Viability of Benzyl Acetate Production Plant

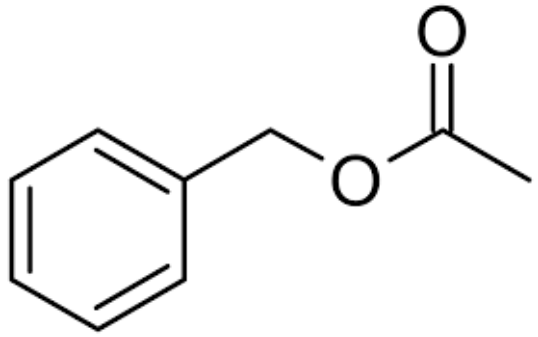
Team 12

Michael Gustafson, Bryent Lee, Renee Mallick, Emily Milburn, Guilherme Pinto

Background

- Benzyl acetate (BAc)
  - Naturally occurring in jasmine
  - Perfumery, food flavoring, soaps
  - Precursor for insecticide and fungicide[1]
- 4 million pounds/year consumed in the US each year[1]

Jasmine Plant[2]



CJB INDUSTRIES, INC.

1. CJB, Presentation to Georgia Tech, 2020
2. https://stock.adobe.com

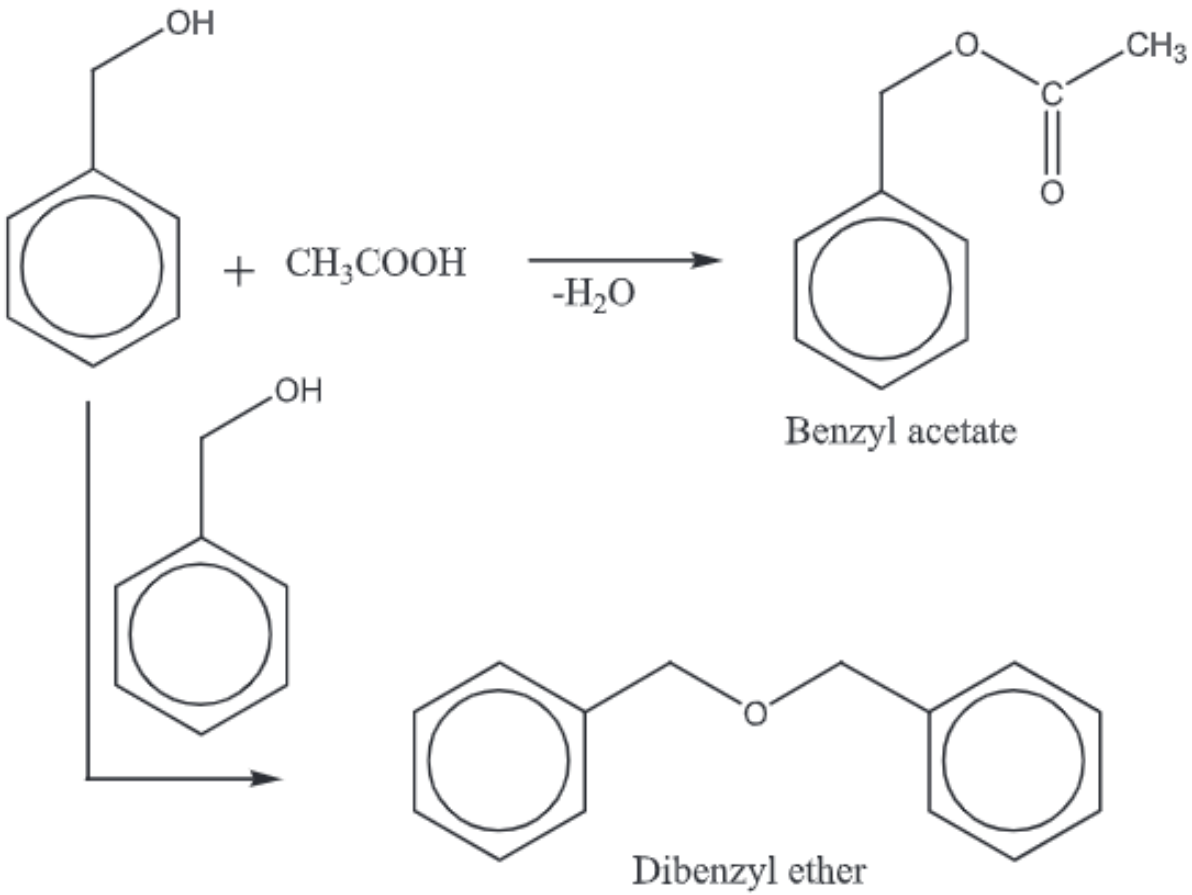
