

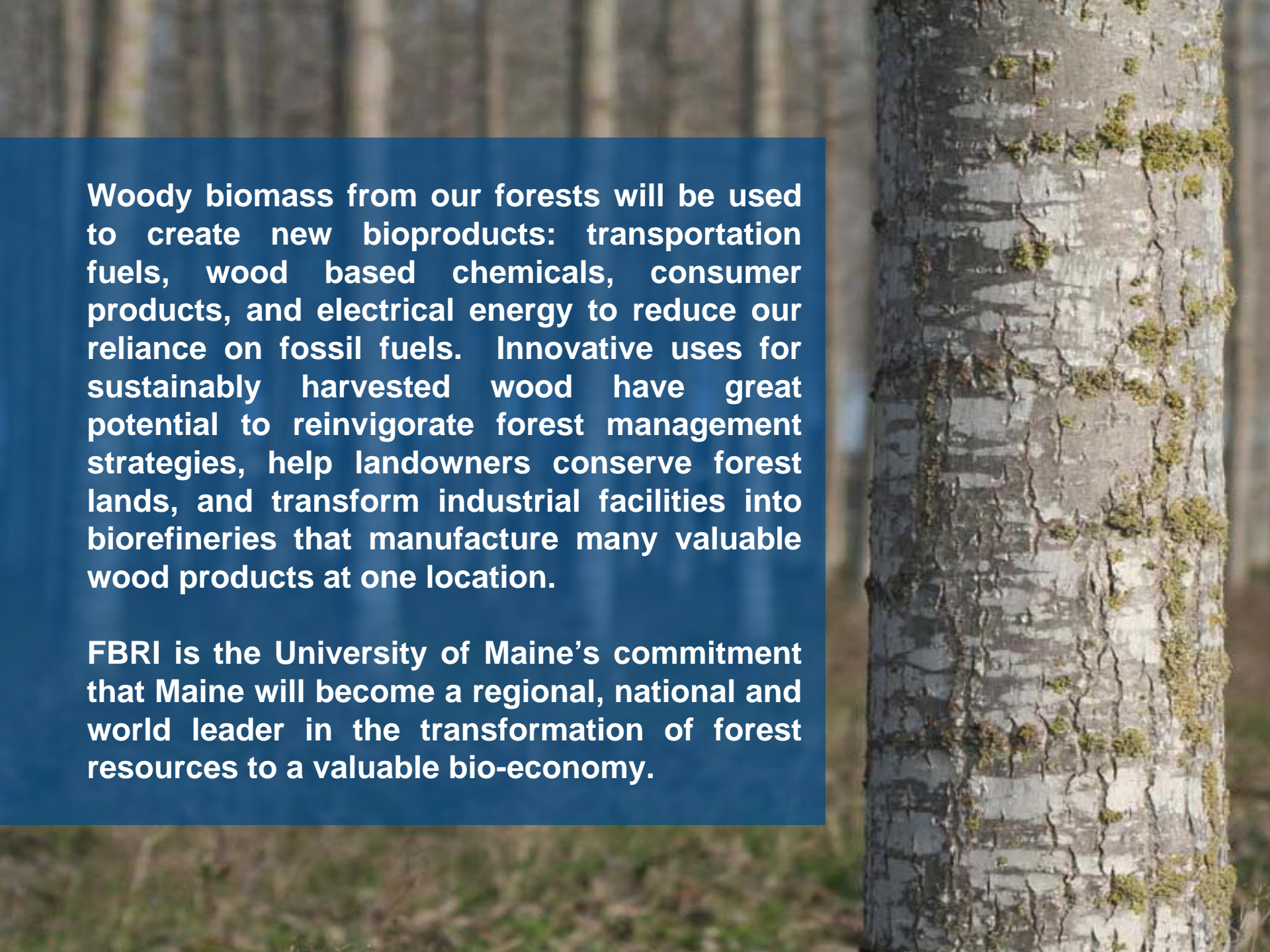


# FBRI

**FOREST BIOPRODUCTS  
RESEARCH INITIATIVE**

**Discovering**

**a Sustainable Bio-Economy**



**Woody biomass from our forests will be used to create new bioproducts: transportation fuels, wood based chemicals, consumer products, and electrical energy to reduce our reliance on fossil fuels. Innovative uses for sustainably harvested wood have great potential to reinvigorate forest management strategies, help landowners conserve forest lands, and transform industrial facilities into biorefineries that manufacture many valuable wood products at one location.**

