MASCOMA

Commercial Development of Cellulosic Ethanol

November 8th 2006

Mascoma Corporation

- **Mission**
  - Mascoma's mission is to generate superior returns for its investors through **continuously reducing** the cost of manufacture of ethanol from cellulosic biomass by application of world leading science in large-scale manufacturing operations.

- **Strategy**
  - The company's overall strategy is to pursue both the **development and deployment** of a suite of advanced technologies.
  - Over time establish **defensible IP** for integration into production plants for rapid market expansion.
  - Mascoma will be active in **licensing and partnering** as necessary to ensure freedom to operate across the cellulose ethanol value chain.

People-Unique knowledge & commitment to cellulose ethanol

Management

- **Dr. Colin South Ph.D**.; President
  - Executive with leadership experience in engineering, genetics, and marketing arenas. Technologist with background in biomass ethanol.
- **Dr. Andrew Richard Ph.D**.; Chief Technology Officer
  - Experience in both biocatalyst and pretreatment development at a range of scales.

Research

- **Professor Lee Lynd**; Dartmouth College; Founder, Chief Scientific Officer
  - Expert in the utilization of plant biomass for production of energy including leading research on fundamental and biotechnological aspects of microbial cellulose utilization.
- **Professor Charles Wyman**; University of Riverside, Founder, Chairman Mascoma SAB
  - Leader in pretreatment research and enzymatic conversion processes.
- **Dr. David Hogsett Ph.D**.; VP Research and Development
  - Experience in the development and deployment of biological process into industrial environments. Technology leader in the field of microbial fermentation of cellulose to ethanol.
- **Dr. Vineet Rajgarhia**;
  - Senior scientist and science group leader with Cubist, Eastman Chemical, and Cargill Dow.

Engineering deployment

- **Siva Sivasubramanian**;
  - Experienced process design engineer with 20 years process design experience including VP development with Aspen Tech.
- **Dr. Herve Garant**
  - 15 years bio-process engineering expertise, including design, start-up, and operation of biomass processing operations.

People - Scientific Advisory Board

- Leading expertise in metabolic engineering, biomass pretreatment, ethanol manufacture and plant design.

Member	Current position	Area of expertise
Prof. Charles Wyman (SAB Chairman)	University of Riverside: *Ford Motor Company Professor of Chem. and Env. Eng.*	Physical and biological conversion of cellulosic biomass to fuels and chemicals
Prof. Frances Arnold	California Institute of Technology *Dick and Barbara Dickinson Prof. Chem. Eng. and Biochem.*	Protein engineering, metabolic engineering, directed evolution, biocatalysis
Prof. Bruce Dale	Michigan State University *Professor*	Biochemical Engineering, Biomass Conversion, Biobased Industrial Products.
Dr. Don Johnson	Retired *Formerly VP R&D; Grain Processing Corporation*	Ethanol manufacture, R&D management, and plant design.
Prof. Lee Lynd	Dartmouth College *Professor of Engineering* *Adjunct Professor of Biology*	Biochemical engineering and applied biology relevant to processing cellulosic biomass
Prof. Jack Saddler	University of British Columbia *Dean - Faculty of Forestry NSERC Industrial Senior Chair.*	Application of enzymes in enhancing pulp and fibre properties Bioconversion of lignocellulosic residues to Ethanol.
Dr. Philippe Soucaille	Metabolic Explorer *Chief scientific Officer* *Professor at the INSA of Toulouse.*	Metabolic and pathway engineering. Previously project leader at Genencor International Inc managing the 1, 3-propanediol project with Dupont de Nemours.