Reaction

Catalyst: HZSM-5 Zeolite

Temperature: 120°C
Endothermic

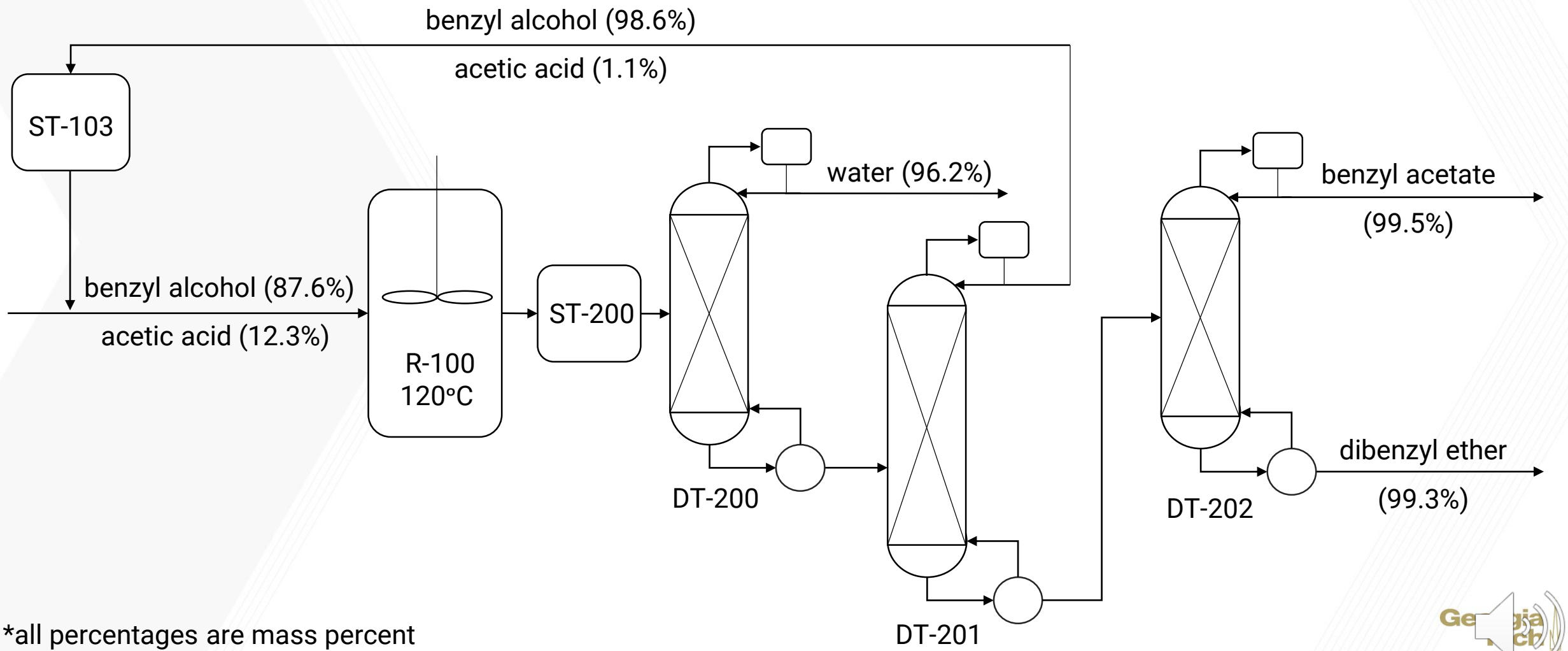
Conversion: 94% AA
Selectivity: 95% BAc

Reaction Time: 2 hours



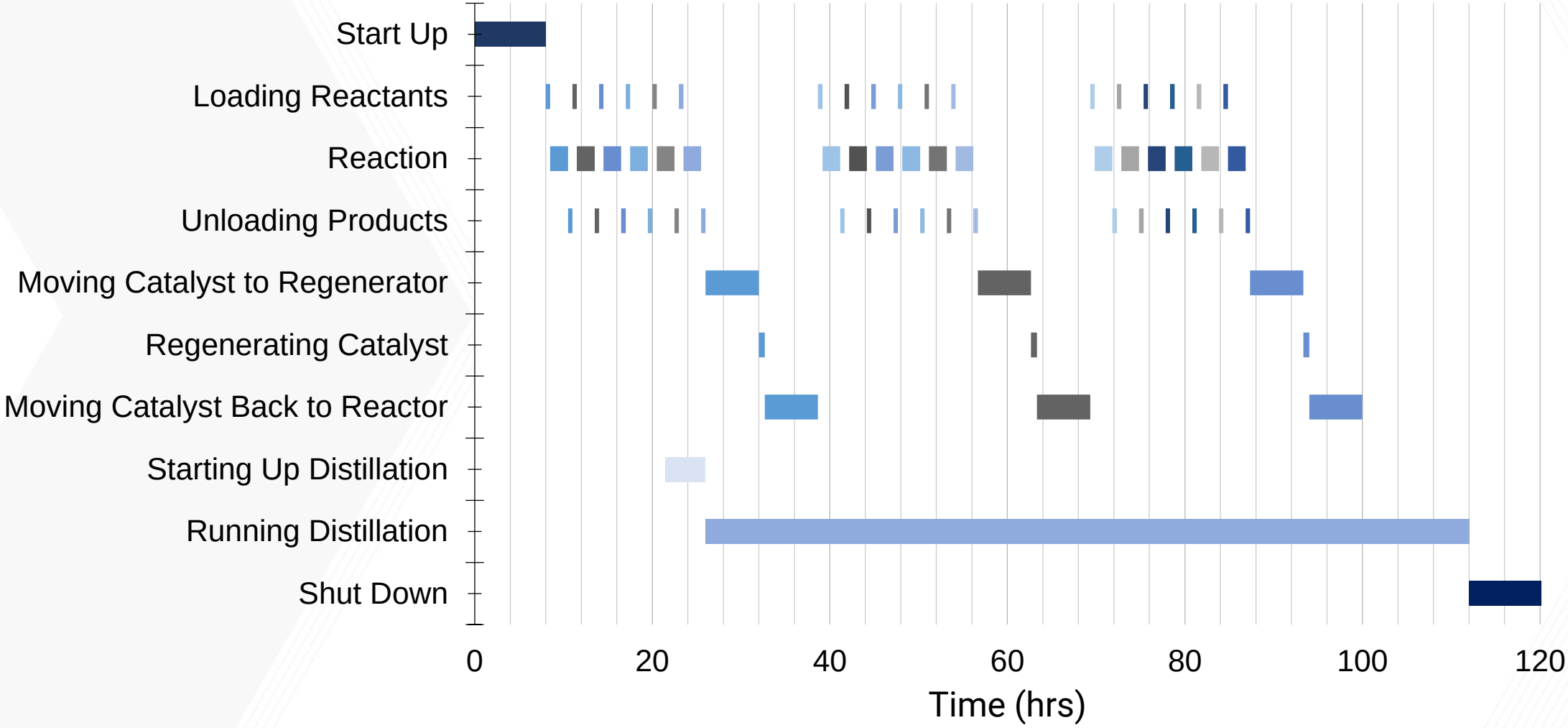
3. Nandiwale et al., Benzylation of Acetic Acid, 2014

