Integrated Approach for Sustainable Bio-refinery
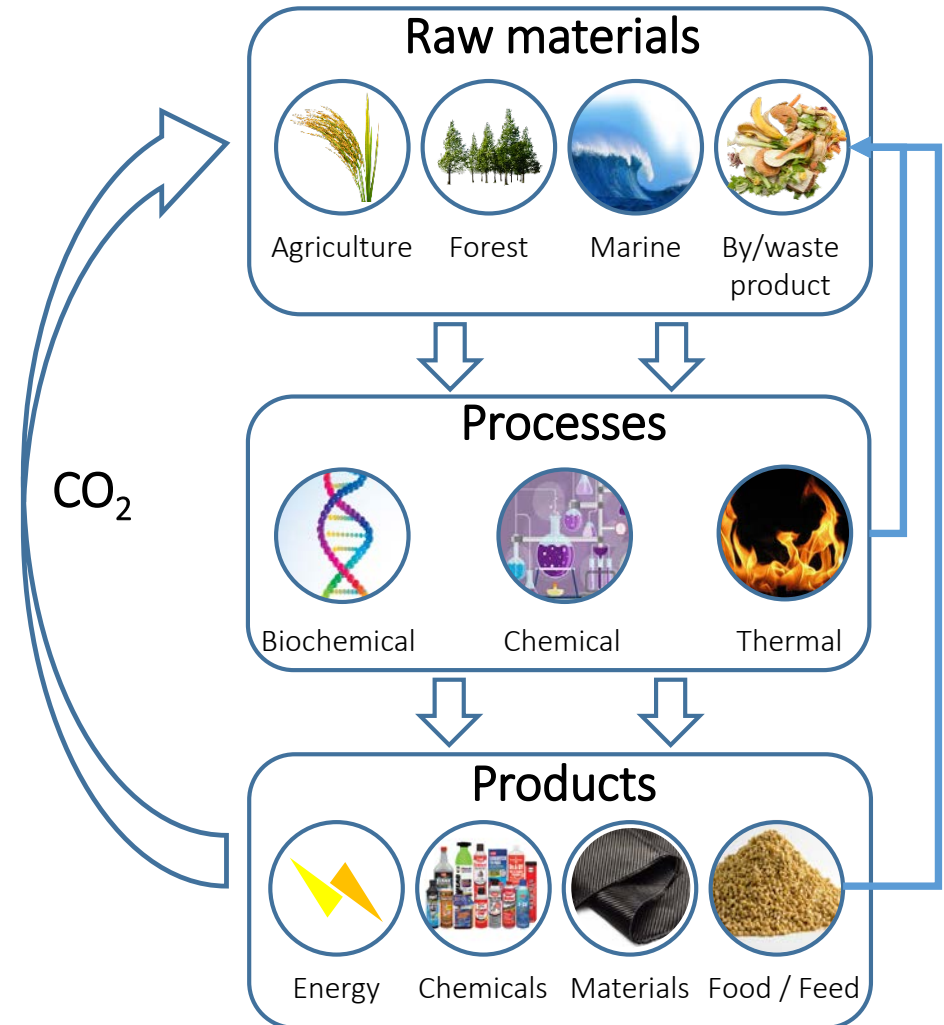
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Energizing through Innovation

Bio-refinery | Introduction

- Biowaste: Major environmental concern

- 500 MMT of crop residues annually *(Source: National Policy for Management of Crop Residues by GoI – Nov'14)*

- Biorefinery aims for "Zero waste"