People-Investors and Partners

Investors

- Khosla Ventures - Palo Alto, CA
- Flagship Ventures; Cambridge, MA

Board of Directors

- Doug Cameron - Khosla Ventures; Chief Science Officer
- Samir Kaul - Khosla Ventures; General Partner
- Jim Matheson – Flagship Ventures; General Partner
- Colin South – Mascoma
- Lee Lynd – Founder
- Charles Wyman – Founder

- **Financing**:
  - $9MM Series A/A1 Financing from initial investors

Establishing Large Scale Cellulosic Ethanol

Key questions

- Feedstock
  - Short term
    - Wood, corn stover, Rice straw, bagasse, corn fiber
  - Longer term
    - High yield dedicated energy crops
    - Switchgrass, Miscanthus, Willow


Stover


Wheat straw


Miscanthus


Hybrid Poplar


Willow

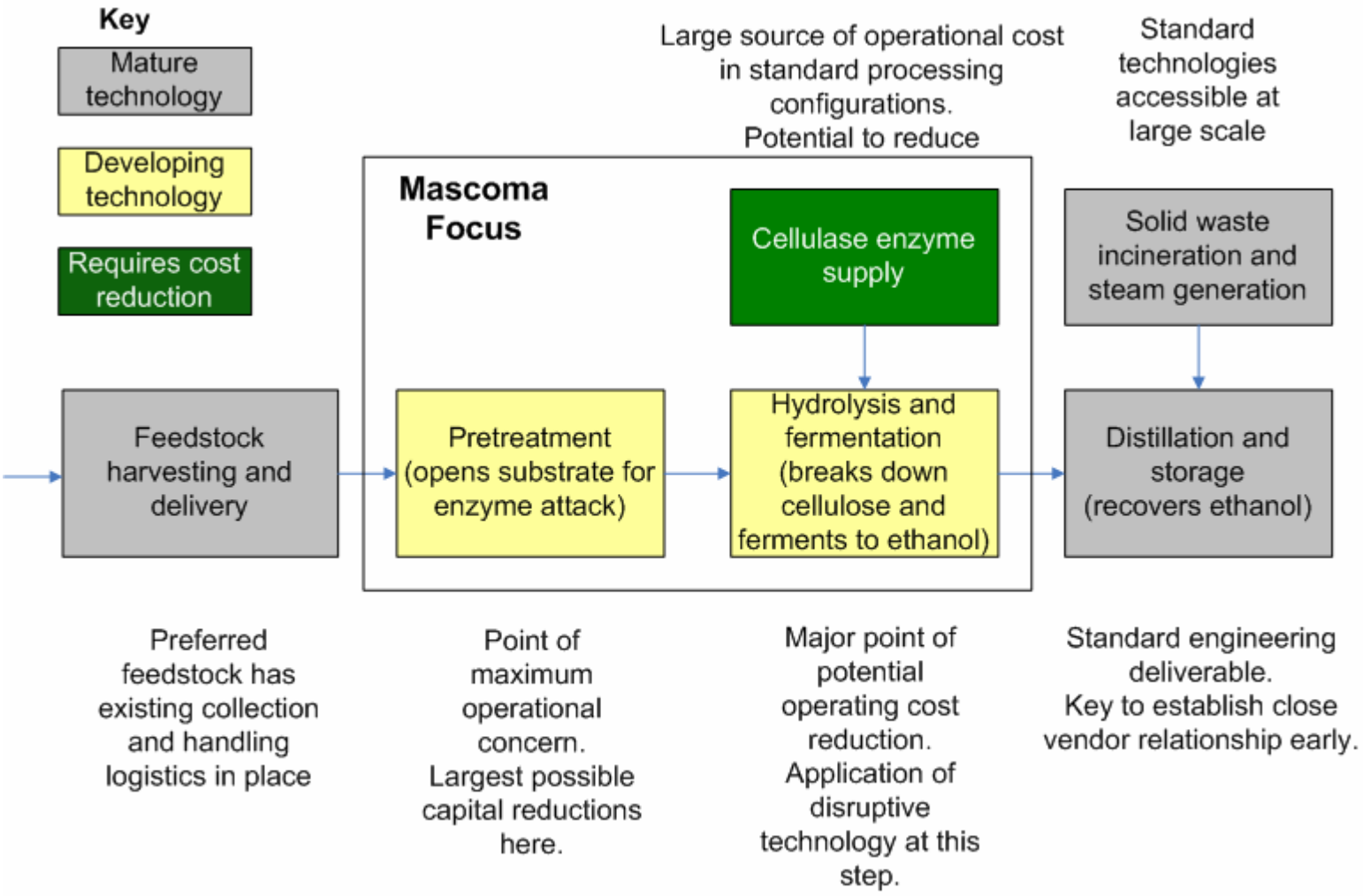

Switchgrass

- **Process**
  - **Pretreatment**
  - **Hydrolysis**
  - **Fermentation**

- Markets

“It’s the COGS stupid”

Cellulosic Ethanol Process



Where To Start?