Process



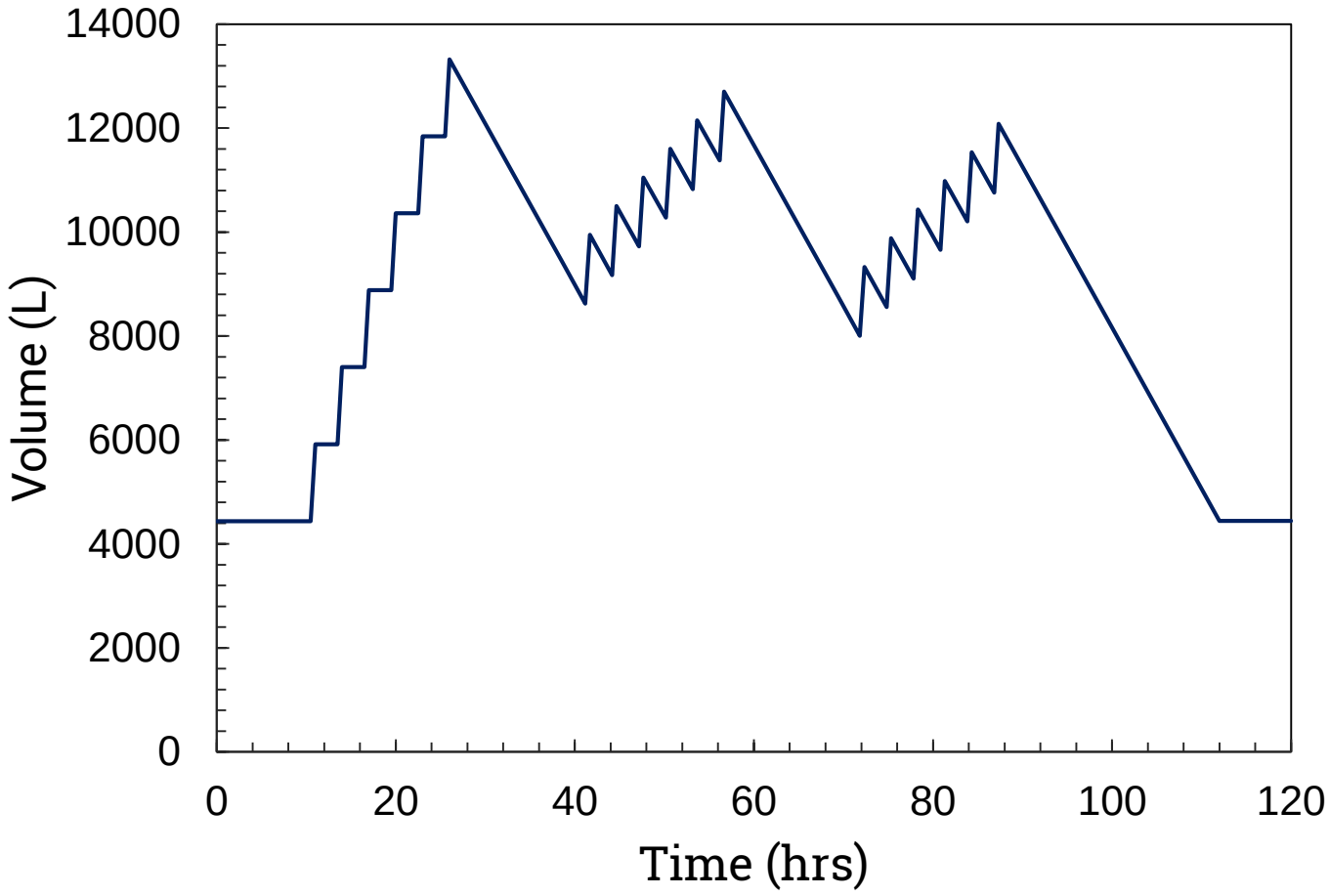
*all percentages are mass percent
*all units operate at 1 atm

