



# CATOFIN<sup>®</sup> Technology Integration Options





This presentation contains forward-looking statements regarding CB&I and represents our expectations and beliefs concerning future events. These forward-looking statements are intended to be covered by the safe harbor for forward-looking statements provided by the Private Securities Litigation Reform Act of 1995. Forward-looking statements involve known and unknown risks and uncertainties. When considering any statements that are predictive in nature, depend upon or refer to future events or conditions, or use or contain words, terms, phrases, or expressions such as “achieve”, “forecast”, “plan”, “propose”, “strategy”, “envision”, “hope”, “will”, “continue”, “potential”, “expect”, “believe”, “anticipate”, “project”, “estimate”, “predict”, “intend”, “should”, “could”, “may”, “might”, or similar forward-looking statements, we refer you to the cautionary statements concerning risk factors and “Forward-Looking Statements” described under “Risk Factors” in Item 1A of our Annual Report filed on Form 10-K filed with the SEC for the year ended December 31, 2013, and any updates to those risk factors or “Forward-Looking Statements” included in our subsequent Quarterly Reports on Form 10-Q filed with the SEC, which cautionary statements are incorporated herein by reference.

- What is CATOFIN/CATADIENE Technology?
- CATOFIN Flowsheet
- CATOFIN PDH Technology Integration Options
- CATOFIN Isobutane/n-Butane Dehydrogenation Plant Integration Options
- CATADIENE Plant Integration Options
- Summary



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- Proven technology platform licensed by CB&I for single-stage, fixed bed dehydrogenation of paraffins
- CATOFIN for propane and isobutane dehydrogenation
  - Propane to Propylene ( $C_3$  CATOFIN)
  - Isobutane to Isobutylene ( $iC_4$  CATOFIN)
  - Mixtures of the above ( $C_3/iC_4$ )
- CATADIENE for n-butane dehydrogenation
  - n-Butane to Butadiene and Butylenes
  - Mixtures of  $iC_4/nC_4$
- Catalyst supplied by Clariant



## CATOFIN

- 30 CATOFIN plants licensed worldwide
- Twelve plants currently in operation (Total capacity > 12 billion lb/annum)
- World's largest propane dehydro unit (> 1.3 billion lb/annum)
- World's largest isobutane dehydro units (> 1.2 billion lb/annum)
- Largest PDH unit with 1.654 billion lb/annum licensed

## CATADIENE

- 19 plants licensed prior to 1990s
- Displaced by steam cracker butadiene
- Three plants currently operating





- Highest Conversion ( $> 45\%$ ) and Selectivity ( $> 86\%$  wt)
- Lowest Raw Material Consumption
- Non-noble Metal Catalyst
- Feed Flexibility (No feed pretreatment required)
- Single Train Capacity ( $> 1.9$  billion lb/annum of propylene,  $> 37,500$  bbl/day of propane)
- Operating Experience
- Simple Metallurgy
- Reliability (On-stream Factors  $> 98\%$ )
- Faster Start-ups/Shutdowns
- Faster to 100% Capacity