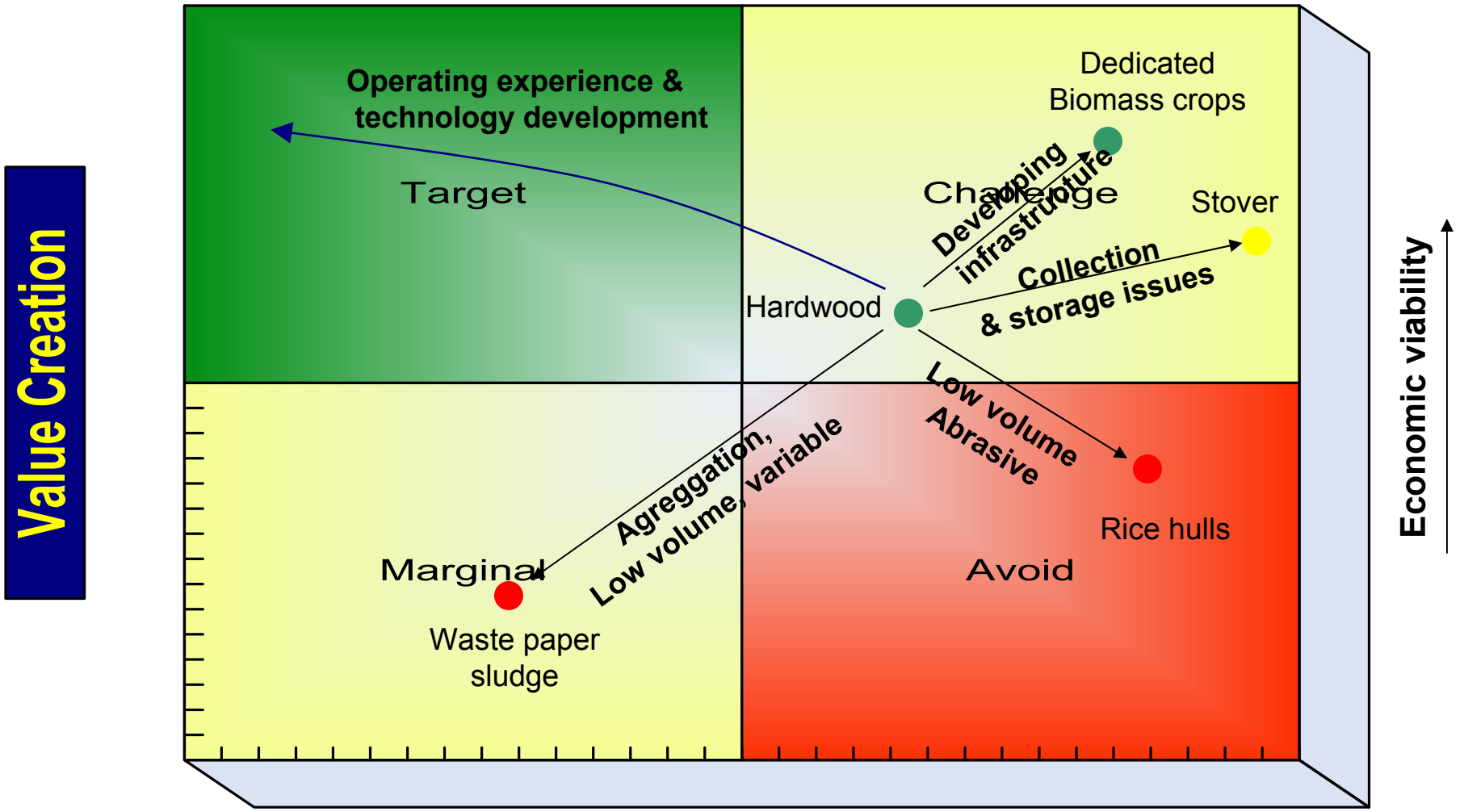
Compositions and processing challenges are similar