**FBRI is the University of Maine's commitment that Maine will become a regional, national and world leader in the transformation of forest resources to a valuable bio-economy.**

# FBRI's Core Research

From the forest floor to the factory floor, researchers, students, and project partners' goals are to:

## Promote

Forest Health for a  
Stable Bio-Economy

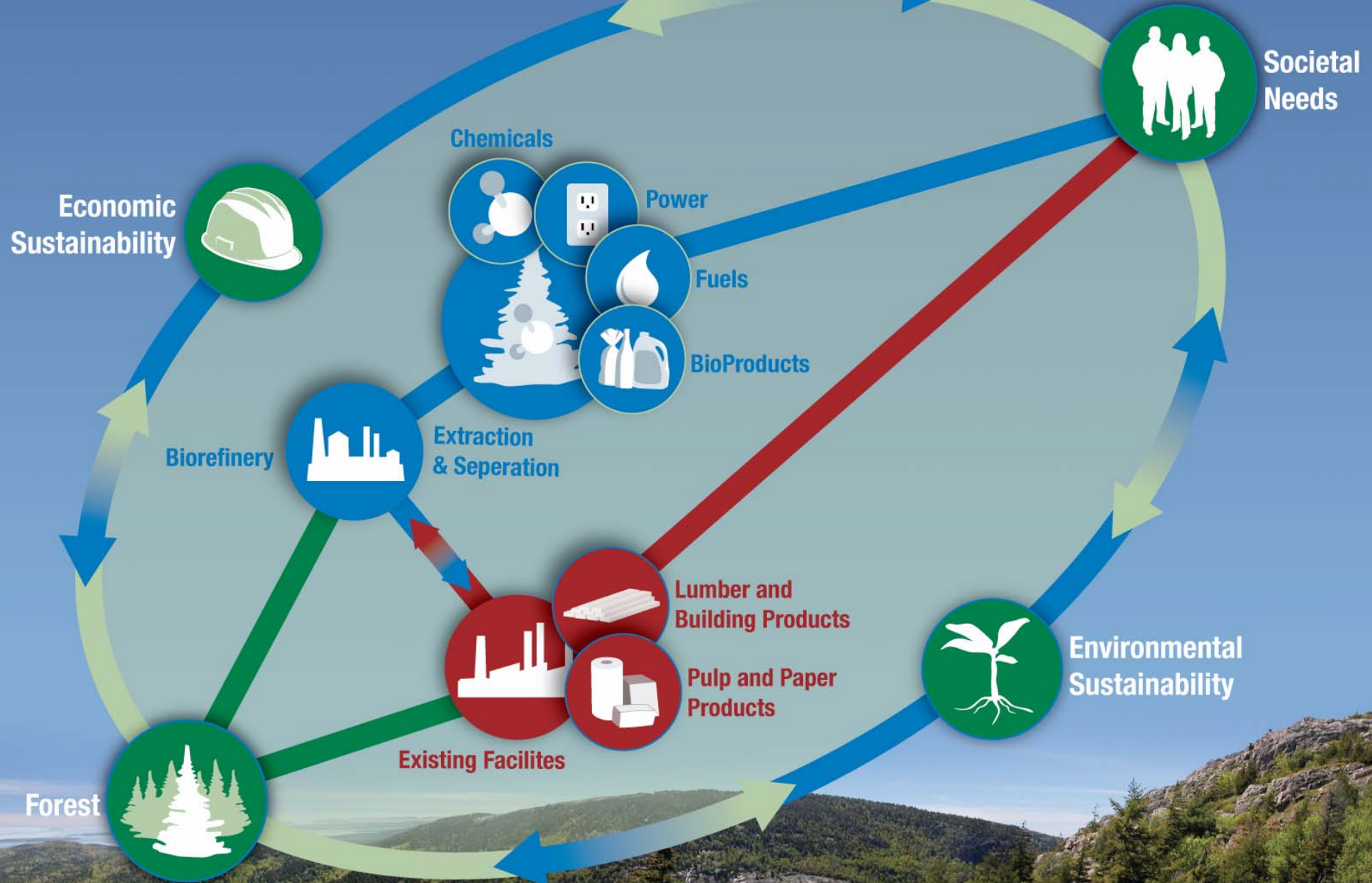


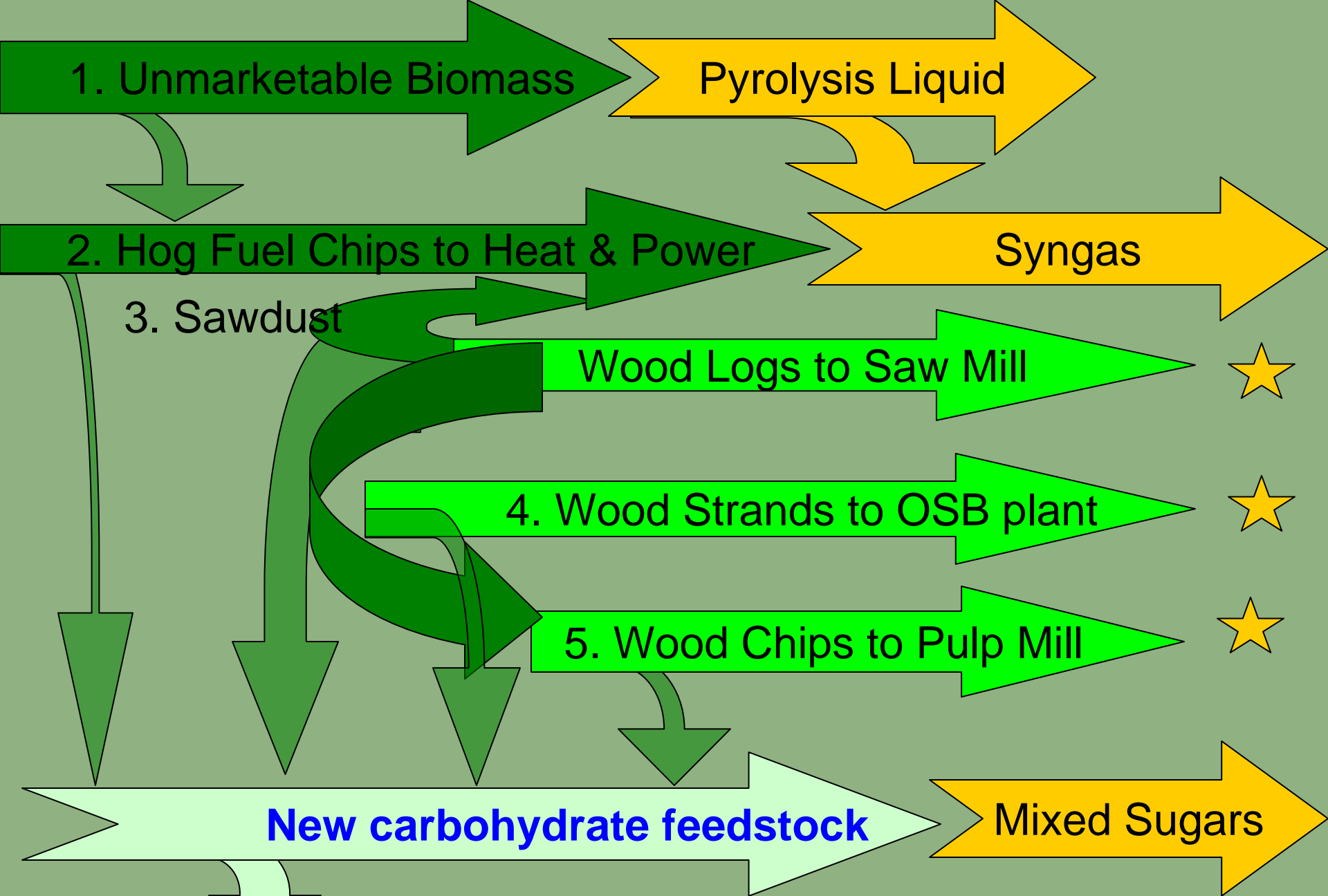
## Create

and Commercialize  
New Bioproducts



# FOREST BIOPRODUCTS RESEARCH INITIATIVE





## Theme 3 – Needs addressed

- Need to optimize extraction for downstream processing options
  - Byproducts recovery
  - Suitability for bioconversion
  - Energy efficiency
  - Water integration
- Need to collaborate
  - Enzymatic processes
  - Separations technologies
  - New woodfiber based products

## Theme 3 - Personnel

- Hemant Pendse (Theme Leader)
- Adriaan van Heiningen –
  - Extract processing
- Mike Bilodeau –
  - Wood fiber product opportunities
- Joe Genco –
  - Process Simulations
- Peter van Walsum
  - Bioprocessing
- Nan Kravit
  - Bioprospecting
- Doug Bousfield
  - Micro-Fibrilated Cellulose
- Clay Wheeler, Brian Fredrick, Bill DeSisto, A. van H.
  - Thermal Conversion

## Theme 3 - Collaborations

- LENZING – Austria – AA Recovery
- UICT – India – Enzyme Immobilization
- NREL – Golden, CO – ‘Zymo’
- UMASS – Amherst, MA – ‘C-Phy’
- API, Atlanta, GA – Process Simulations
- UOP, Chicago, ILL – Petrochemical
- ORNL, Oak Ridge, TN – High Temp. Mat’ls



## Theme 3 Active Projects -

- Hemi-rich Extract Fermentation- Sara
- Micro-Fibrillated Cellulose – Nazia
- Biorefinery Techno-economics - Haibo