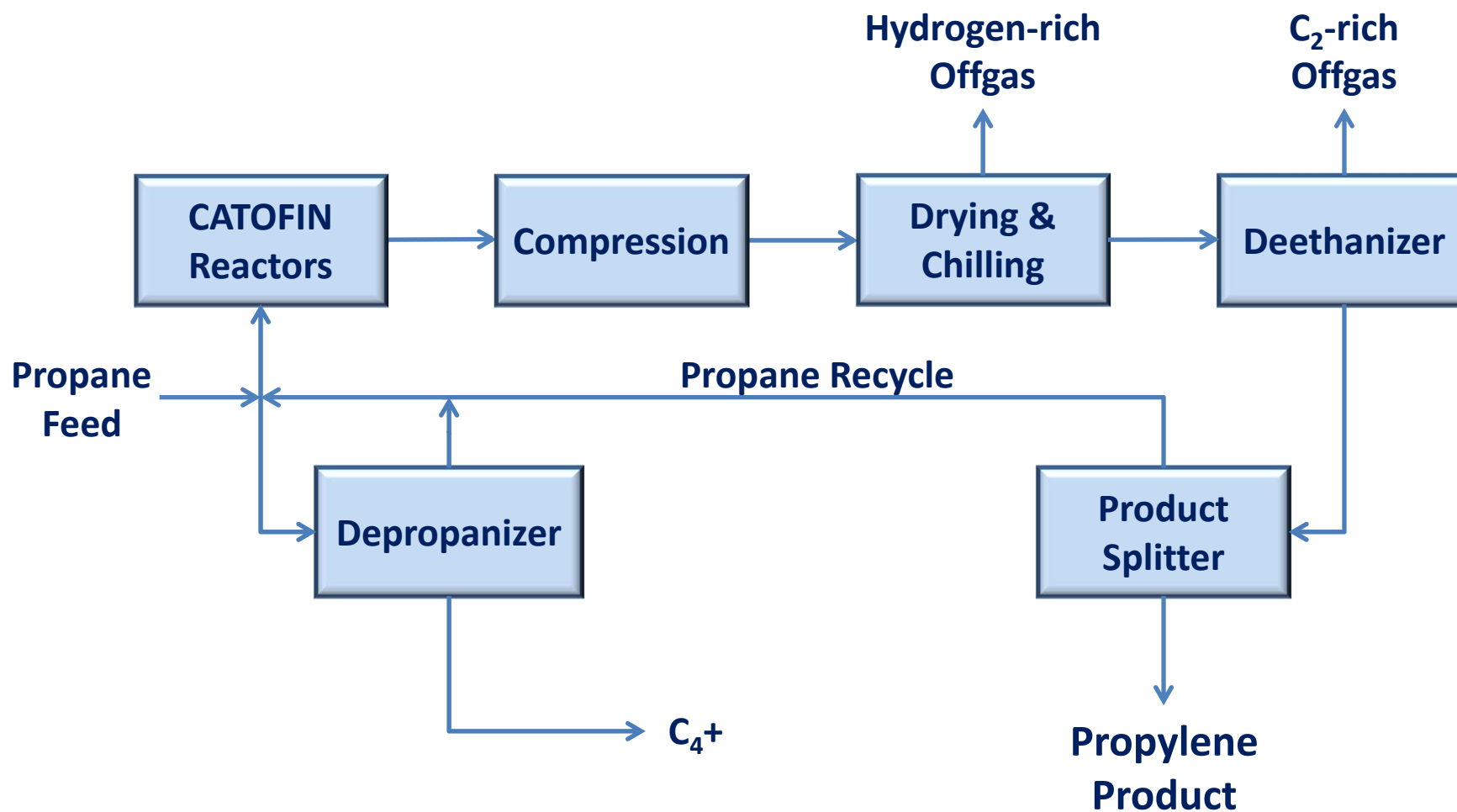


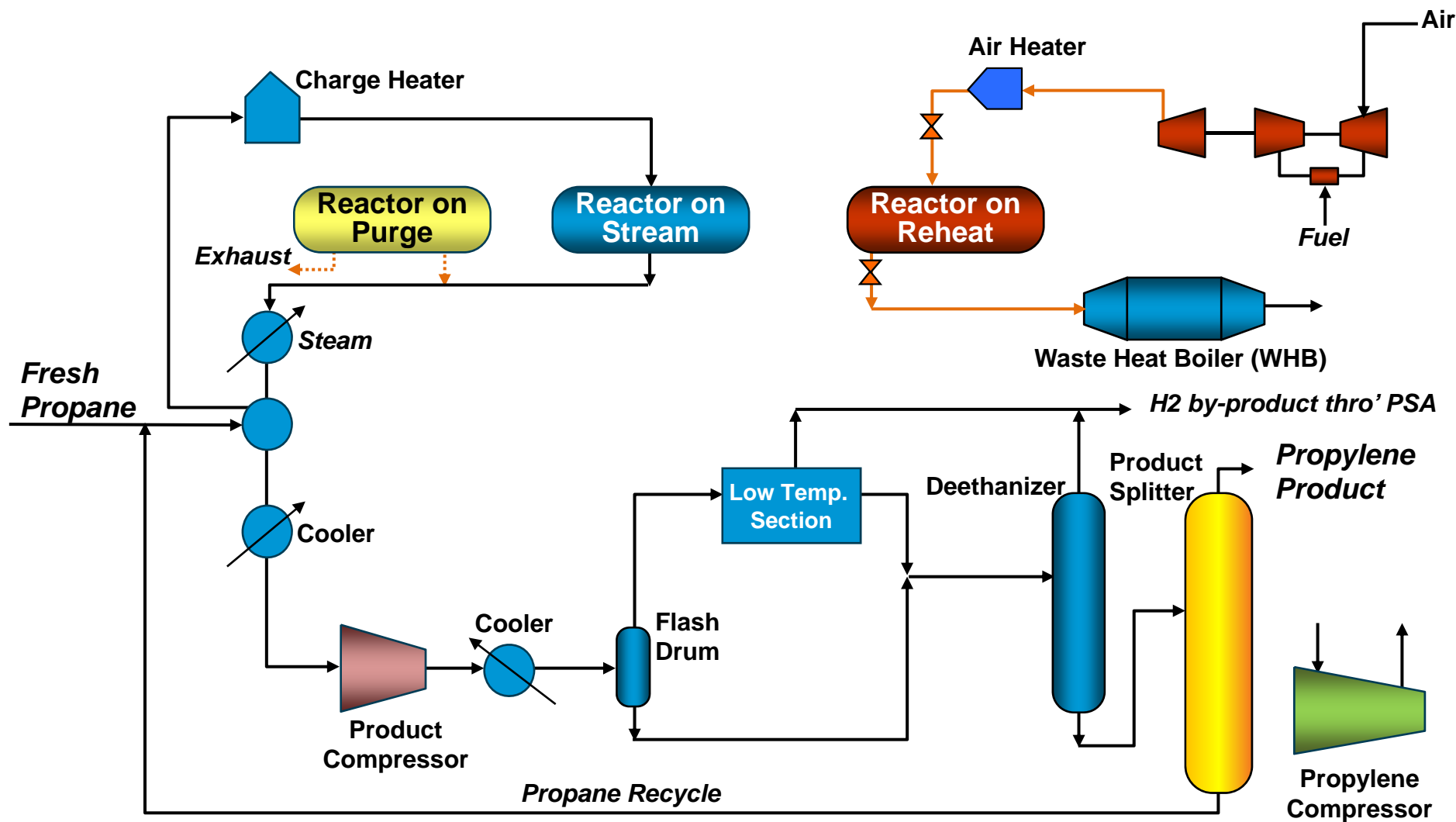
- CATOFIN PDH plant integration with
  - PP Plant
  - Cracker
  - Gas Plant
  - Cumene Plant
  
- CATOFIN Isobutane dehydrogenation plant integration with
  - Isomerization Plant