Feedstock	Composition				Easily aggregated	Relatively inexpensive	Depth of literature	Available in commercial quantities	Consistent composition
	Cellulose (%)	Hemicellulose (%)	Lignin (%)	Ash (%)					
Hardwood (Aspen)	45-50	29	16-20	0.2					
Softwood (Spruce)	42	27	29	0.04					
Corn Stover	34	30	19	3					
Sugarcane Bagasse	38	25	15	3					
Rice Straw	32	24	13	18					
Rice Hulls	55	10	17	15					
Switchgrass	31	25	18	4					
Miscanthus	45	22	17	3					

Answer: Start with substrates which simplify your life.

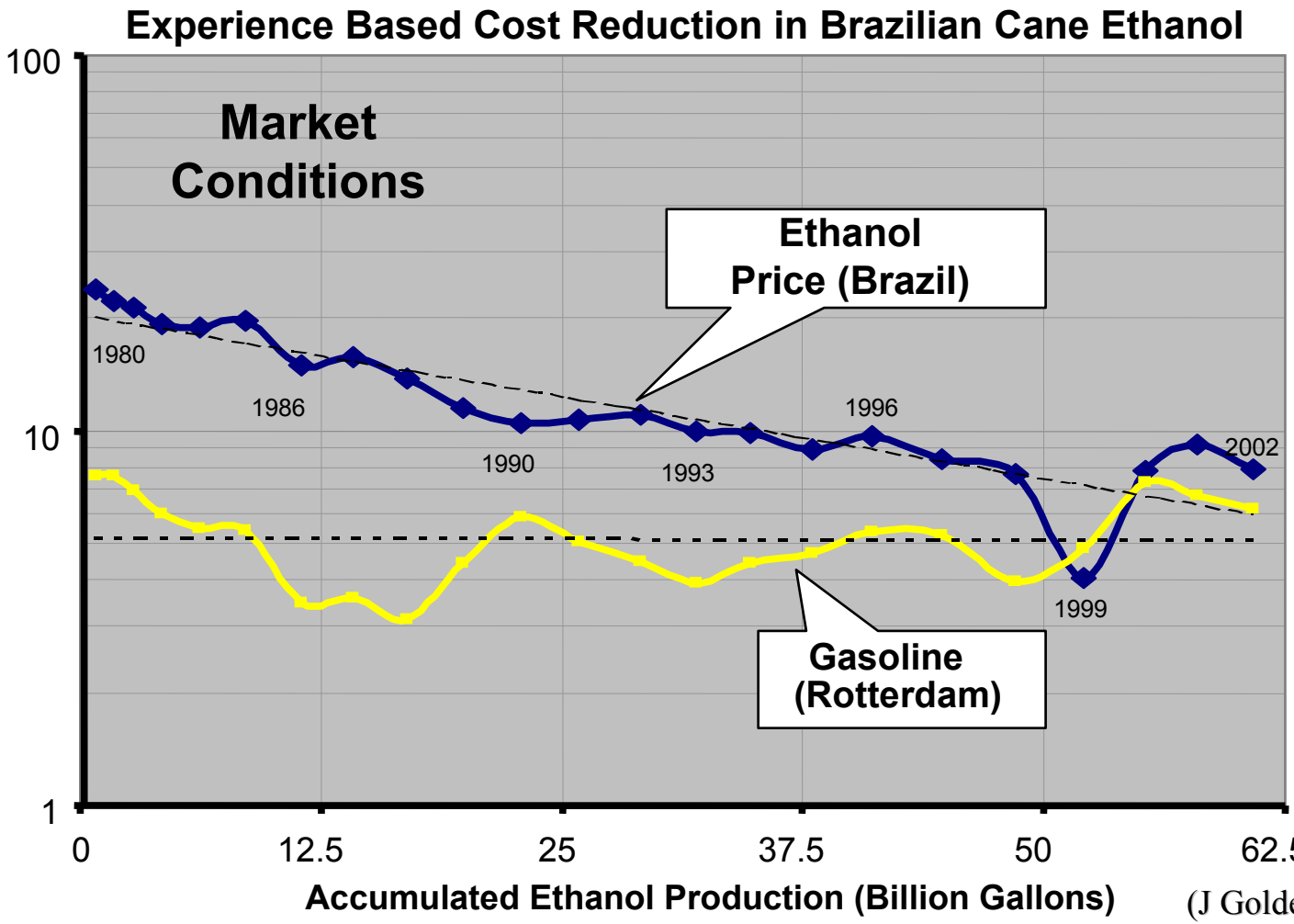
It Doesn't Matter Where You Start

As long as you start!



Cost Reductions will be Driven by Experiential Learning