# Integrated Forest Products Refinery

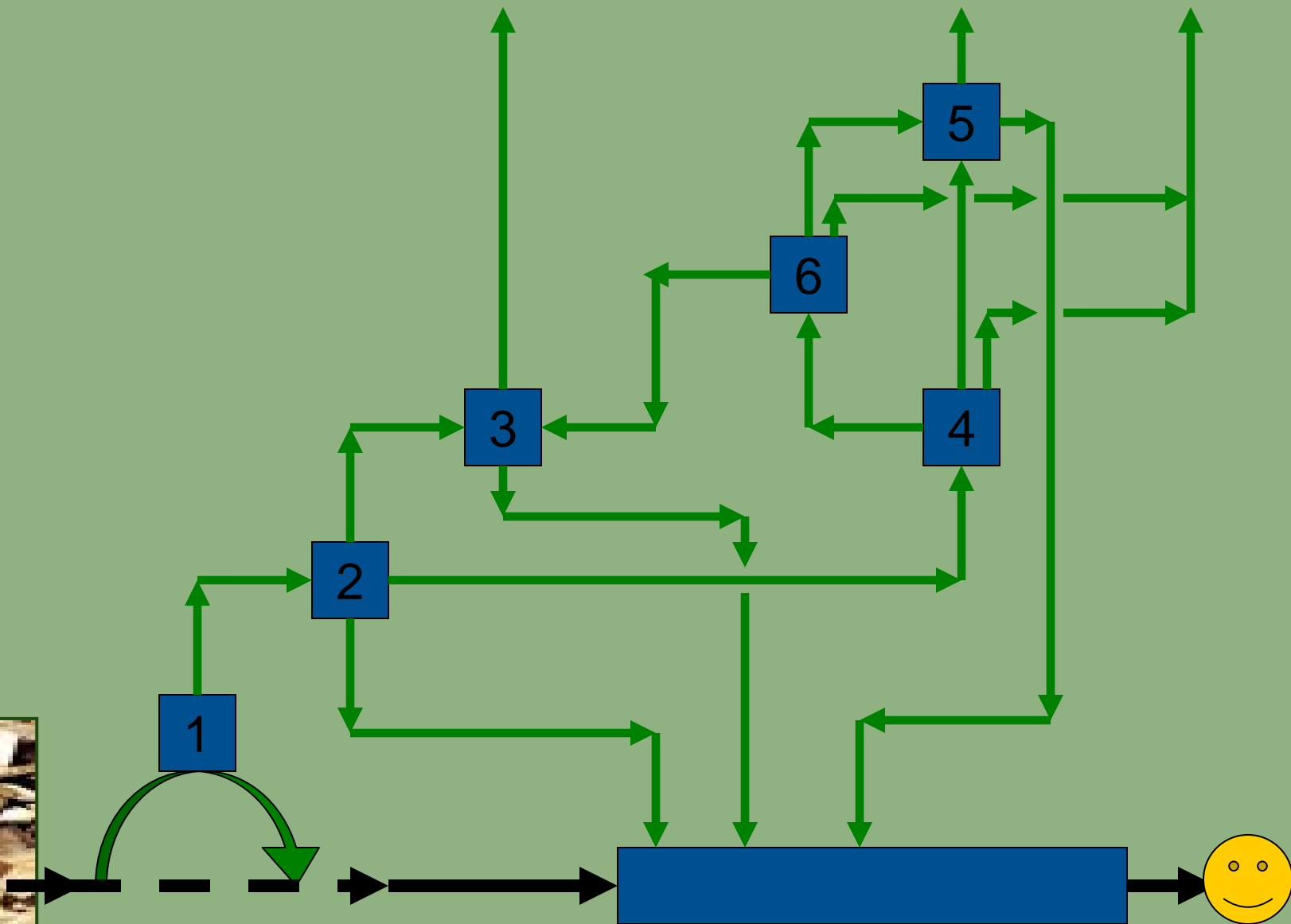
## – Six Steps in Four Stages