  - MTBE Plant
  - Alkylation Plant
  
- CATADIENE plant has integration with
  - Butadiene Extraction Plant
  - Butane/Butene Separation Plant



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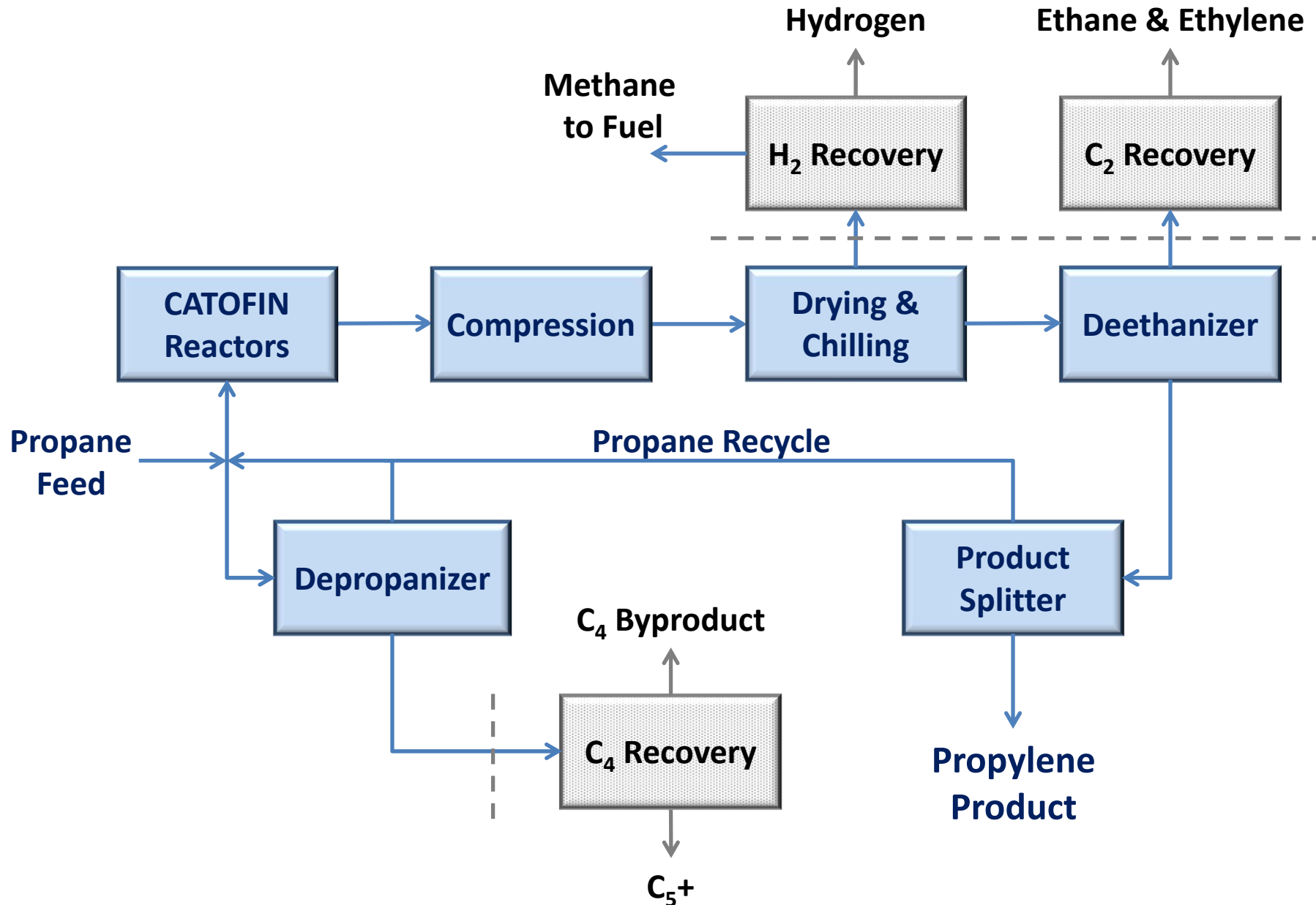