Scheduling – Weekly Gantt Chart



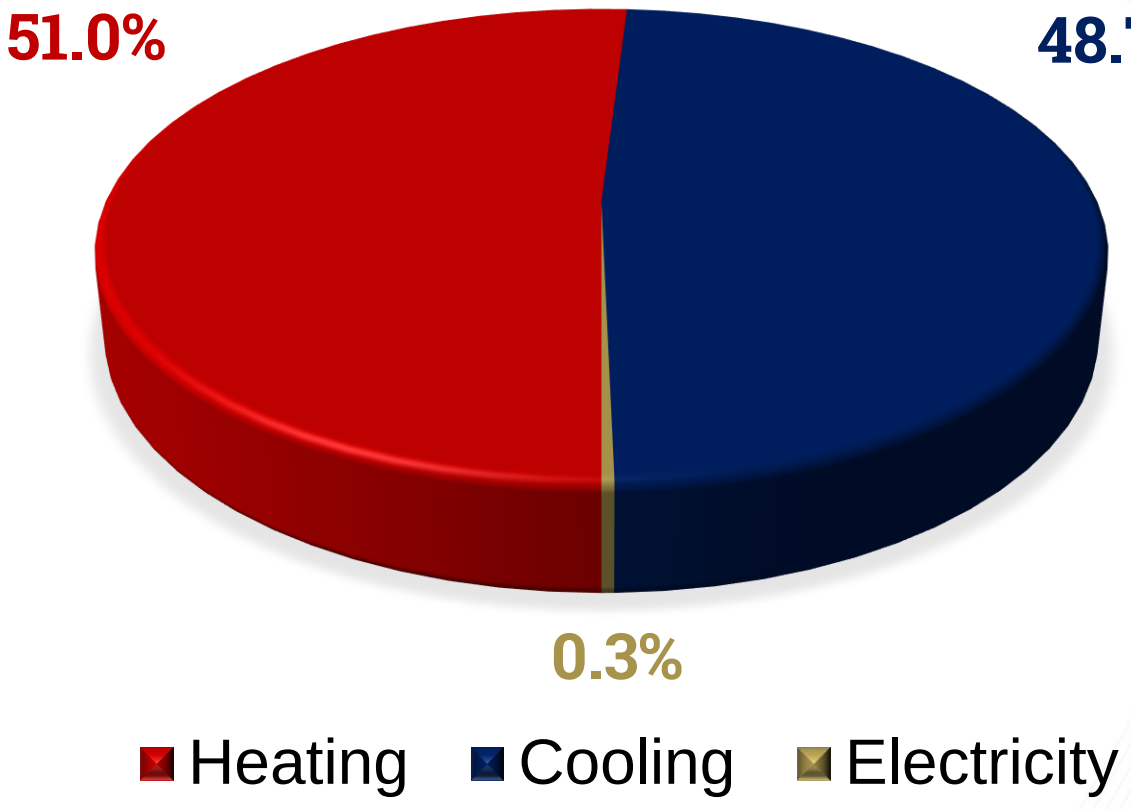
Inventory - (ST-200)

- Intermediate storage
  - Between reactor and separations
- Ensures distillation columns never run dry
  - Non-zero baseline
  - Six batches at the beginning of each week