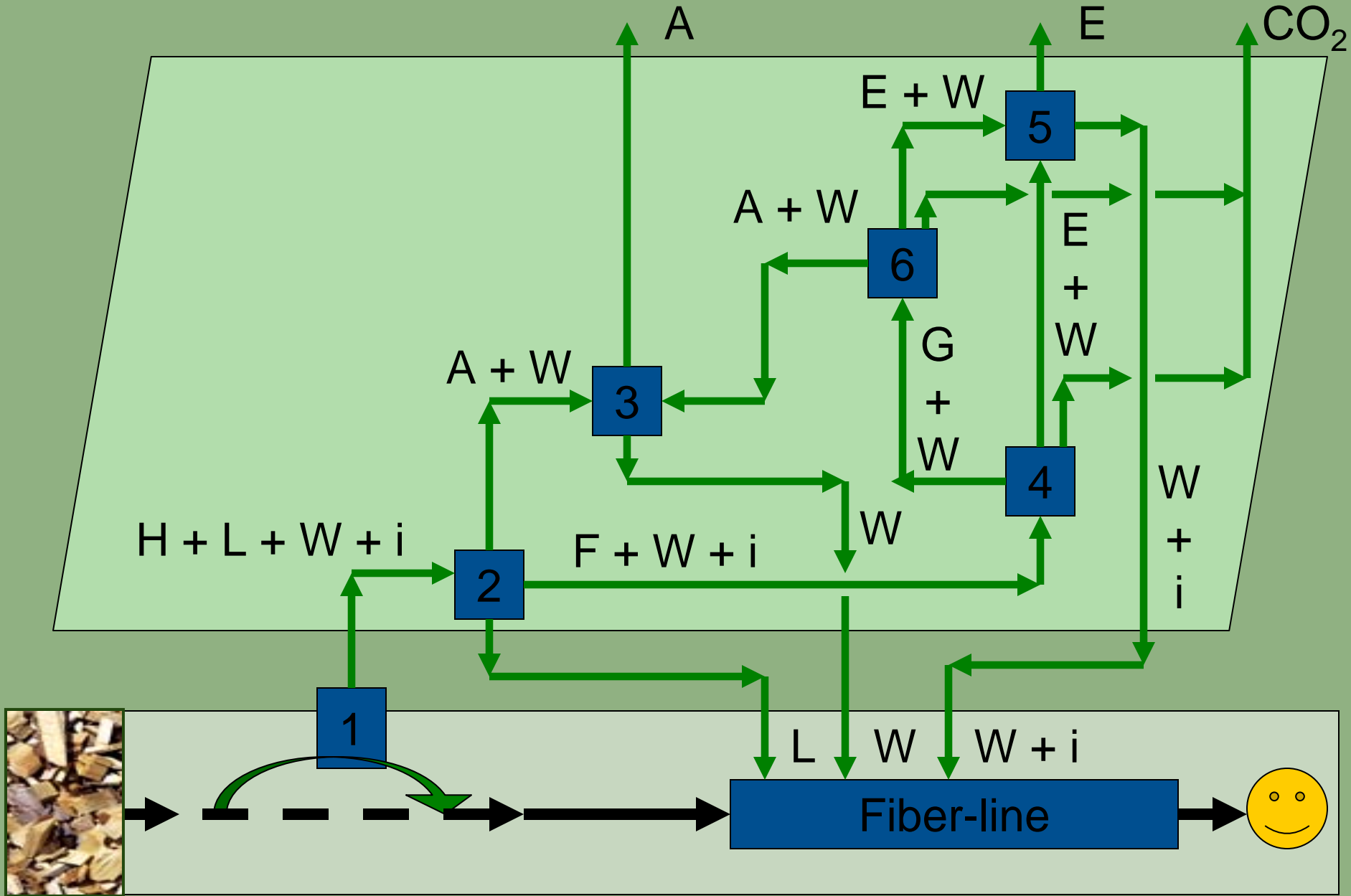
1. Separation of **Hemis** from wood fibers in a near-neutral aqueous extract with dissolved **Lignin**

