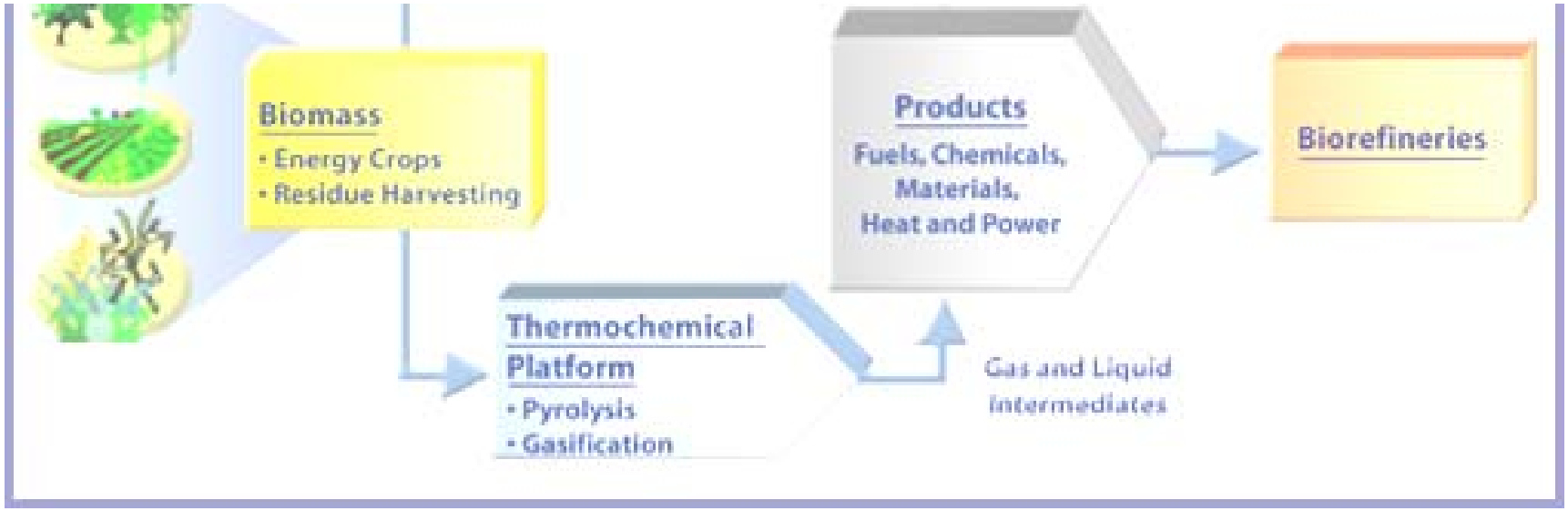
열분해오일 개질

Presentation Outline

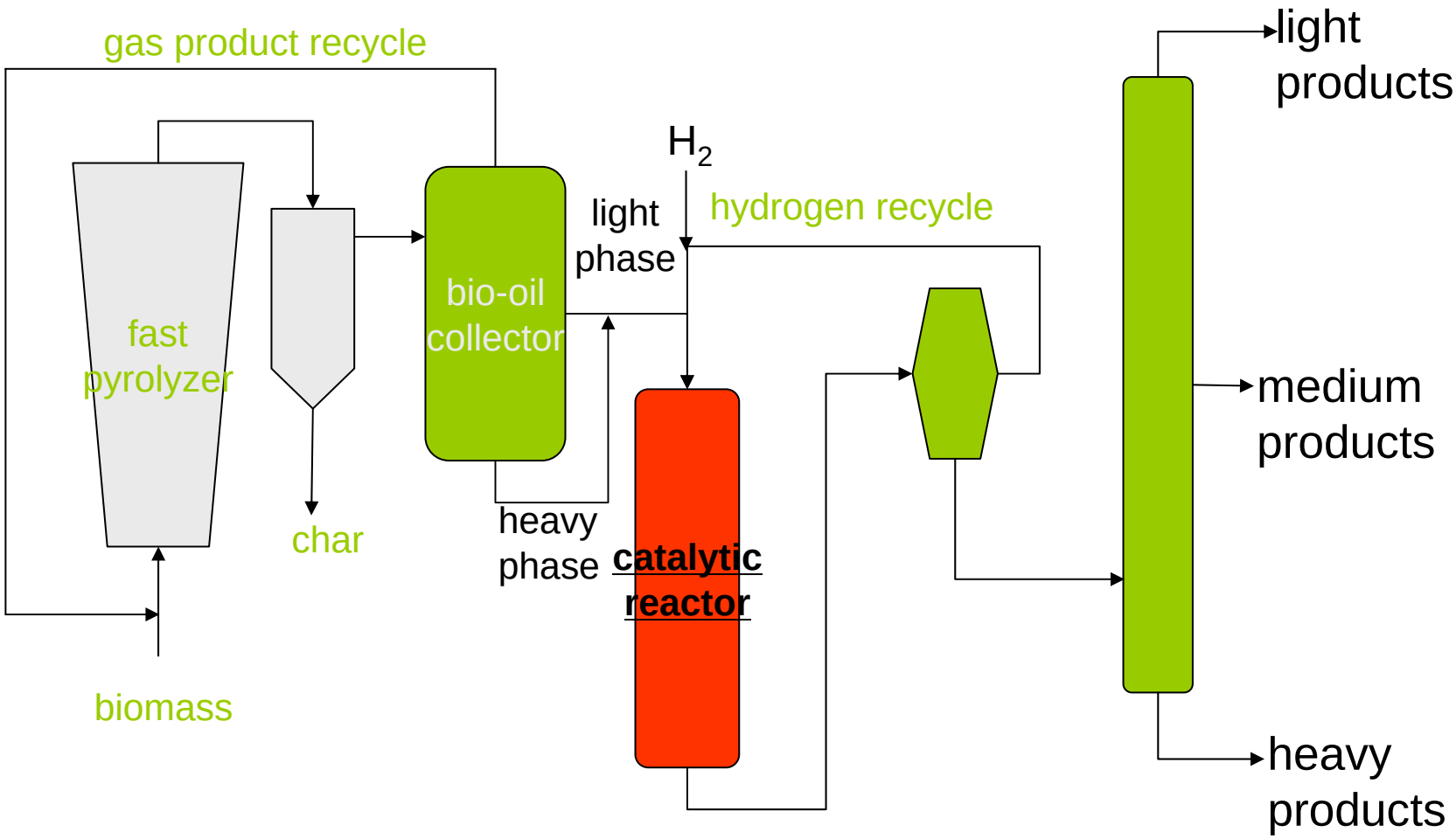
1. Overall Project Goals and Objectives
2. Organization of the Approach to meeting these Goals and Objectives (tasks and subtasks)
3. For each major task or objective please address in more detail
   a) Technical or economic target or objective
   b) All risks associated with meeting these targets or objectives
   c) Milestones established to measure progress and financial or performance metrics
   d) Go No/Go decision points
   e) Accomplishments to date
   f) Future plans and partners
4. Market and customers
5. Competitive Advantage
6. Strategic Fit
7. Conclusions and Discussion

Overall Project Goals & Objectives

- Development of enabling technology for catalytic hydrogenation of bio-oils to upgraded liquid fuels and chemicals.
  - To develop more cost-effective means to convert biomass into useful fuels and chemicals by a thermochemical process.



Pyrolysis Bio-oils Upgrading Approach



Organization/Approach

- Batch reactor tests
- Continuous-flow reactor tests
- Economic assessments

Batch Testing

- Stirred batch reactor

- Goals:
  - Screening tests
    - Identify new catalyst concepts
    - Determine value of feedstocks and feedstock fractions

Continuous-Flow Reactor

- Fixed-bed tubular reactor
  - 400 mL catalyst
- Operational flexibility
  - 100 to 350 deg C
  - 10 to 200 atm
  - 0.01 to 10 LHSV
- Goals:
  - develop concepts from batch tests
    - processing kinetics
    - products for analysis and testing

Technical or Economic Target

- Product costs need to be competitive with petroleum feedstocks
- Upgrading for fuel product cost target
  - $26/bbl processing cost (refinery product slate from heavy bio-oil phase)
- Upgrading for chemical product cost target
  - $26/bbl processing cost (10% cyclohexanol with balance stable fuel oil)