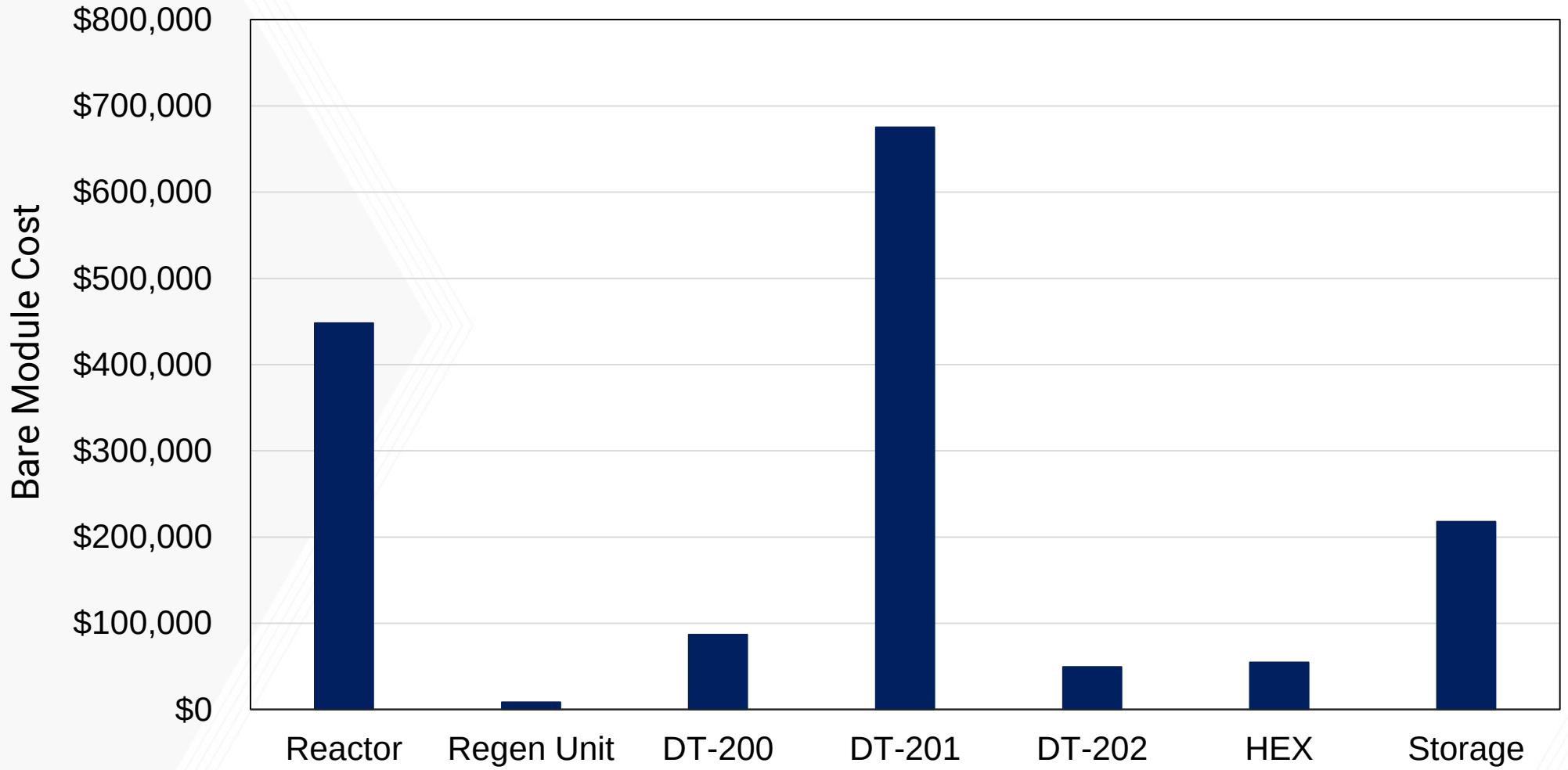


Utilities

- Heating (Hot Oil)
  - 2.28×10^6 kJ/hr
  - $46,000/yr
- Cooling (Chilled Water)
  - 2.17×10^6 kJ/hr
  - $49,000/yr
- Electricity
  - 1.55×10^4 kJ/hr
  - $1,000/yr