- Expect cellulose ethanol cost reduction to mimic Brazilian ethanol
- With much reduced timeline



(J Goldemberg, 2003)

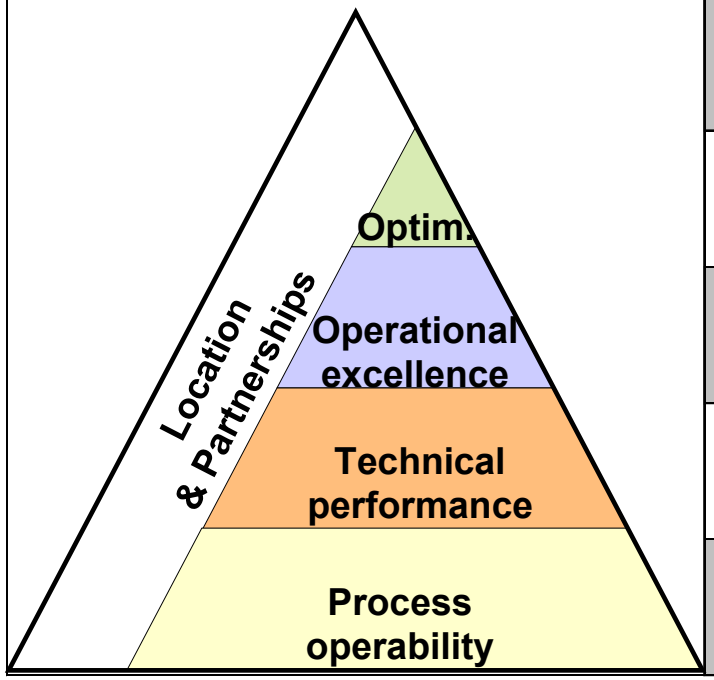
Mascoma Deployment Focus

Focus on:

- **Development of simple, operable, and robust solutions**
  - Phased entry with wood chips as initial feedstock
  - Look to existing feedstock aggregation and logistics
  - Establishing key operational performance

- **Streamlined introduction of technology improvements**
  - Concurrent development of new technology improvements
  - Value creation of defensible IP through microorganism development and process improvements