- Waste considered as a resource

- Solution- To produce sustainable products, intermediates, biofuels/biochemical
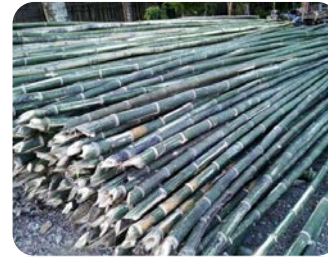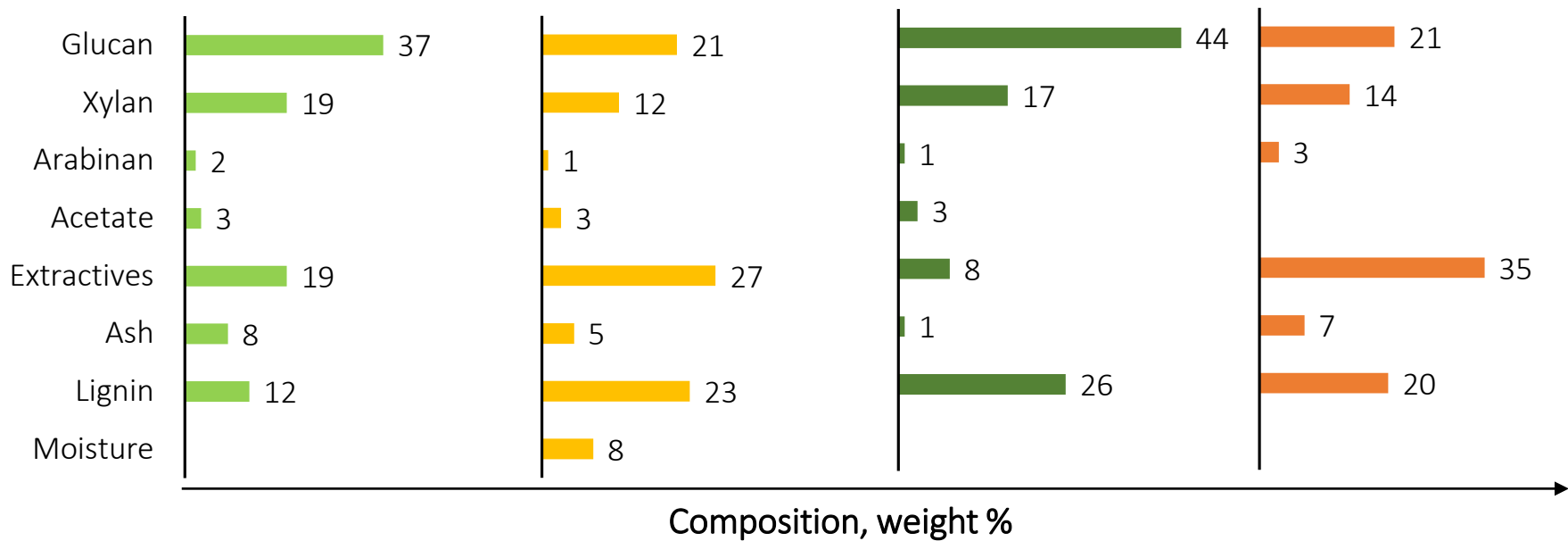
- Reduction of carbon footprint

Raw materials

Agriculture   Forest   Marine   By/waste product

CO_2

Processes

Biochemical   Chemical   Thermal

Products

Energy   Chemicals   Materials   Food / Feed

Lignocellulosic Feedstock

Rice straw

Soya stalk

Assam bamboo

Maize

Composition	Rice straw	Soya stalk	Assam bamboo	Maize
Glucan	37	21	44	21
Xylan	19	12	17	14
Arabinan	2	1	1	3
Acetate	3	3	3	
Extractives	19	27	8	35
Ash	8	5	1	7
Lignin	12	23	26	20
Moisture		8		