Risks

- Risks for production of Liquid Transportation Fuels and Chemicals and Materials are similar
- Product Risks
  - yield of specific product
  - production rate for specific product
  - final concentration to justify recovery
- Catalyst Development risks
  - catalyst lifetime
  - processing rate
  - chemical reaction pathway

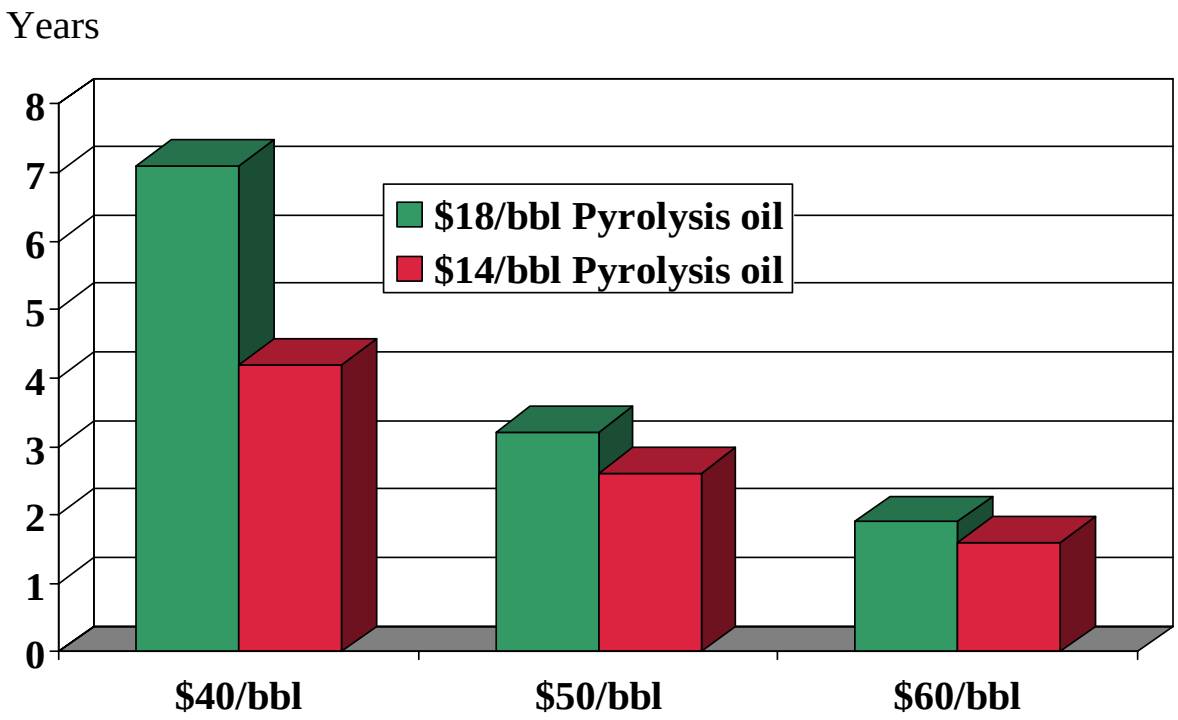
Project Milestones

Project Milestones	Type	Performance Expectations	Due Date
Upgrading Pyrolysis Oil	D	Evaluation of Innovative Process Concept	Sept 2005
Upgrading Pyrolysis Oil	D	Bench-scale evaluation of Bio-oil upgrading	Jan 2007 Go/No Go
Upgrading Pyrolysis Oil	D	Demonstration of Bio-Oil Upgrading with industrial participation	Sept 2008 Go/ No Go

Accomplishments

- Evaluated precious metal catalysts at low temperature for upgrading bio-oils and bio-oil fractions
  - Direct processing can be accomplished without pre-processing for stabilization
  - Different catalyst metals can be used to vary the product slate depending on intent for use as chemical or fuel products
  - Heavy bio-oil fractions can be processed for higher yields of liquid product
  - Industrially-performed economic assessments of use of products for petroleum refinery feedstock show promising results