Layers of Influence on COGS

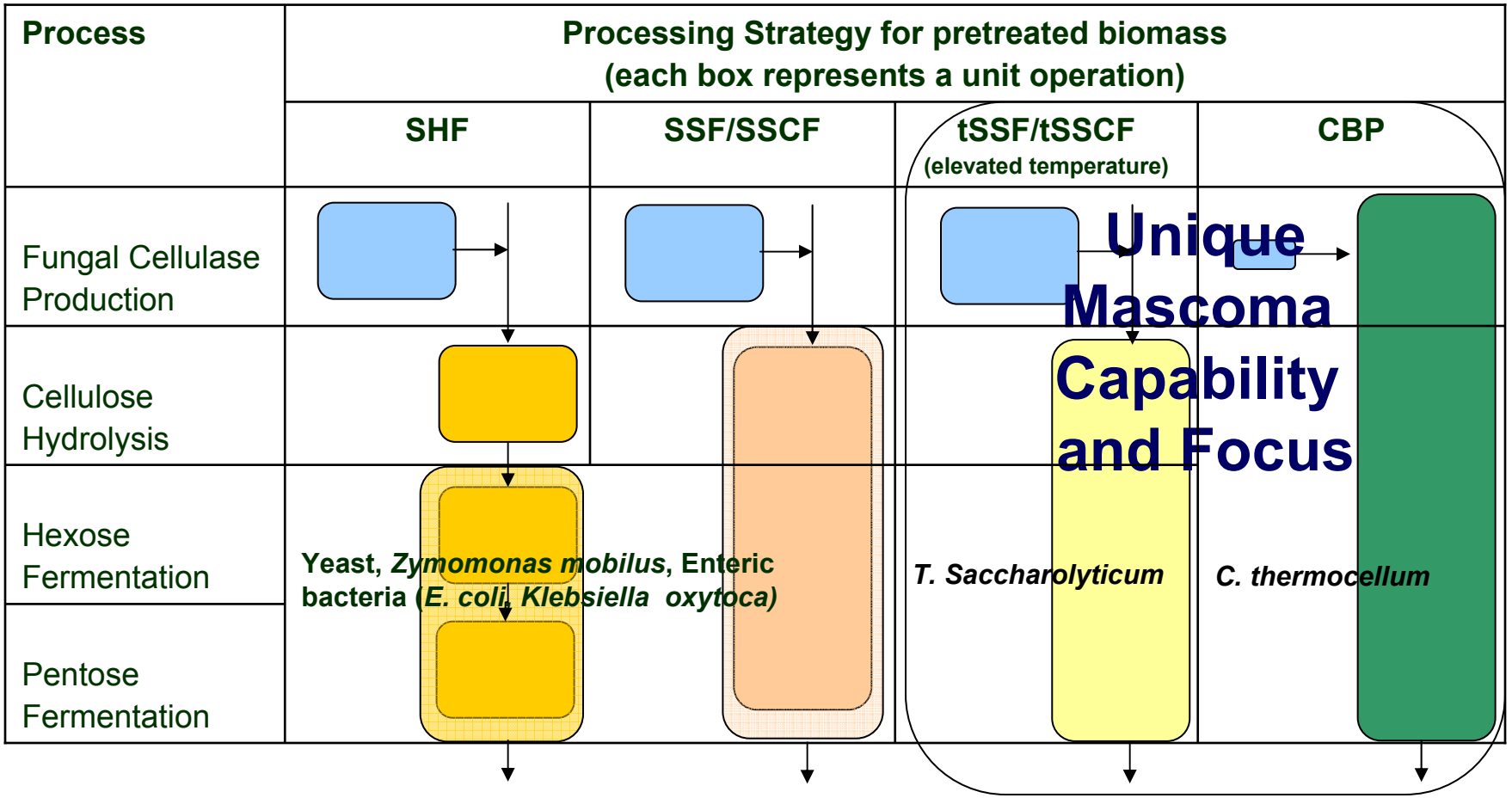


Layers of influence on Cost Of Goods	Design Focus: Process simplification	Design Focus: Organism development	Design Focus: Operating models	Design Focus: Feedstock development	Point of COGS influence
	■	■	■	■	Applicable across COGS for entire operation
			■	■	Reduced operating costs Improved capital utilisation
	■		■		Reduced labor Improved capital utilisation Reduced consumables/waste
		■			Improved yield Decreased consumables/waste
	■	■	■		Reduced labor Improved capital utilisation Reduced consumables/waste Reduced yield

Mascoma Development Focus - Consolidated Bioprocessing

- **Simplification of processing operations**
  - Reduced capital cost
  - Simplification of operation and reduced downtime
  - Use of complementary capital
- **Reduced requirement for external cellulase production**
  - Reduced capital and operating costs
  - Additional required enzymes tailored for application by specialist enzyme suppliers
- **Reduced fermentation time**
  - Continuous hydrolysis and fermentation of pretreated biomass to high conversion in under 48hrs
  - Reduced capital cost
  - More robust operation
- **Operating cost impact >30c/gallon ethanol derived from cellulose**

