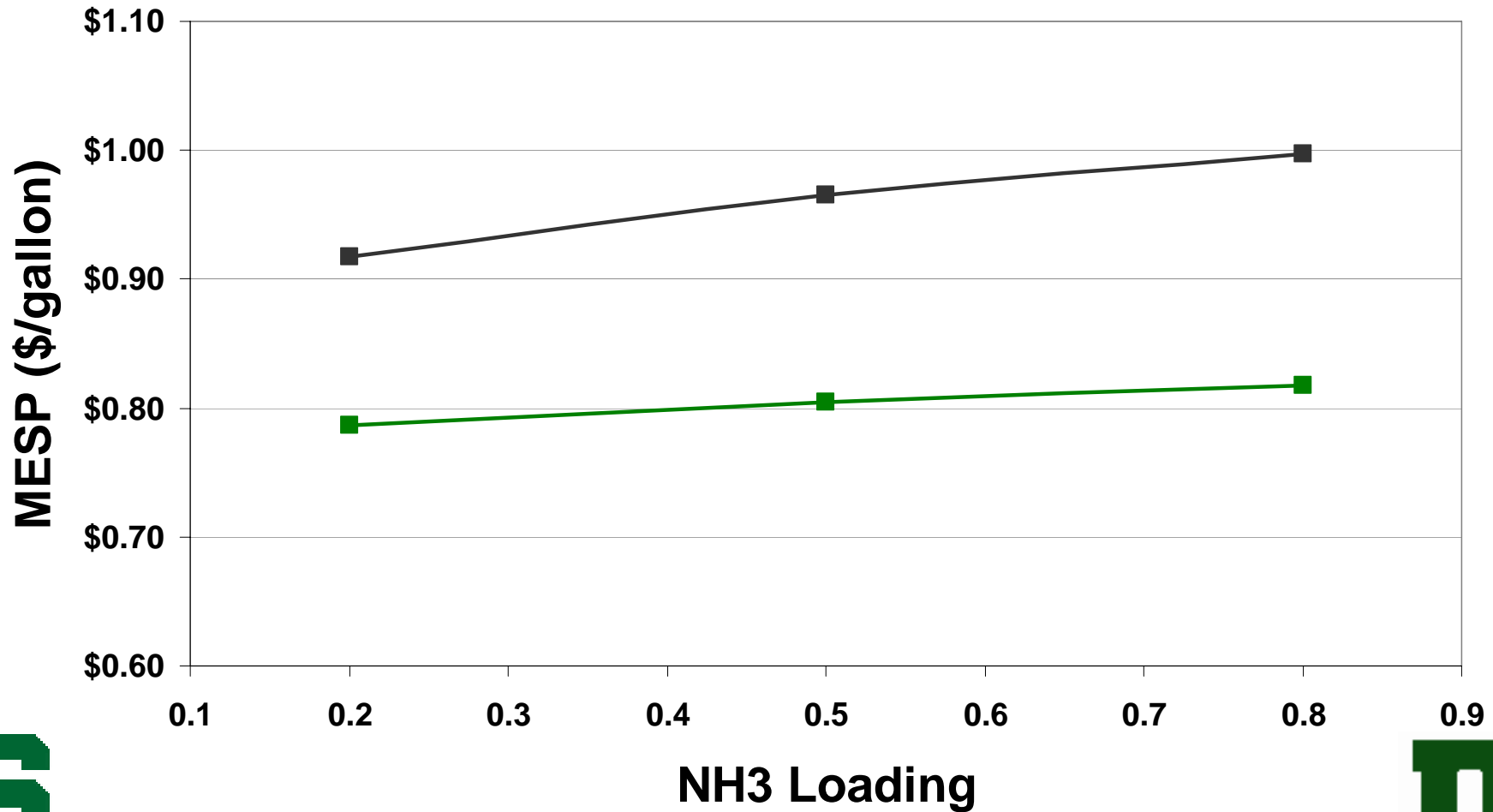
- SSF Configuration
 - Biomass Feed (2,205 dry ton/day)
 - NH₃ Loading (0.8g:1g of dry biomass)
 - NH₃ Recycle Concentration (99.2%)
- CBP Configuration
 - Biomass Feed (5,000 dry ton/day)
 - NH₃ Loading (< 0.8g:1g of dry biomass)
 - NH₃ Recycle Concentration (< 99%)