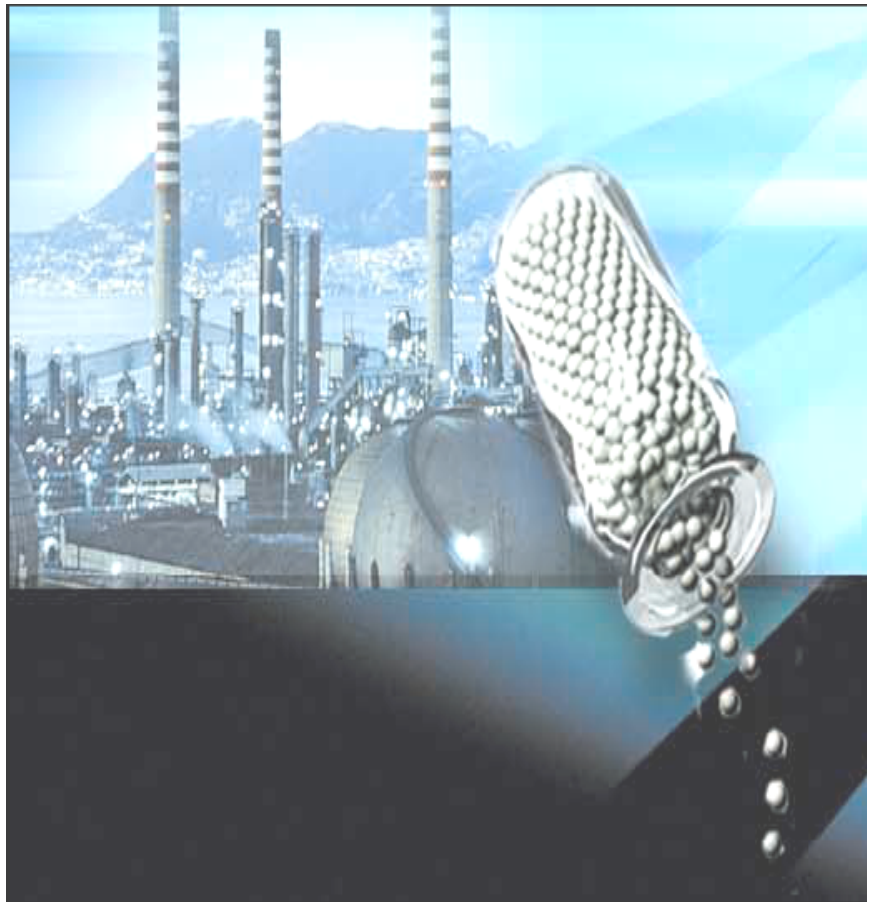
Year to Simple Payback for Conversion of Pyrolytic Lignin to Gasoline



Based on Capital Cost of $30MM for HT/HCK Unit

Future Plans

- Continue catalyst development at bench-scale
  - Batch testing of catalyst candidates
  - longer-term operation of catalyst candidates of commercial interest
- Work with UOP for process incorporation into the petroleum refining industry



Market & Customers

- Potential customers:
  - chemical marketers
  - petroleum refiners
  - petroleum refining technology marketers
- Range of production costs:
  - need to be competitive with fuel/chemical products from petroleum feedstocks
- Market dynamics:
  - Petroleum refining feedstock for liquid transportation fuels is a large market remaining strong for the foreseeable future

Competitive Advantage

- Window of opportunity:
  - medium- to long-term development
- Direct competition:
  - petroleum-derived feedstocks, fuels and chemicals
- Issues of change:
  - petroleum costs are single largest factor
  - incentives for renewables may facilitate market penetration
- State of economics:
  - UOP assessments suggest good near-term economics for feedstock to hydrocracking

Strategic Fit

- Company fit:
  - catalyst development is a laboratory core competency
- OBP fit:
  - Ag Residue, Perennials, Pulp & Paper, Forest Products pathways
  - Product R&D Level B&C milestones
- Stage placement:
  - Research track – Exploratory Research
- FY08 solicitation fit:
  - Demonstration phase of an engineering scale prototype by FY08 is our current milestone.
  - Industrial interest has been expressed.