Composition, weight %
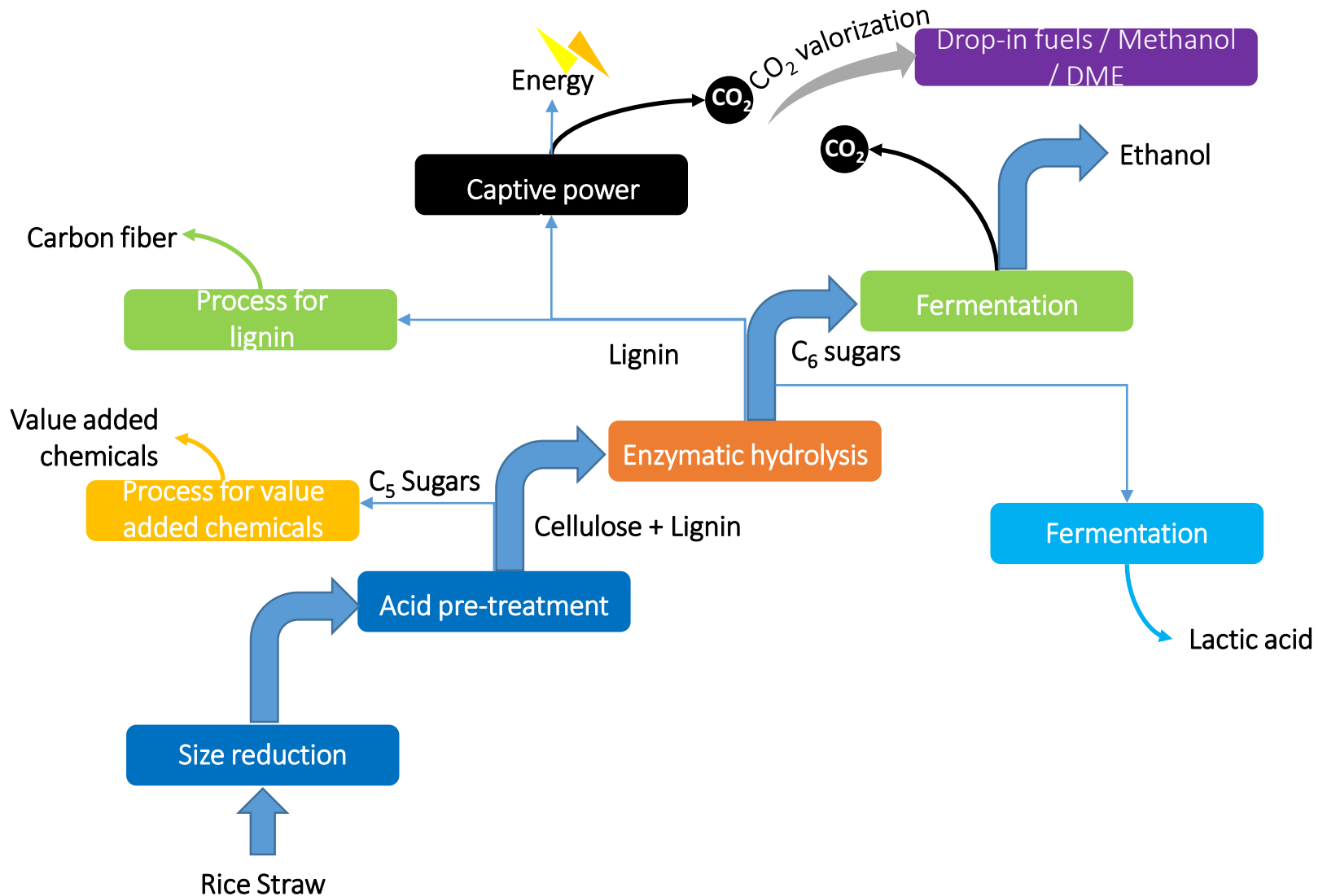
BPCL Process

BPCL Process | Differentiator

Pretreatment

Valorization

Enzymes

Engineered yeast

Economics
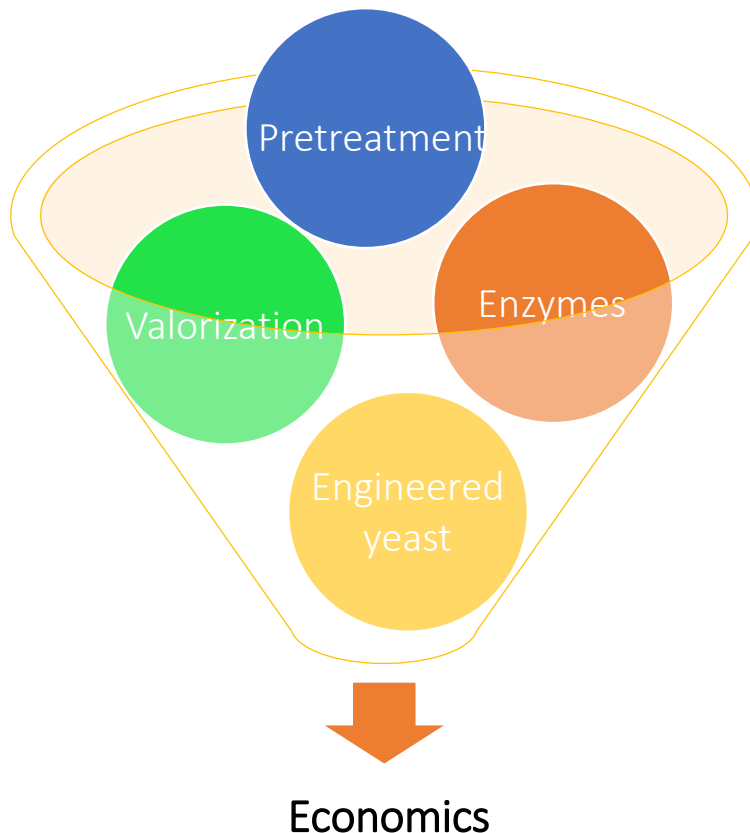
In-house pretreatment targets:
- Separation of C_5 and C_6 streams
- Sugar recovery more than 90%
- Pretreatment process-38 minutes
- Overall process time - 50 hours
- Lignin Recovery

In-house enzymes development:
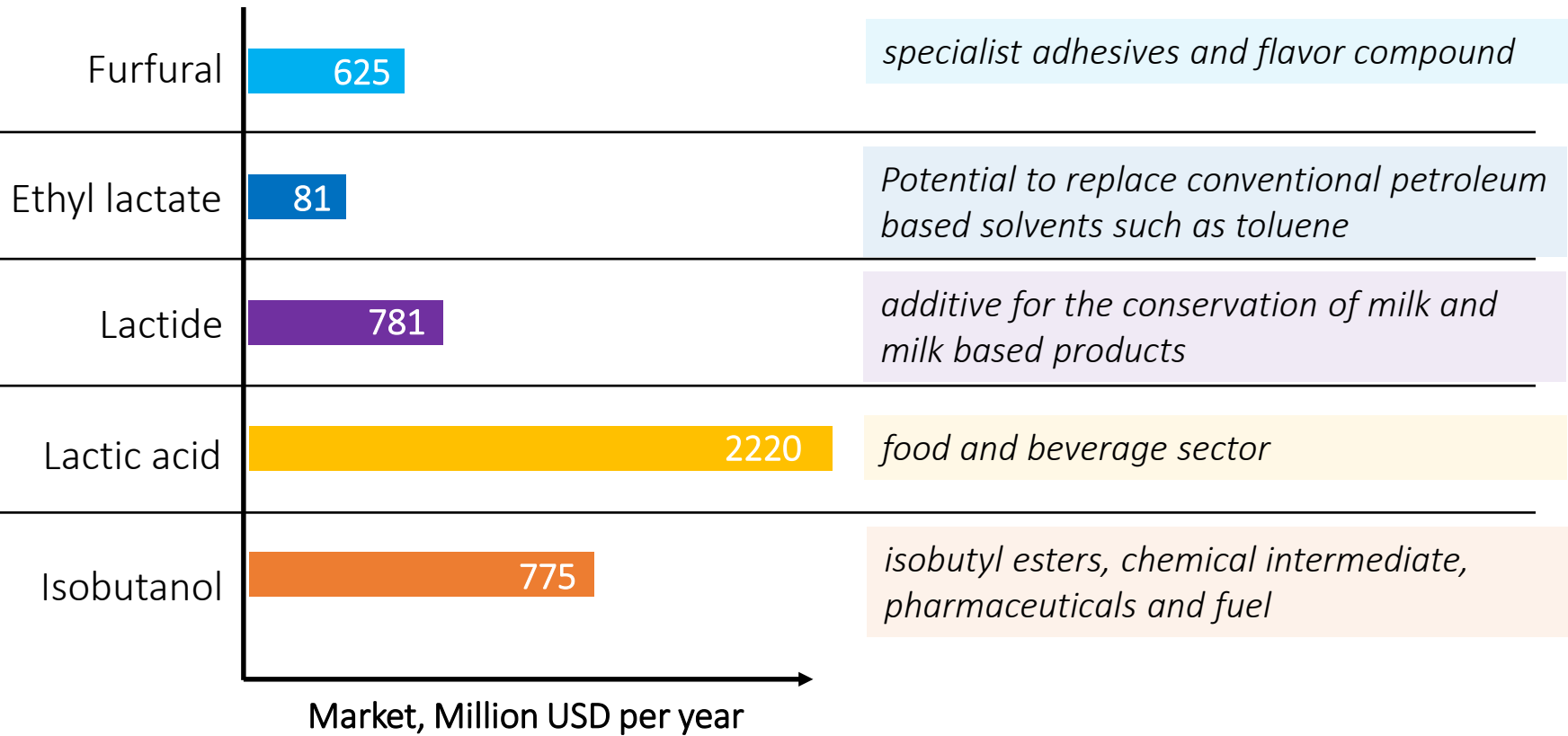- Cost reduction
- On-site production