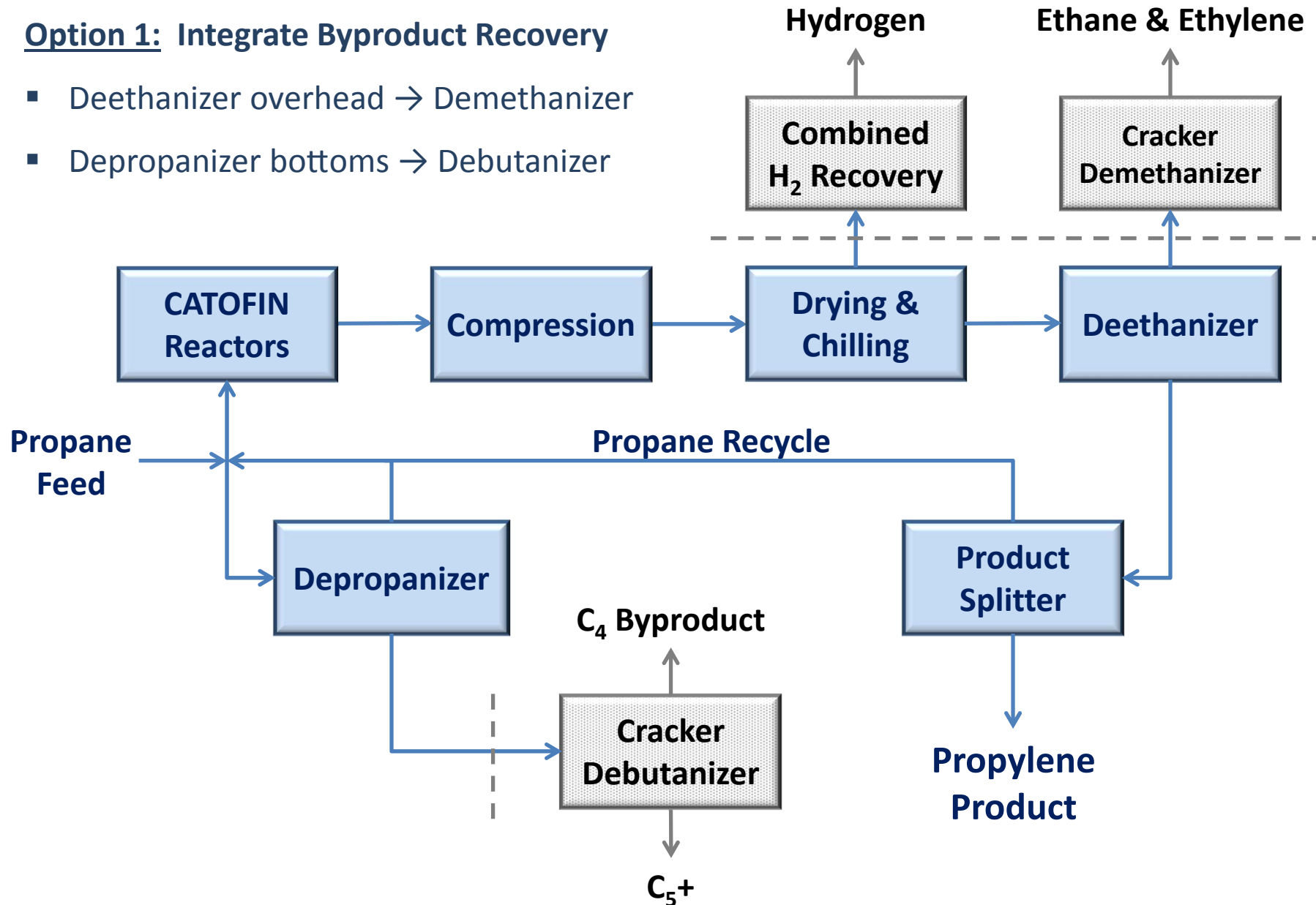
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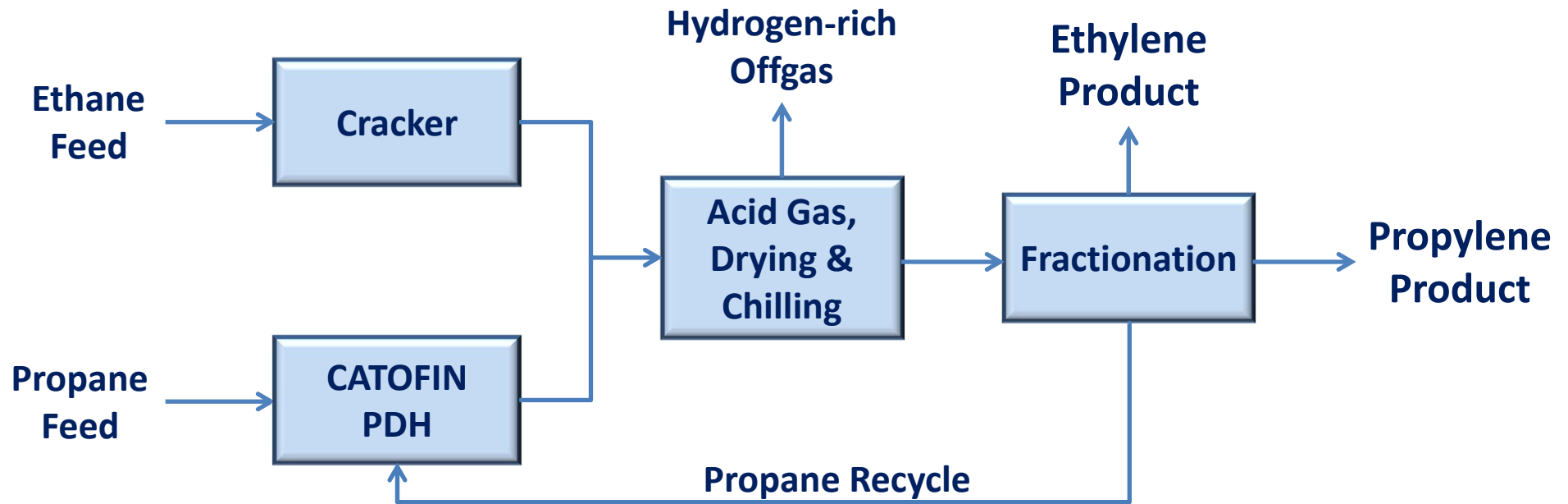
**Option 1: Integrate Byproduct Recovery**