Milestone Fit

Milestone Hierarchy –Agricultural Residue Processing Pathway

Ethanol Production from Mixed Sugars

B Milestone
(M 4.6) Demonstrate and validate ethanol from 5 biomass sugars that are economically viable (need multiple cost targets for specific products) ($/gal EtOH)

Supporting C Milestones:

1. Develop new organisms that can utilize five carbon sugars at a rate consistent with C6 sugar utilization
2. Develop new organisms that are robust with respect to impurities
3. Develop new organisms capable of co-fermenting (use C5 sugars at the same time C6 sugars are utilized in order to minimize fermentation time)

C5 or C6 or mixed C5/C6 Sugars conversion to Chemical and Material Products

B Milestone
(M 4.7) Demonstrate and validate chemical building blocks, chemicals, or materials from 5 biomass sugars that are economically viable (need multiple cost targets for specific products) ($/lbs product)

Supporting C Milestones:

- Same 1-10 as for B milestone (M 2.2)

Lignin Intermediates/ Residue Conversion to Products

B Milestone
(M 4.8) Demonstrate and validate high value chemical and material products from lignin intermediates ($/lb product)

Supporting C Milestones:

1. **Catalysts must achieve selectivity of greater than 90%**
2. **Catalyst lifetime of at least 1 year**
3. **Catalyst fouling minimized**
4. New membrane technologies need to be developed to recover products at low cost (cost target is less than 10-15% of product value)

B Milestone
(M4.9) Demonstrate and validate fuel products from lignin intermediates ($/gal)

Supporting C Milestones TBD

B Milestone
(M 4.10) Demonstrate and validate combined heat & power from lignin intermediates/residues ($/KwHr, $/Klb Stm)

Supporting C Milestones TBD

Clean Syngas Conversion to Products

B Milestone
(M 4.13) Demonstrate and validate products (i.e. ethanol from mixed alcohols) from lignin or biomass derived syngas for $0.60/gal by 2025

Supporting C Milestones:

1. Catalysts must achieve selectivity of greater than 90%
2. Catalyst lifetime of at least 1 year
3. Catalyst fouling minimized
4. Separation technologies need to be developed/demonstrated that can recover products at low cost (cost target is less than 10-15% of product value)

B Milestone
(M 4.14) Demonstrate and validate H2 production from lignin or biomass derived syngas for $xx/kg by 2025

Supporting C Milestones TBD

B Milestone
(M 4.15) Demonstrate and validate CHP production from lignin or biomass derived syngas by 2025

Supporting C Milestones TBD

Milestone Fit

Milestone Hierarchy –Perennial Biomass Processing Pathway

Ethanol Production From Mixed Sugars

B Milestone
(M 5.6) Demonstrate and validate ethanol from 5 biomass sugars that are economically viable – similar to agro. residues with different biorefinery opportunities ($/gal EtOH)

Supporting C Milestones:
- Same as 1-3 of B milestone (M 4.6)

C5 or C6 or mixed C5/C6 Sugars conversion to Chemical and Material Products

B Milestone
(M 5.7) Demonstrate and validate products from 5 biomass sugars (need multiple cost targets for specific products) – similar to agro. Residues with different biorefinery opportunities ($/gal EtOH)

Supporting C Milestones:
- Same 1-10 as for B milestone (M 2.2)

Lignin Intermediates/ Residue Conversion to Products

B Milestone
(M 5.8) Demonstrate and validate high value chemical and material products from lignin intermediates ($/lb product)

Supporting C Milestones:
- Same 1-4 as for B milestone (M 4.8)

B Milestone
(M 5.9) Demonstrate and validate fuel products from lignin intermediates ($/gal)

Supporting C Milestones TBD

B Milestone
(M 5.10) Demonstrate and validate combined heat & power from lignin intermediates/residues ($/KwHr, $/Klb Stm)

Supporting C Milestones TBD

Clean Syngas Conversion to Products

B Milestone
(M 5.13) Demonstrate and validate products (i.e. ethanol from mixed alcohols) from lignin or biomass derived syngas for $0.60/gal by 2025