Engineered yeast:
- Thermo-tolerant to produce higher ethanol titer
- Able to utilize C_5 & C_6
- Cost effective
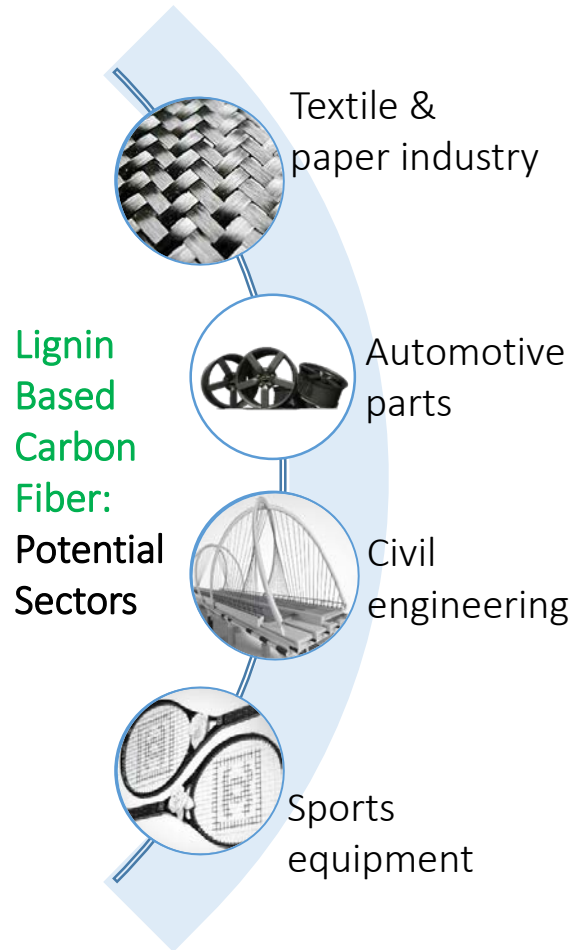- Tolerant for inhibitors- Hydroxymethyl furfural, furfural

Valorization:
- Value added chemicals such as lactic acid
- Lignin to carbon fiber
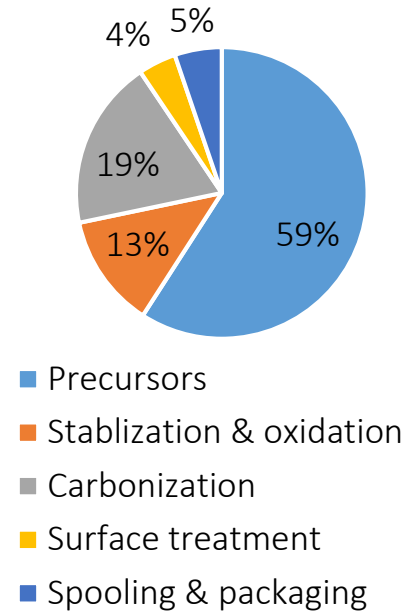- CO_2 to drop-in fuels, methanol, DME