Major Equipment Costs



Economics

- Operating Costs: $1.7 million/yr
- Capital Costs: $3.5 million

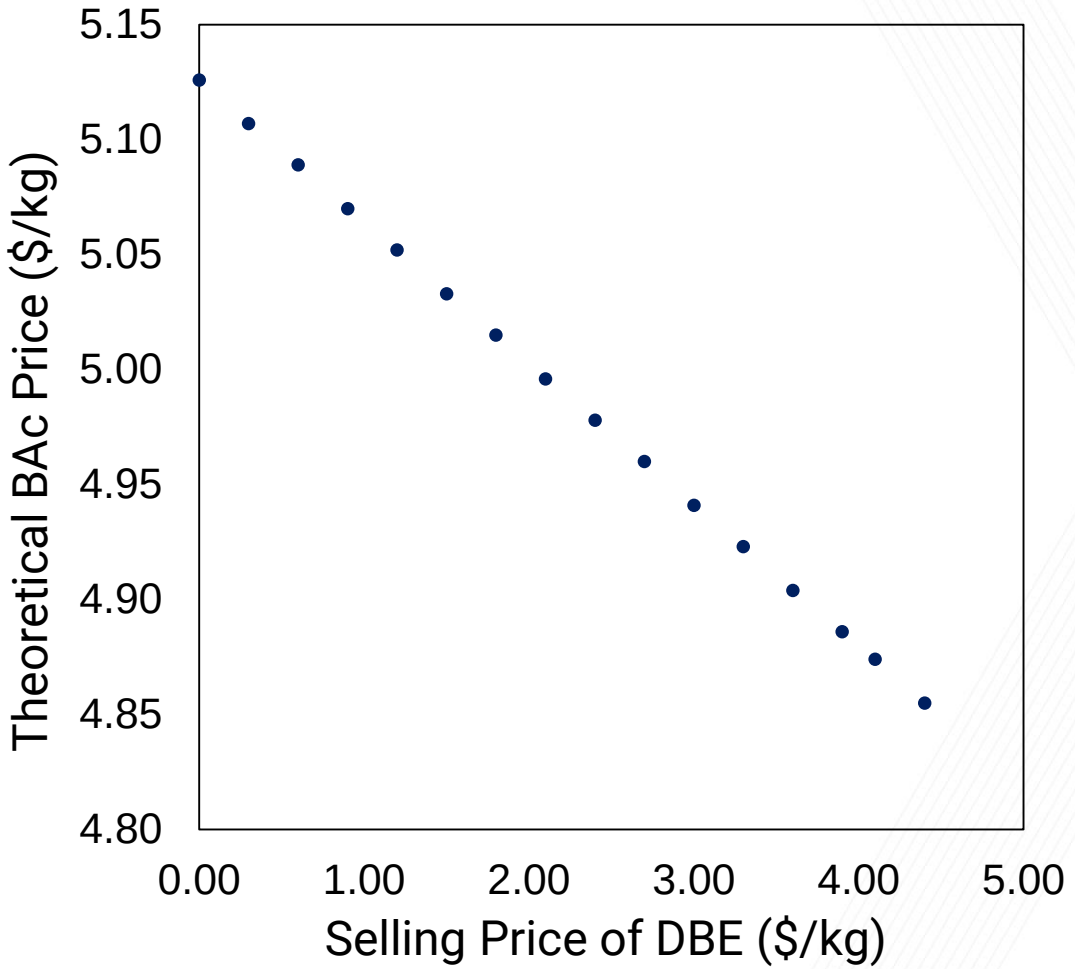
Supplier BAc Price:
$6.40/kg

BAc Price for IRR of 15%:
$5.10/kg

Lifetime Savings:
$10.4 million

Economic Sensitivity

- Changes with minimal effect:
  - Heat integration
  - Catalyst replacement rate
- Changes with moderate effect:
  - Selling price of dibenzyl ether (DBE)
  - Capital equipment costs
- Changes with substantial effect:
  - Number of additional operators



Safety

- Feedstocks and products are irritants

- High temperatures
  - Reactor (120°C), hot oil system (340°C) and regen. unit (550°C)
- Flammability hazards
  - ➡ Moderate **flash points** and **flammability ranges**
  - ⬆ High **autoignition** temperature

- Risk analysis
  - Reactor HAZOP study

4. https://www.sigmaaldrich.com

Environmental

- Aquatic toxicity[4]
  - Benzyl alcohol
  - Dibenzyl ether
- EPA Regulations[5]
  - All chemicals ➡ TOSCA inventory
  - No hazardous air pollutants (HAPs)
- Waste disposal
  - Wastewater treatment (CWA)
  - Catalyst disposal (RCRA)

4. https://www.sigmaaldrich.com
5. https://www.epa.gov

Unique Aspects of Process Design


Low number of batches per week


40-minute catalyst regeneration time


Limiting reactant is acetic acid


Single reactor


Analysis of storage tank inventory

Recommendations

- CJB **should** construct the benzyl acetate production plant
- Considerations before implementation:
  - $3.5 million capital investment
  - Full safety investigation
  - Realistic to facility
  - Legal requirements
  - Management of changes