Supporting C Milestones:
- Same 1-4 as for B milestone (M 4.8)

B Milestone
(M 5.14) Demonstrate and validate H2 production from lignin or biomass derived syngas for $xx/kg by 2025

Supporting C Milestones TBD

B Milestone
(M 5.15) Demonstrate and validate CHP production from lignin or biomass derived syngas by 2025

Supporting C Milestones TBD

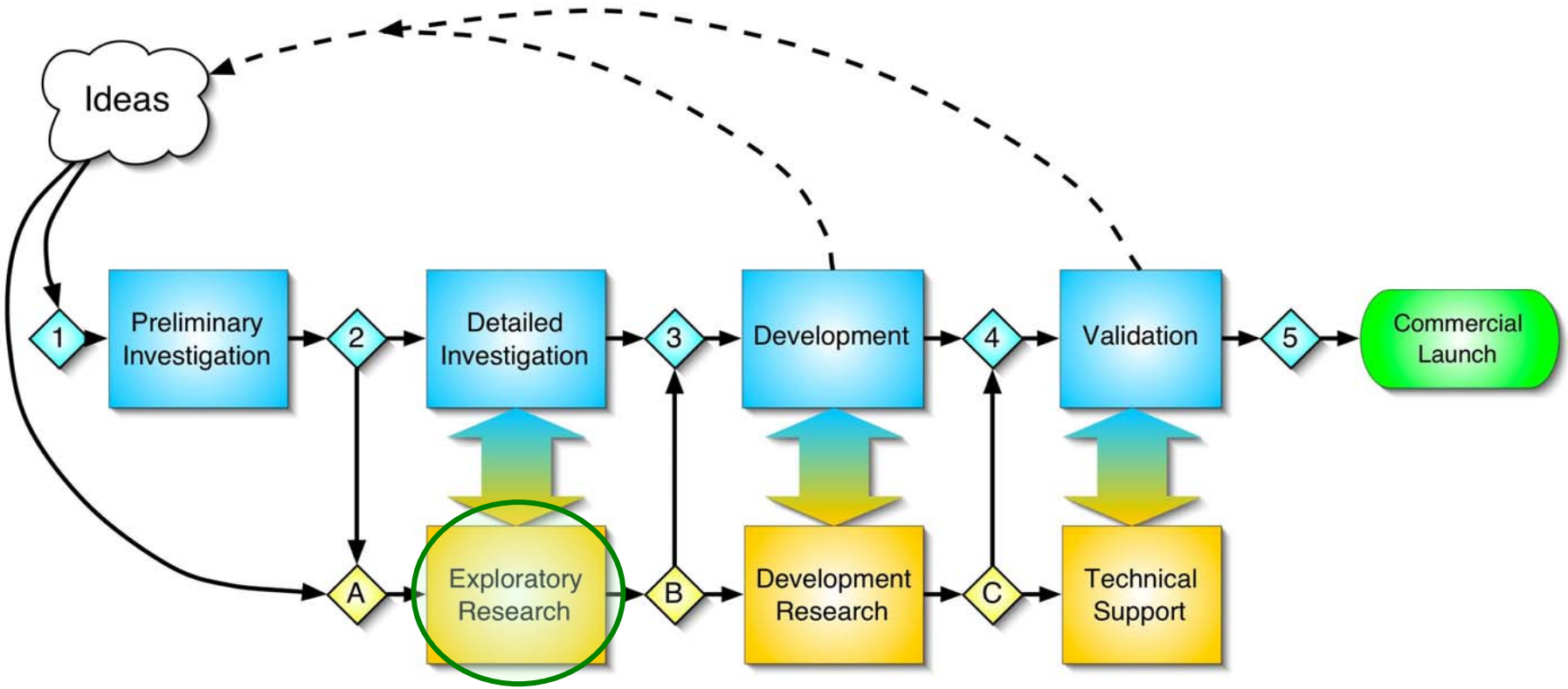
Advanced Biomass Fractionation and Conversion

B Milestone
(M 5.17) Demonstrate and validate products from new fractionation/consolidated process intermediates