Broad Spectrum of Products | Market

Product	Market, Million USD per year	Description
Furfural	625	*specialist adhesives and flavor compound*
Ethyl lactate	81	*Potential to replace conventional petroleum based solvents such as toluene*
Lactide	781	*additive for the conservation of milk and milk based products*
Lactic acid	2220	*food and beverage sector*
Isobutanol	775	*isobutyl esters, chemical intermediate, pharmaceuticals and fuel*

Market, Million USD per year

Source: *Rosales-Calderon and Arantes Biotechnol Biofuels (2019)*

Valorization | Lignin to Carbon Fiber

Textile & paper industry

Lignin Based Carbon Fiber:
Potential Sectors

Automotive parts

Civil engineering

Sports equipment

Manufacturing cost of CF

4% 5%

19%

13% 59%

- ■ Precursors
- ■ Stablization & oxidation
- ■ Carbonization
- ■ Surface treatment
- ■ Spooling & packaging

Precursors are the most cost intensive part of CF manufacturing

Valorization | Lignin to Carbon Fiber

Lignin → Purification

1. PAN Lignin copolymer
2. PAN Lignin blend
3. Purified lignin

Wet spinning → Stabilization → Carbonization → Surface treatment → Carbon Fiber

Melt spinning
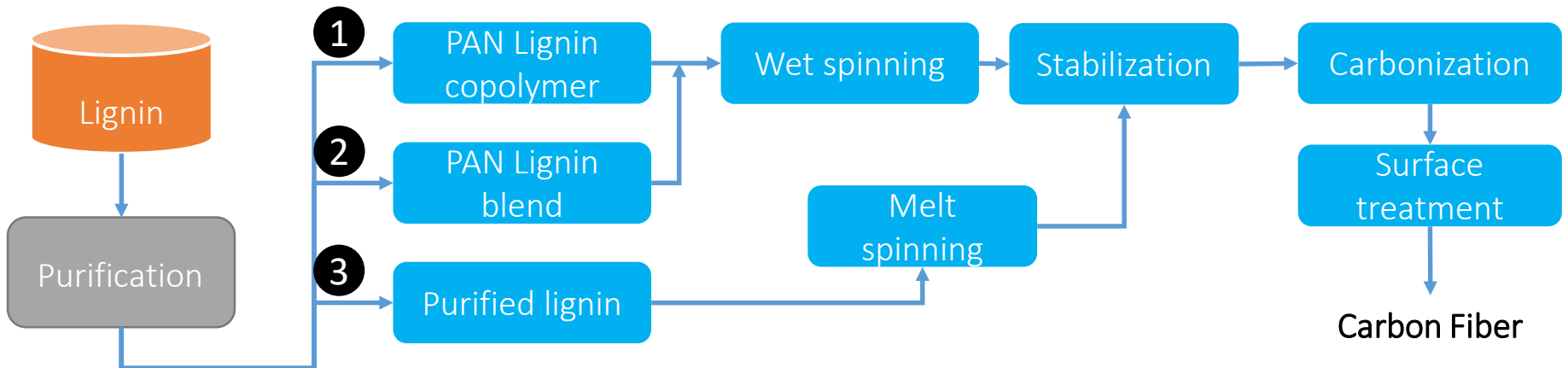
BPCL Process for Carbon Fiber Production from Lignin

Valorization | Lactic Acid

BPCL Process

Biomass Feed stock → Pretreatment → Enzyme hydrolysis → Fermentation → Purification → Lactic acid