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2. Acid treatment of extract with removal of **Lignin** and sulfates, with separation of **Acetic acid** from **Fermentables**
3. Separation of **Acetic acid** from **Water**, with recovery of **methanol** and **furfural**

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4. Sugar fermentation to yield **CO<sub>2</sub>** and (**Ethanol** + **Water**) mixture, with further separation of **Ethanol** from **Water**
5. Dehydration of **Ethanol** from (**Ethanol** + **Water**) mixture

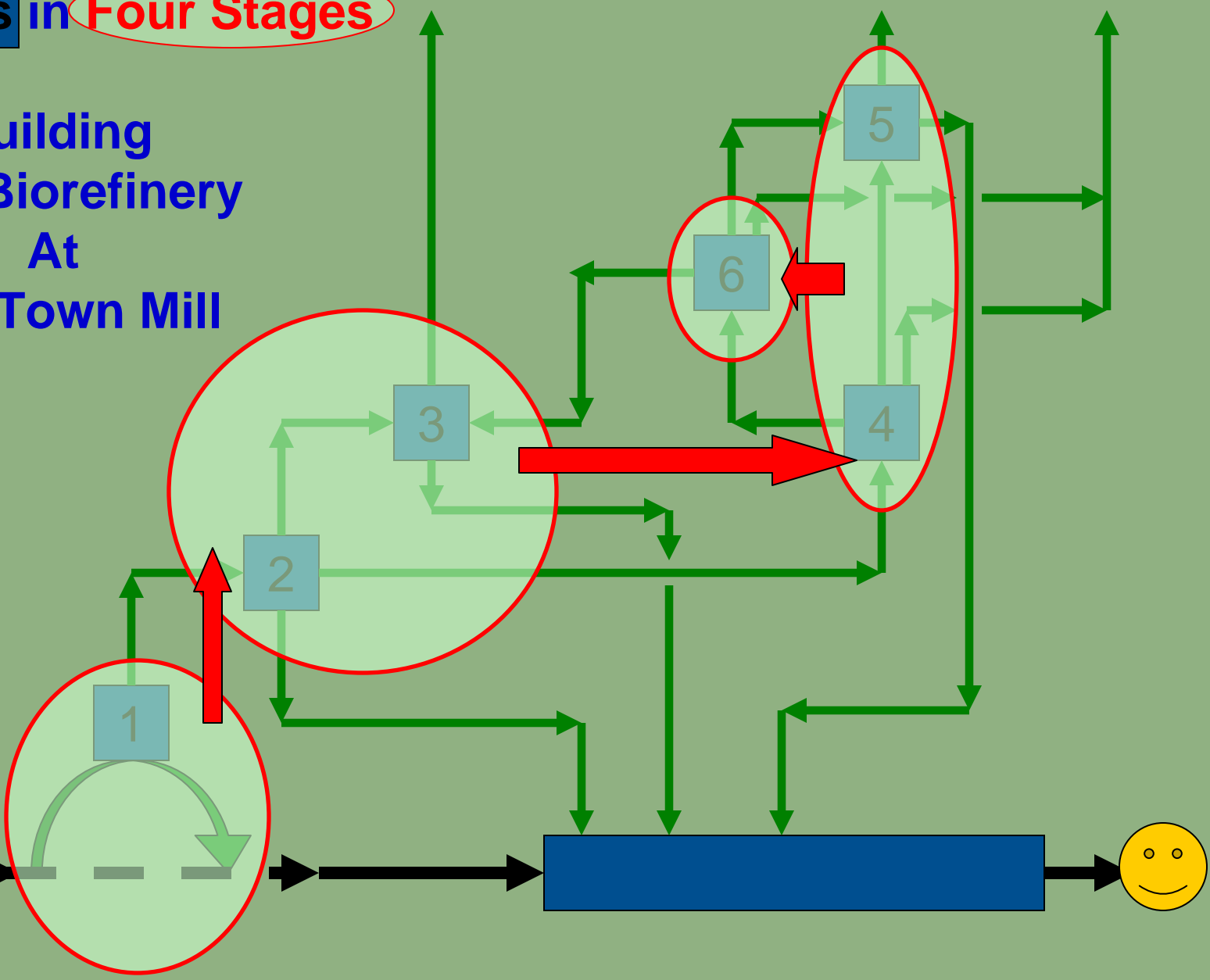
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6. **Glucuronic Acid** fermentation to yield **CO<sub>2</sub>** and (**Acetic acid** + **Ethanol** + **Water**) mixture, with further separation of **Acetic acid** from **Ethanol**





- Six Steps in Four Stages

Building  
New Biorefinery  
At  
Old Town Mill



				<b>BASIS</b>		
Pulp Production	550 tonnes/day					
Woodchips	1200 tonnes/day			46%	Pulp yield on wood	