- Deethanizer overhead → Demethanizer
- Depropanizer bottoms → Debutanizer



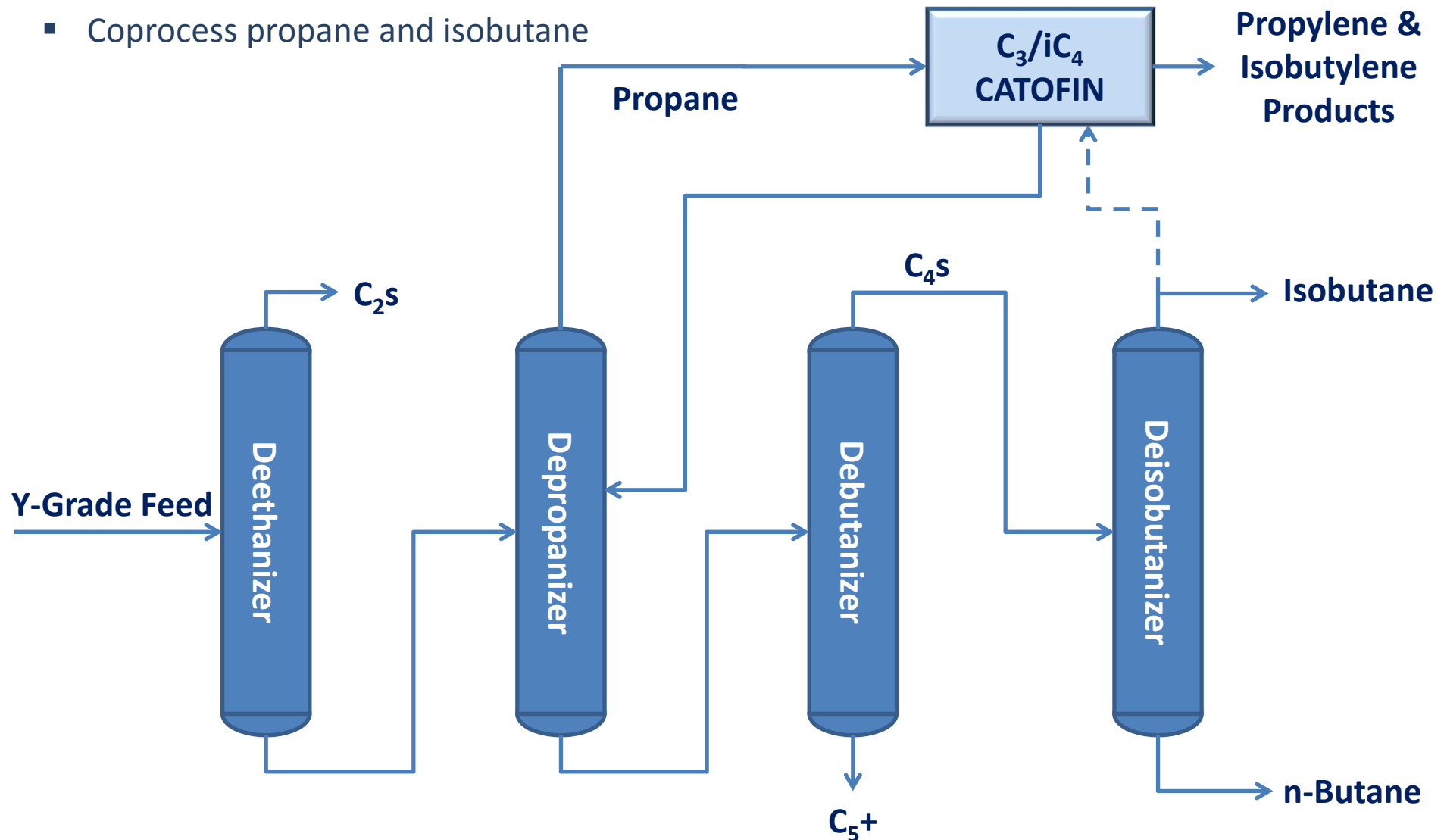
**Option 2: Complete Downstream Integration**

- CATOFIN Compression Section effluent → Cracker Acid Gas, Drying Section





- Eliminate CATOFIN Depropanizer
- Coprocess propane and isobutane



## Integration Considerations

- Common Depropanizer
- Fuel Gas System
- Dryer Regeneration
- Refrigeration
- **CB&I has designed one complex**