Lactic acid → Food / beverages

Lactic acid → Poly-condensation → Poly lactic acid
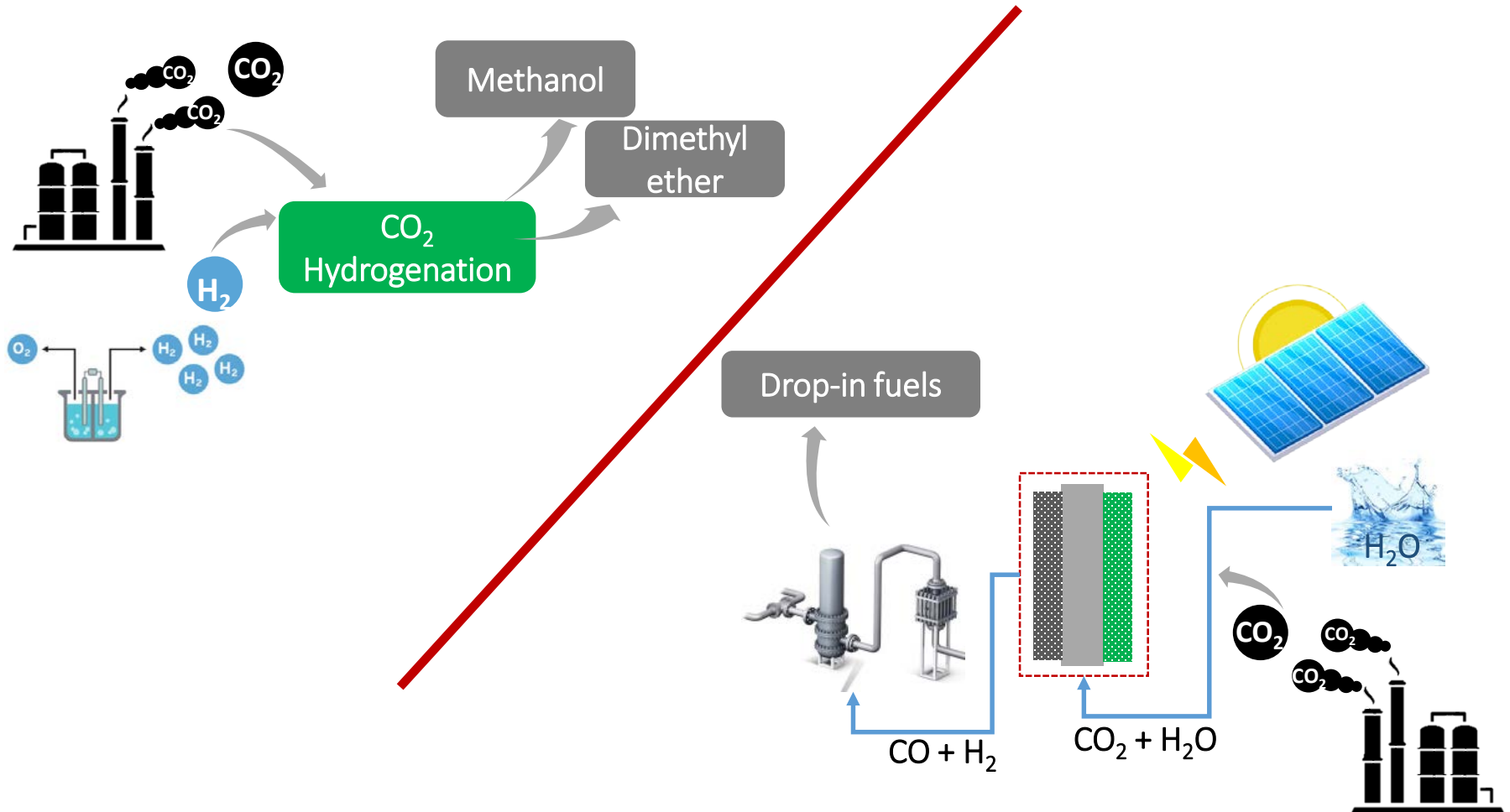
Poly lactic acid → Bottles / Films / Clothes
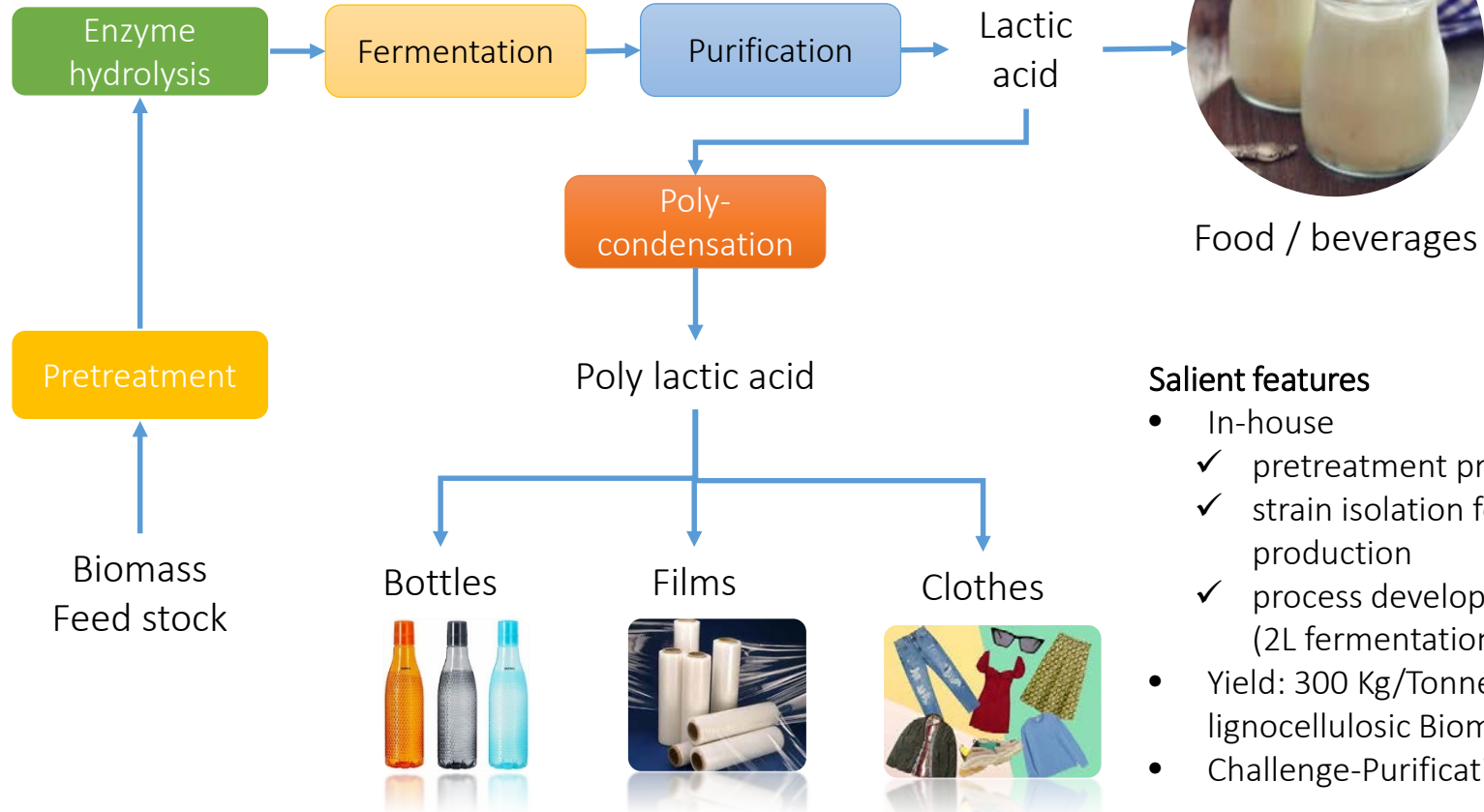
Salient features

- In-house
  - ✓ pretreatment process
  - ✓ strain isolation for lactic acid production
  - ✓ process developed at lab scale (2L fermentation)
- Yield: 300 Kg/Tonne of lignocellulosic Biomass
- Challenge-Purification

Valorization | CO_2 to Drop-in Fuel, Methanol, DME

Thank You!