<b>wood organics extracted for processing</b>	<b>100 tonnes/day</b>			8.33%	Extract recovery on wood	38 \$/tonne
<b>Lignin ppt Recovered</b>	<b>12 tonnes/day</b>			12%	of organics	
Acetic Acid Recovered	18 tonnes/day			18%	of organics	
Glucuronic acid Recovered	22 tonnes/day			22%	of organics	
Carbohydrates Recovered	40 tonnes/day			40%	of organics	
Fermentable monosugar feedstock	36 tonnes/day			90%	of carbohydrates	
Ethanol from C5/C6 fermentation	16.4 tonnes/day			46%	of fermentable monosugars	
Ethanol from Glucuronic Acid Fermentation	3.9 tonnes/day			18%	of Glucuronic Acid	
<b>Total Ethanol Produced</b>	<b>20 tonnes/day</b>					\$668 \$/tonne
	<b>6,766 gal/day</b>					2 \$/gal
Acetic Acid from Glucuronic Acid Fermentation	4 tonnes/day			18%	of Glucuronic Acid	
<b>Total Acetic Acid Produced</b>	<b>22 tonnes/day</b>					\$1,046 \$/tonne
	<b>5,721 gal/day</b>					4 \$/gal
Ethanol Yield	68 gal/dry tonne			55	gal from sugars/dry tonne	
Acetic Acid Yield	57 gal/dry tonne			47	gal from recovery	