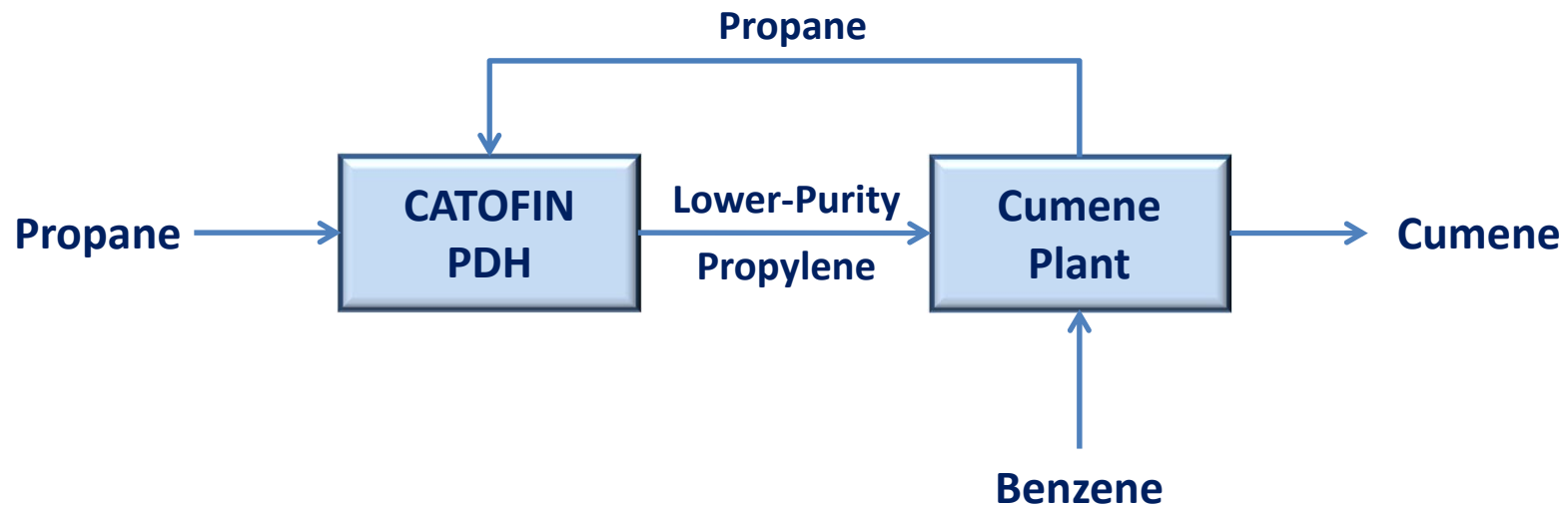
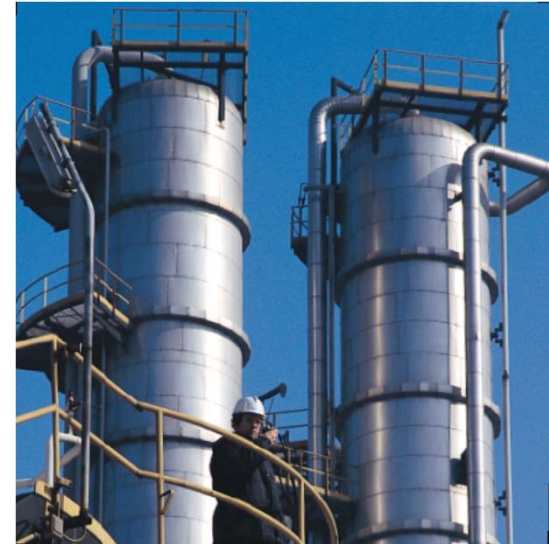
- CB&I offers both CATOFIN Propane Dehydrogenation (PDH) and NOVOLEN<sup>®</sup> Polypropylene (PP) technologies
- Has designed three plants with integrated PDH and PP units – two complexes are in operation at higher than 1.1 billion lb/annum propylene



- Integration Aspects
  - Purge Gas Stream
  - Recycle Gas Stream
  - Carrier Gas Stream
- Investment cost and operating cost savings for the PDH plus PP complex



- Reduced propylene product purity from CATOFIN PDH – utility savings in the PDH unit
- Steam Integration – the PDH and Cumene complex can be made steam neutral



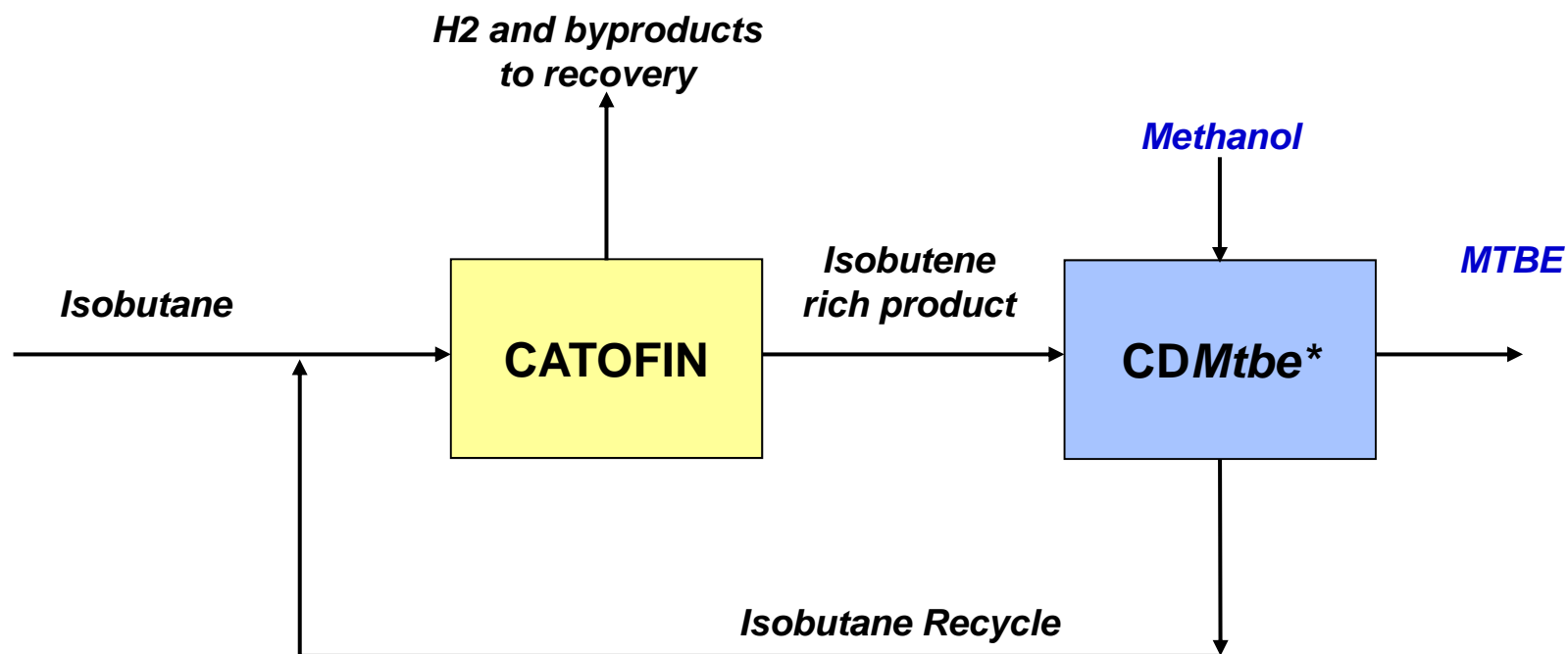
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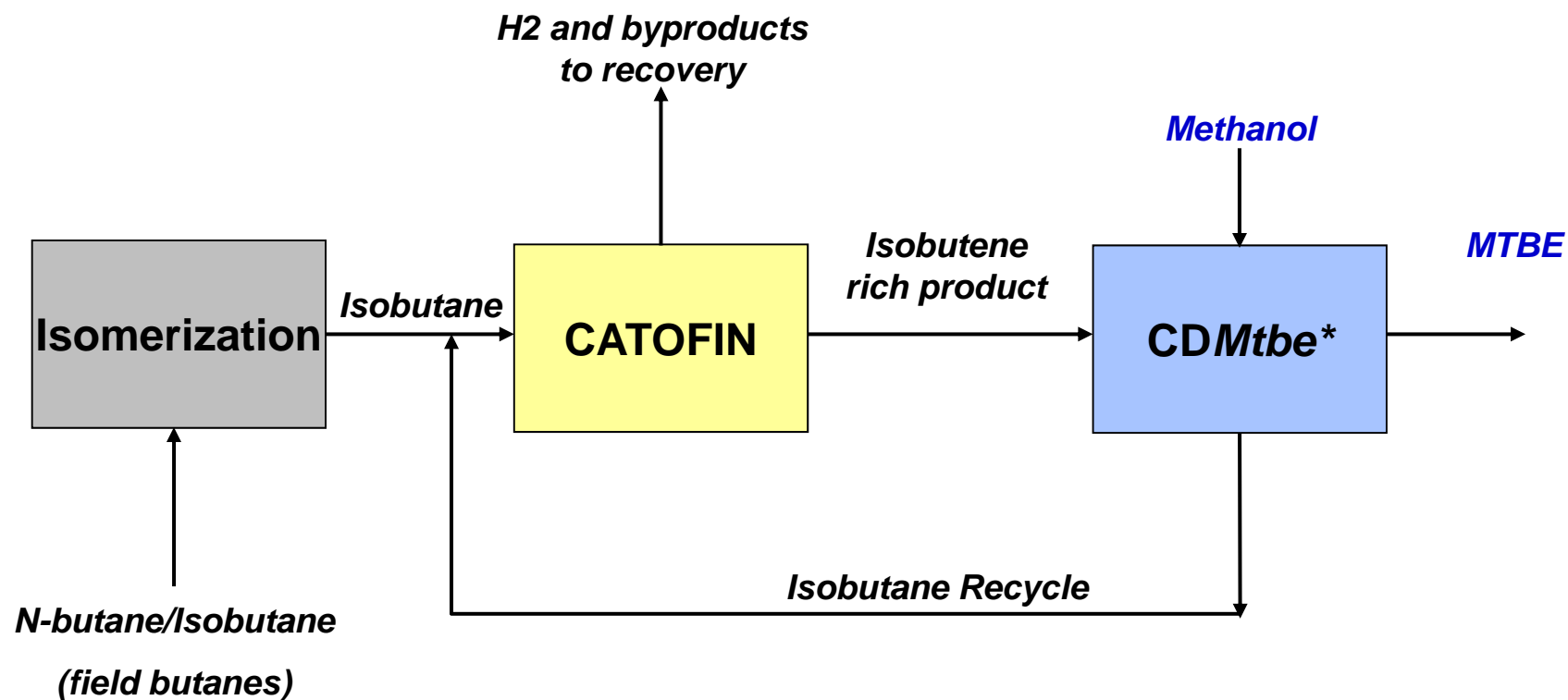
- N-butylenes main uses
  - Alkylation – removing MTBE creates demand for high-octane alkylate
  - Olefin Conversion Technology – n-butylene + ethylene → propylene
  - Butene-1 used as co-monomer in some polyethylene grades
- N-butylenes supply
  - Byproduct of steam crackers – similar to butadiene
    - Shift to lighter feeds produces less butylenes (similar to butadiene)
  - Byproduct of catalytic crackers
  - Byproduct of Methanol to Olefins (MTO)
  - On-purpose sources
    - Ethylene dimerization
    - CATOFIN n-butane dehydrogenation