Simulations Tested

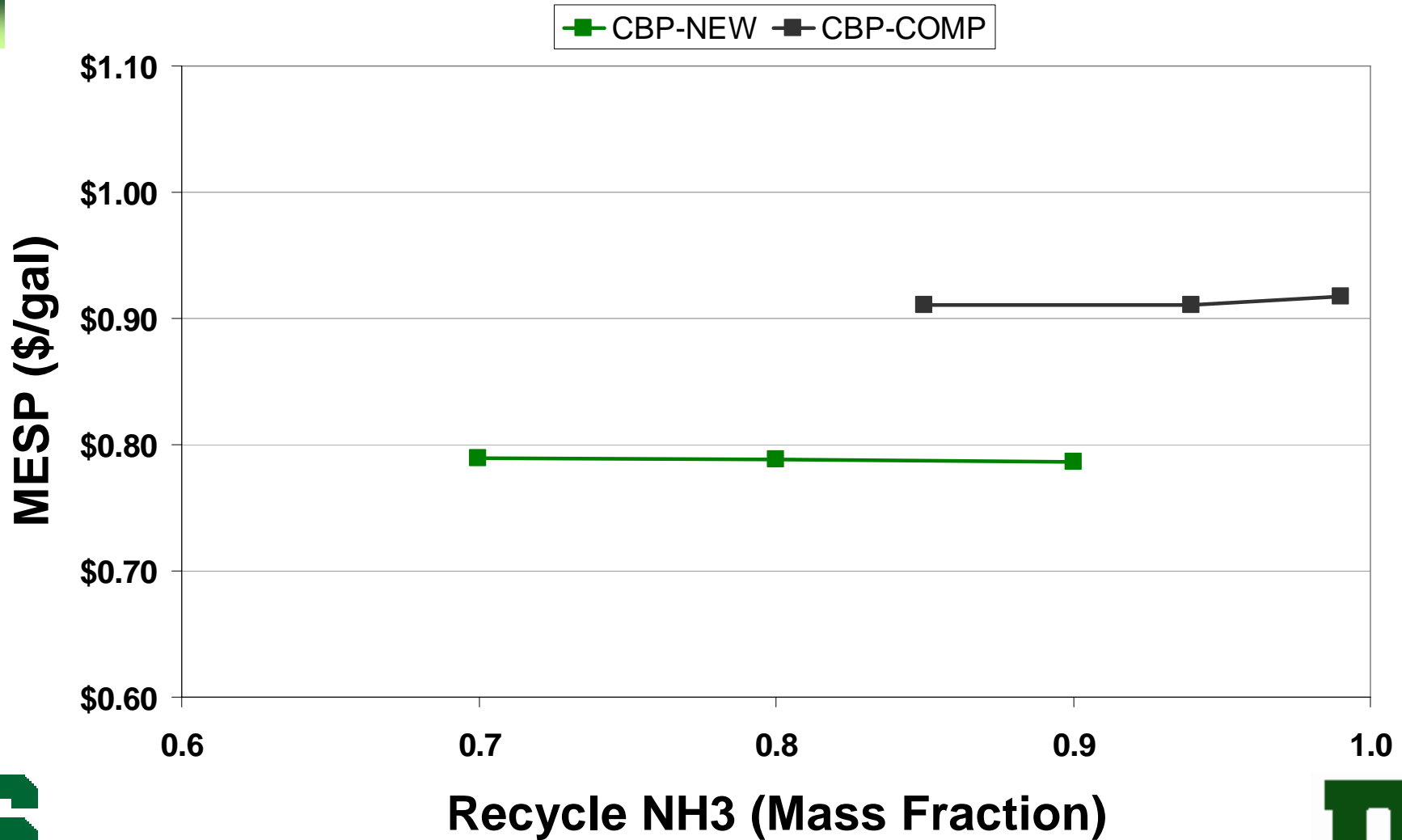
| Abbreviation | Meaning |
|--------------|---|
| SSF-COMP-OLD | SSF, NH3 Recompression, Old AFEX parameters |
| CBP-COMP-OLD | CBP, NH3 Recompression, Old AFEX parameters |
| CBP-COMP-UPD | CBP, NH3 Recompression, Updated AFEX parameters |
| CBP-NEW-OLD | CBP, New NH3 Recovery approach, Old AFEX parameters |
| CBP-NEW-UPD | CBP, New NH3 Recovery approach, Updated AFEX parameters |