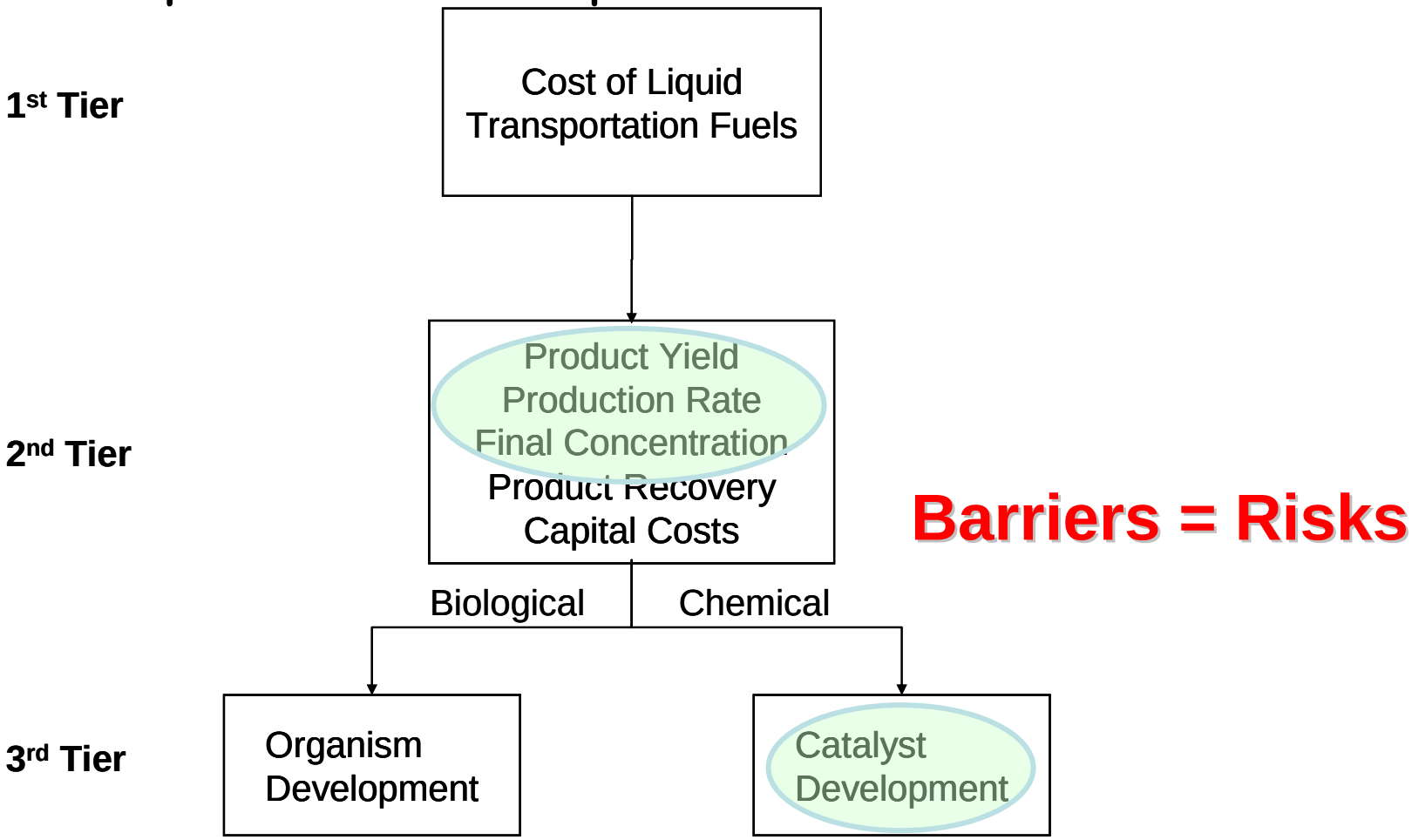
Supporting C Milestones TBD

Stage Gate Fit

What Stage is the project in?