- N-butane to n-butylenes
  - Higher pressure to minimize butadiene formation
  - Add butadiene selective hydrogenation to react butadiene (if needed)
- N-butane to n-butylenes and butadiene
  - Lower operating pressure to maximize butadiene yield
  - Recover both 1,3 butadiene product and n-butylenes product
- Coproduction of isobutylene and n-butylenes
  - Higher operating pressure
  - Either mixed stream or in separate reactors
  - Recover both isobutylene and n-butylenes as product
  - Add butadiene selective hydrogenation to react butadiene (if needed)

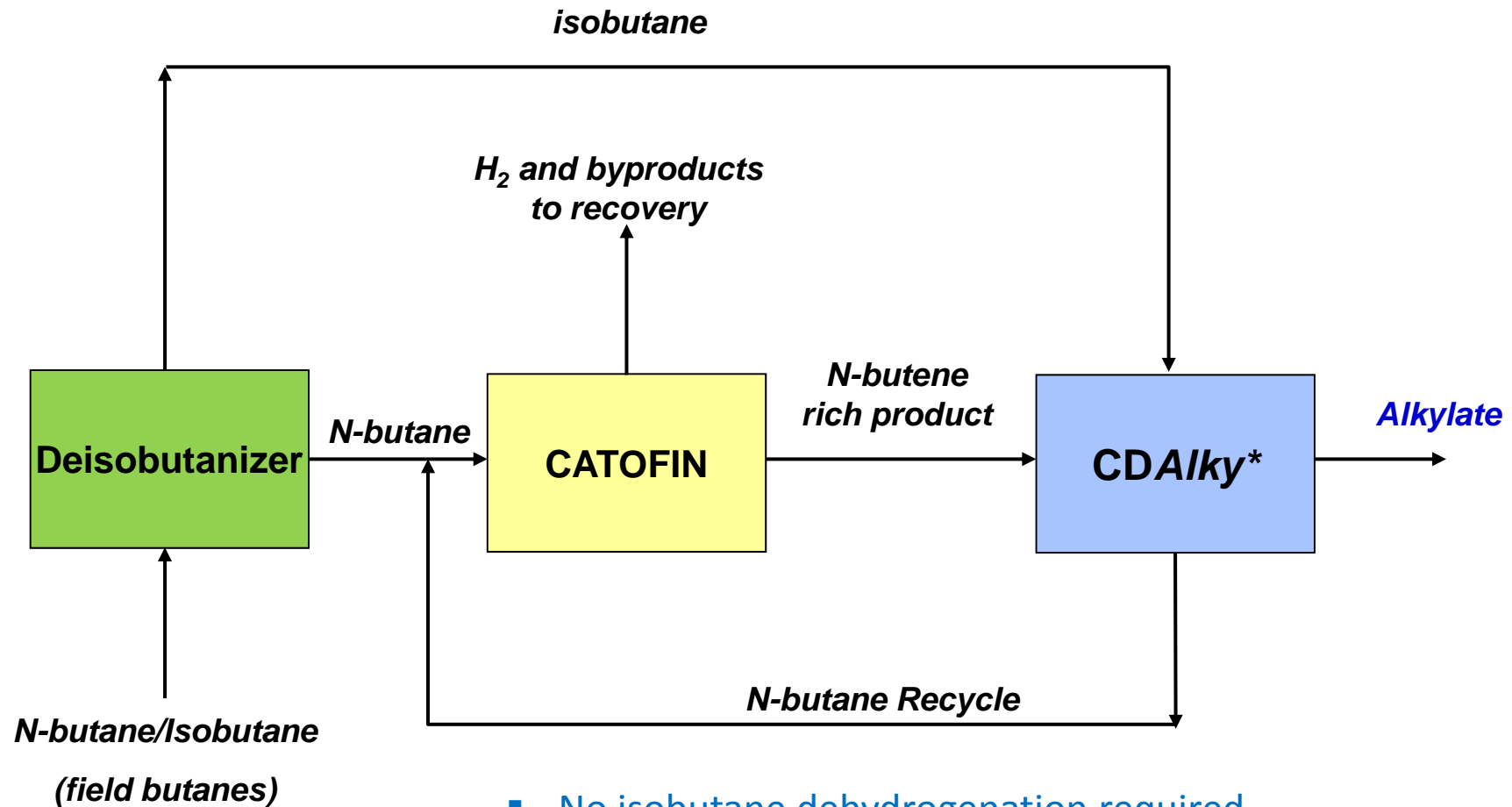




\*Registered trademark of CB&I

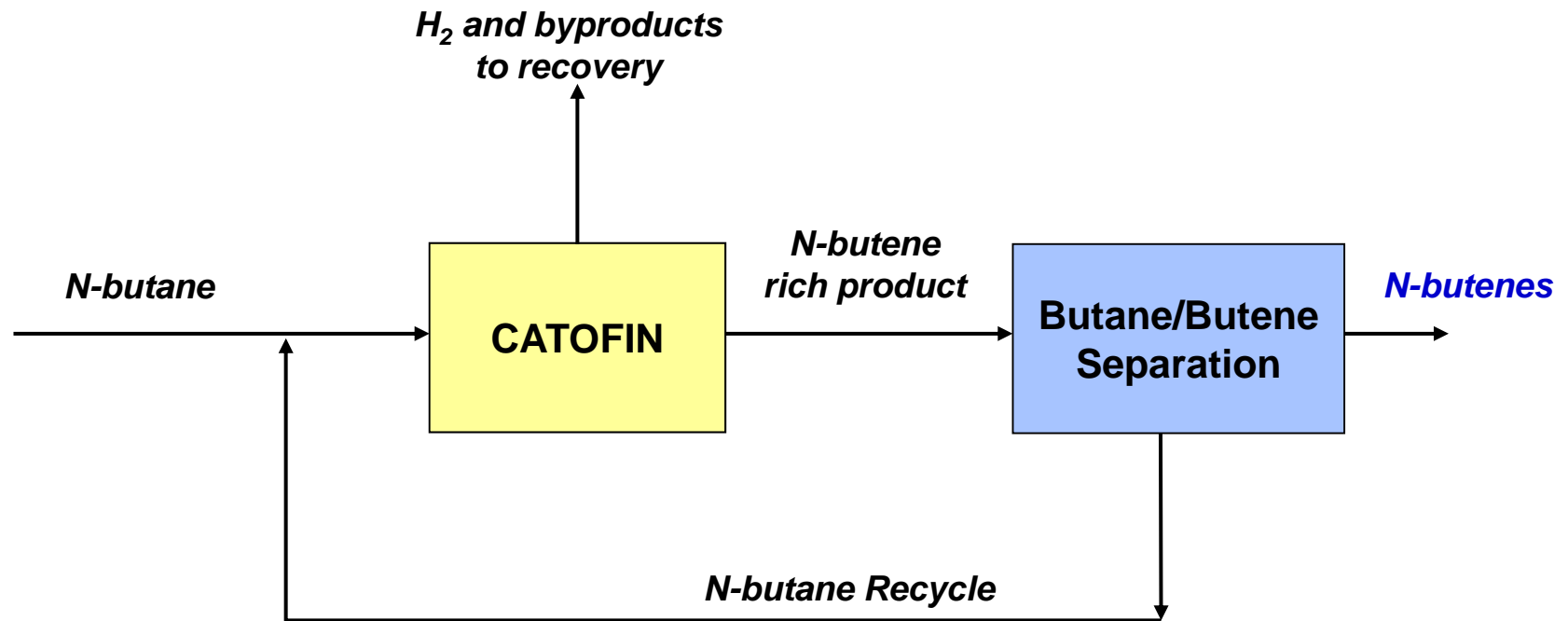


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- No isobutane dehydrogenation required
- High octane product (97 RON min.)
- High overall selectivity – minimal isobutane losses
- No (or small) isomerization unit