Final Results

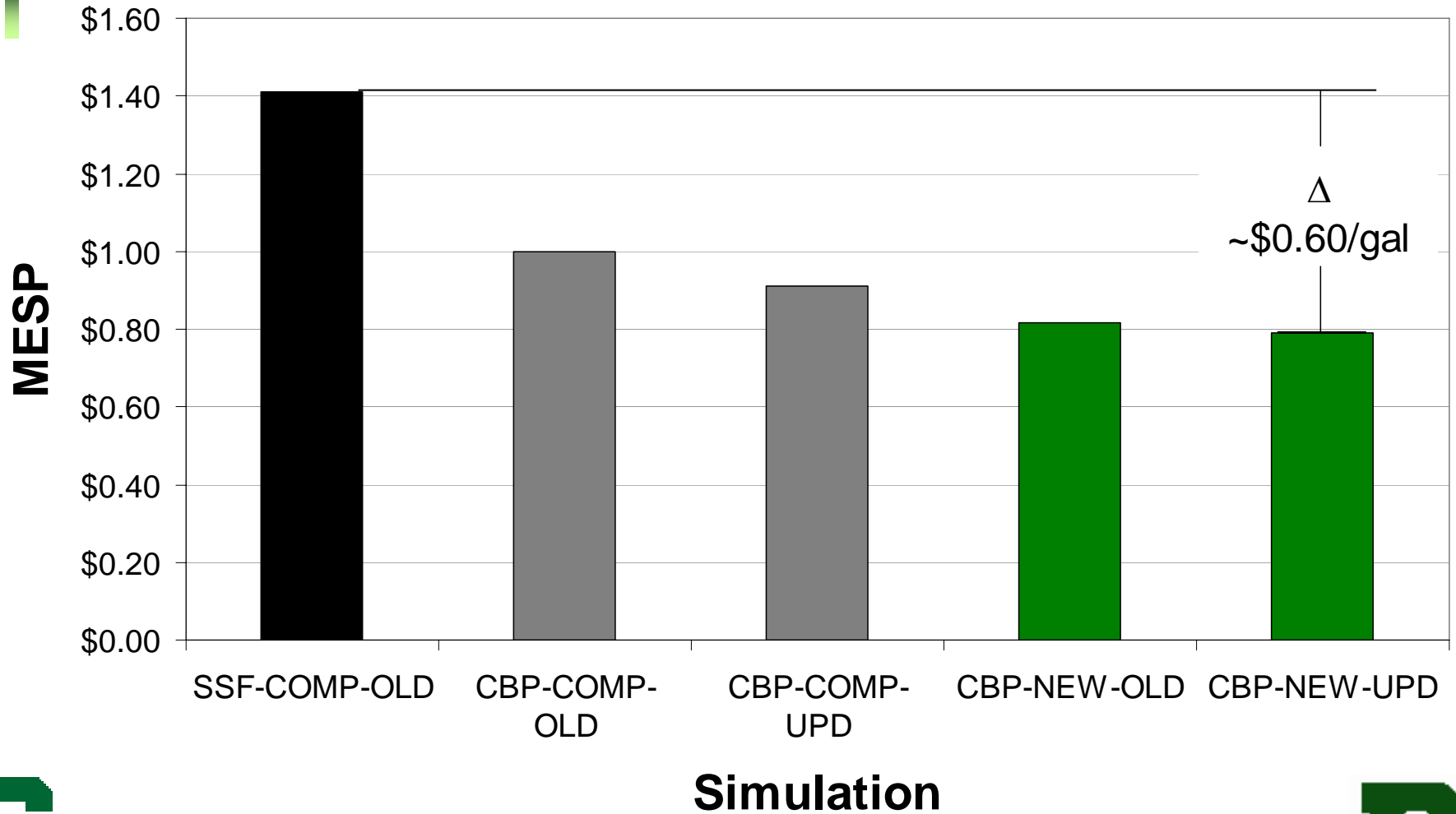
■ CBP-NEW ■ CBP-COMP



Final Results



Final Results



The way ahead!

- Keep working on
 - AFEX Design
 - AFEX Process Parameters
 - AFEX Integration into Overall System
- Further Advances Likely
- Dr. Eggeman's Previous MESP ~\$1.40/gal
- Current Best Result ~\$0.80/gal
- More Details When the Lawyers Say So



Questions?



- Thank You for Your Attention
- Thanks to All Our Collaborators
- For Further Questions Contact Elizabeth Newton at newtone3@msu.edu or visit www.everythingbiomass.org