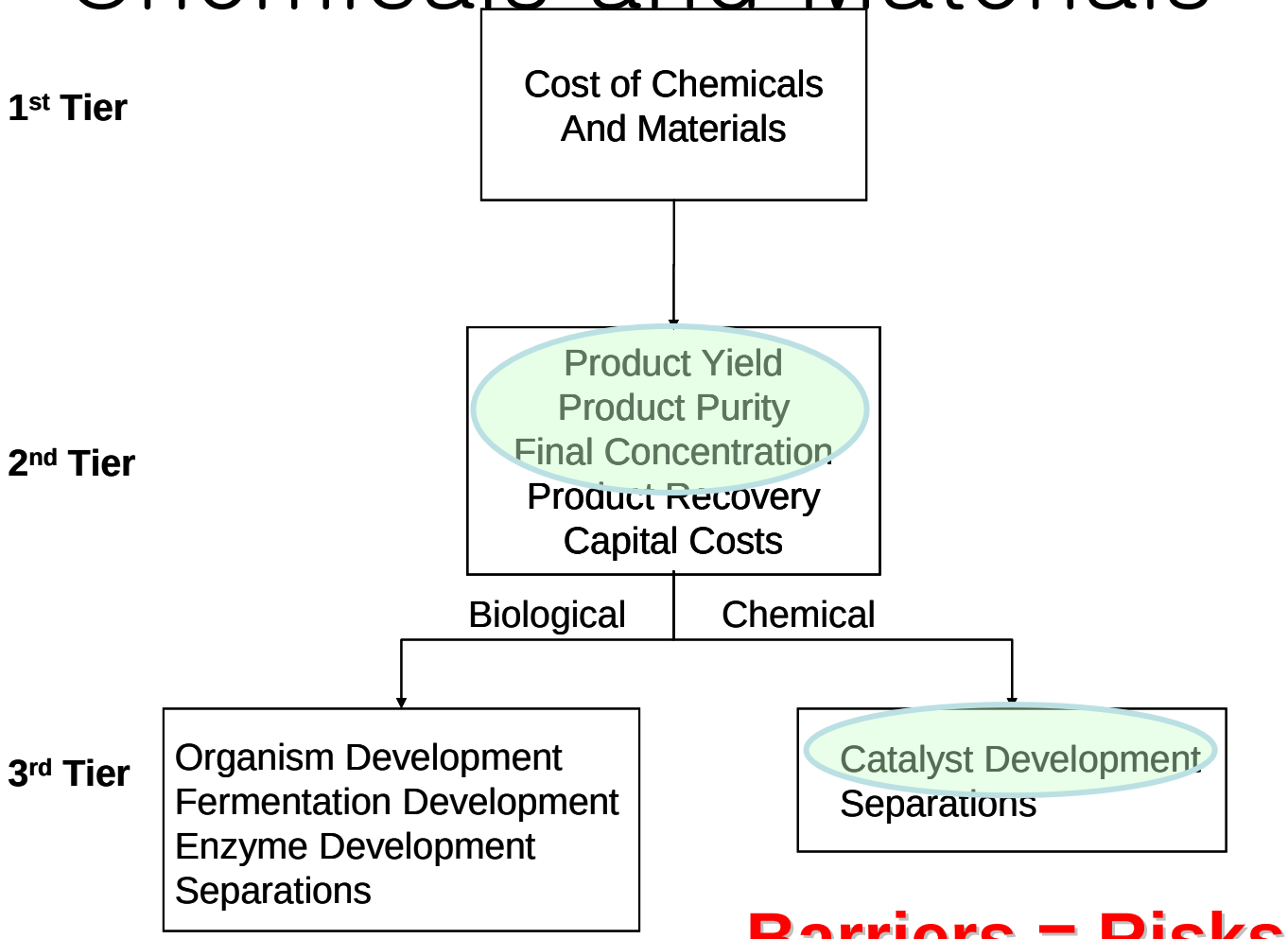


Technical Barriers Addressed: Liquid Transportation Fuels



Barriers = Risks

Technical Barriers Addressed: Chemicals and Materials



Barriers = Risks

Conclusions/Summary

- Low-temperature catalytic hydrogenation of bio-oil can be accomplished
  - different metals give different products
  - processing conditions can be varied to produce different products
- Certain process conditions and catalysts can be used to produce petroleum refinery feedstock with economically interesting results