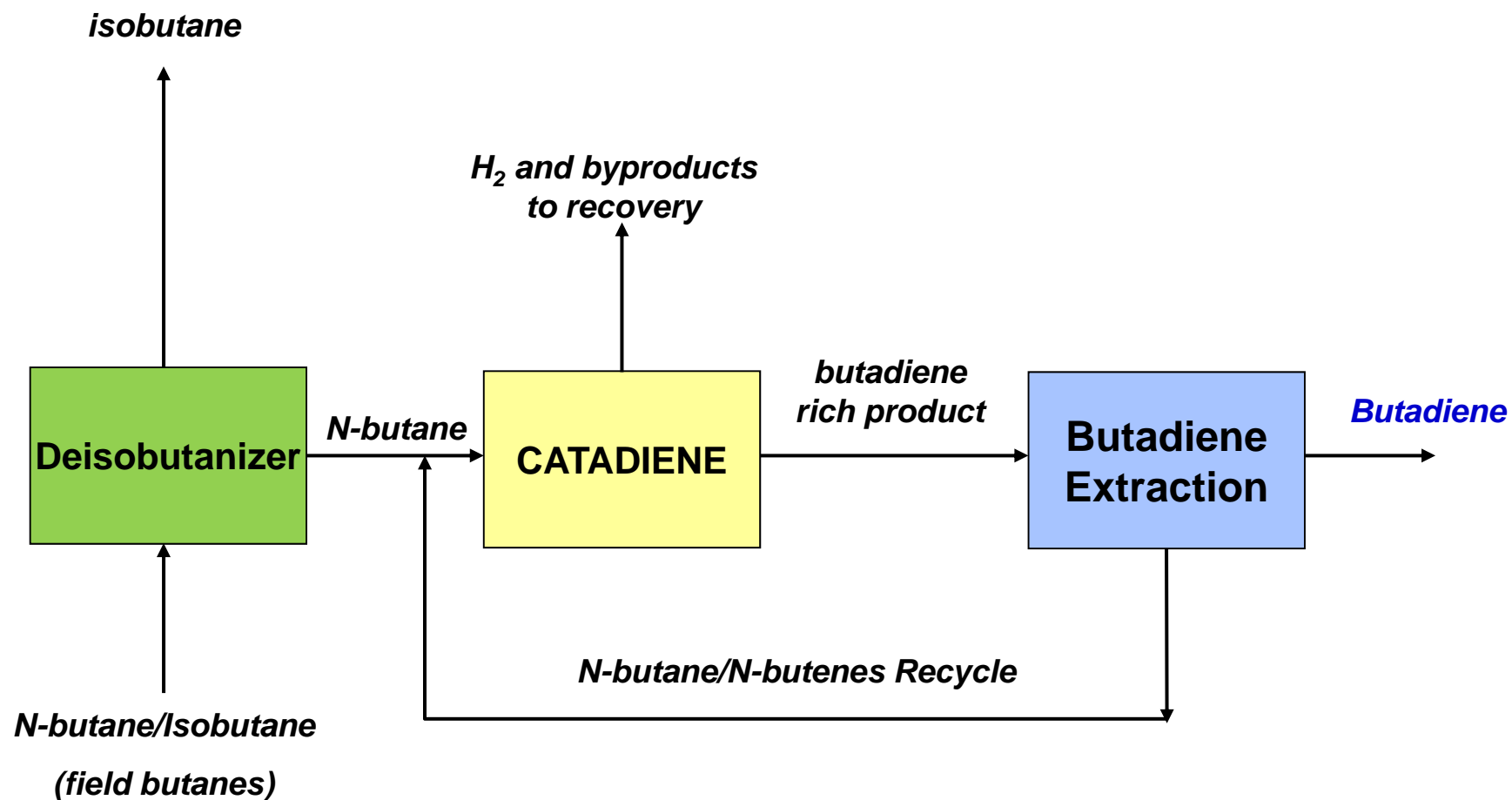
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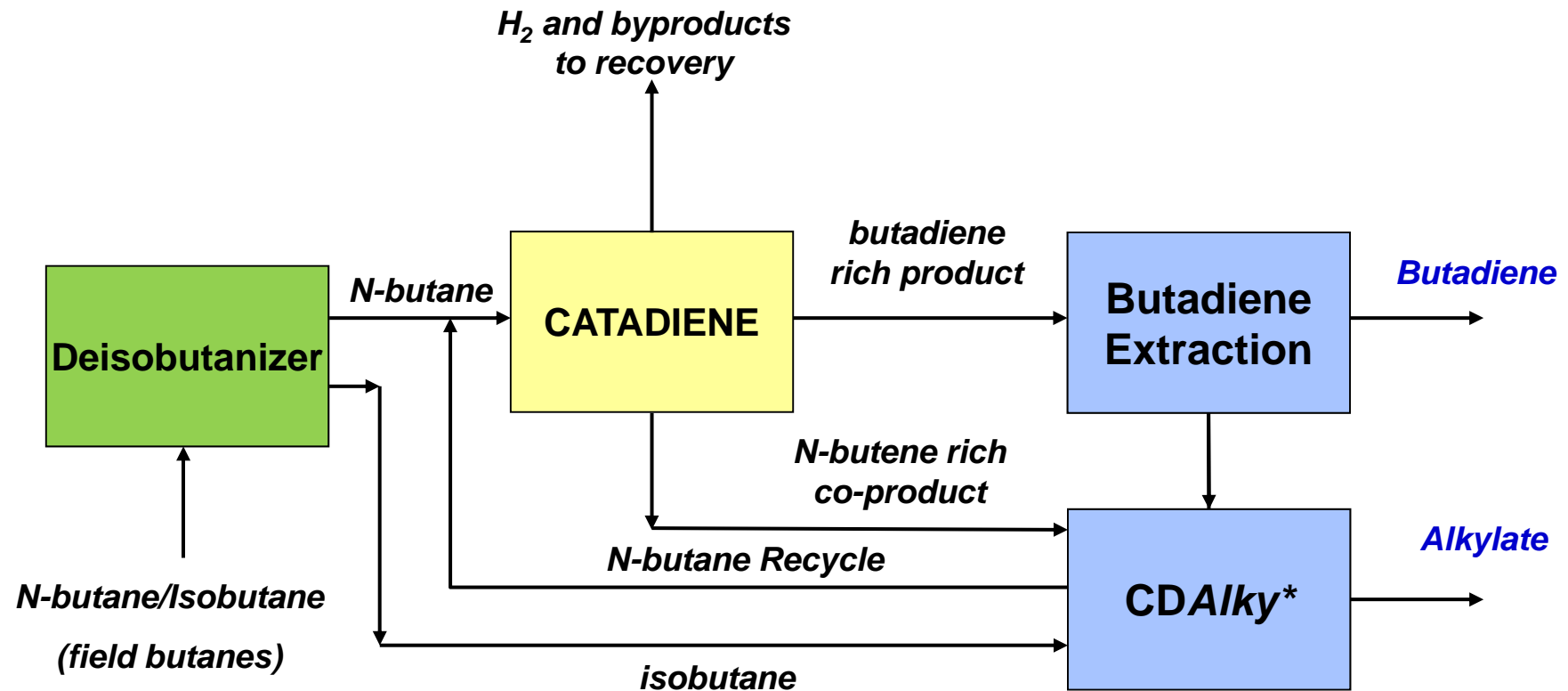


- Feed to Olefin Conversion Unit to make propylene
- Recover Butene-1
- Feed to oxy-dehydro to make butadiene

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- Provides product flexibility
- High octane alkylate product
- No (or small) isomerization unit

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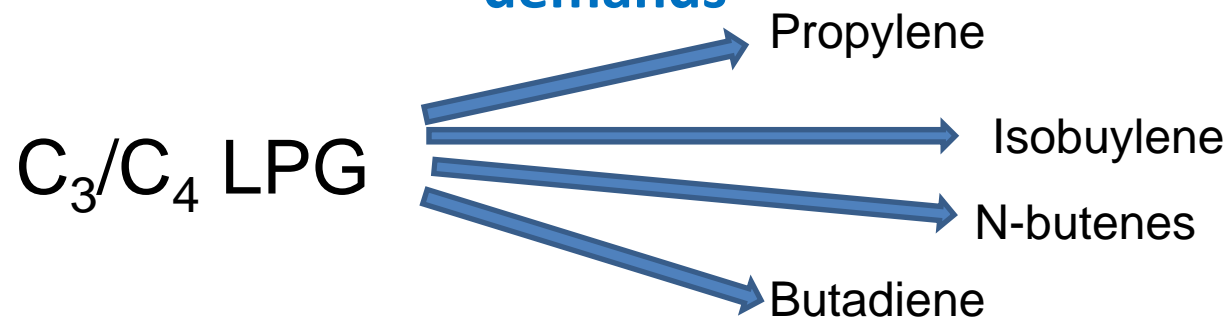


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- CATOFIN/CATADIENE is a flexible technology that can be integrated with other processes for maximizing product value
- Integration of technologies provides:
  - ✓ Significant investment cost and operating cost savings
  - ✓ Operational flexibility
  - ✓ More efficient feedstock utilization

**CB&I can customize CATOFIN/CATADIENE configuration to meet changing feedstock availability and product demands**





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