Simplification Through Consolidation of Processing Operations



Process Simplification and Lowered Product Cost

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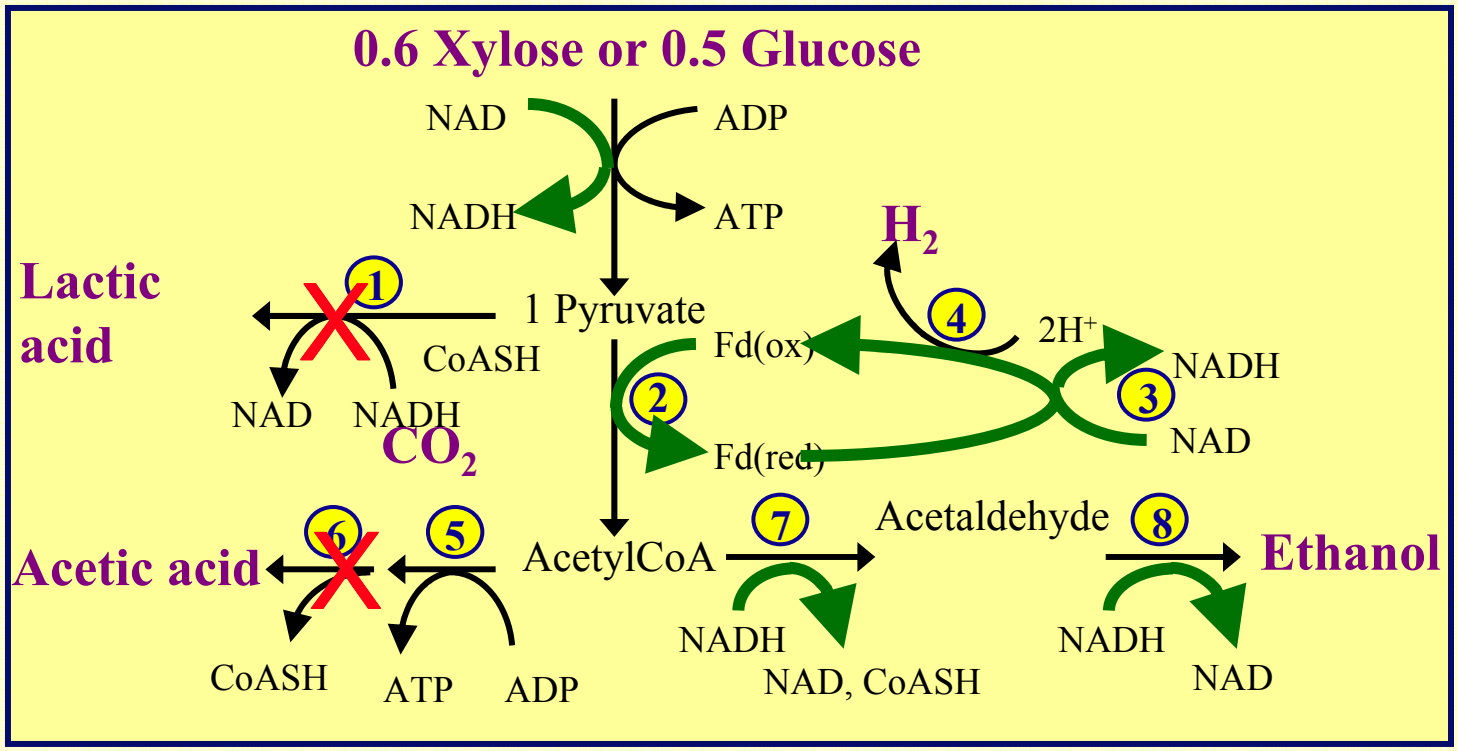
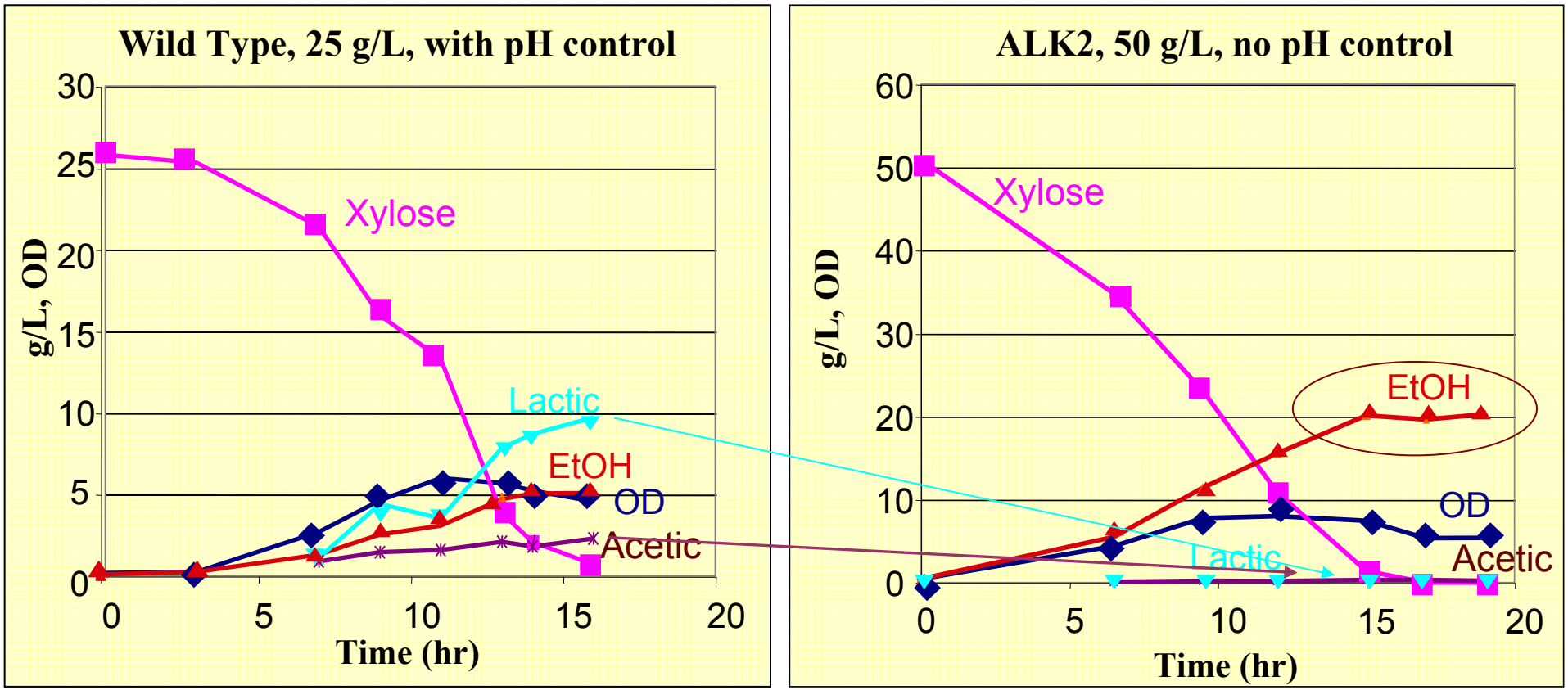
SHF: Separate hydrolysis & fermentation SSF: Simultaneous saccharification & fermentation
SSCF: Simultaneous saccharification & co-fermentation CBP: Consolidated bioprocessing

Gene knock-out in *Thermoanaerobacterium saccharolyticum*



Stoichiometric ethanol production requires that all electrons from Fd(red) go to NADH and none to H_2 formation

Double knock-out proof of concept - *T. saccharolyticum**



- Organism grows vigorously in continuous culture with 12 hour residence time
- Focus
  - Development of this organism into commercial form
  - Apply techniques to *C. thermocellum* to develop CBP organism

Mascoma Priorities

- **Maintain and expand Mascoma's world class team**
  - Ensure a blend of management, technical, and deployment skills required to execute at the complexity of this business
  - Investors with unequaled domain knowledge, contacts and capability

- **Development of pilot/precommercial plants to allow**
  - Process refinement and development and experiential learning
  - Operating basis for EPC guarantee
  - Execute in low risk configuration and progressively reduce risk in subsequent plants/configurations

- **Focus on the future**
  - Robustness/operability
  - Long term COGS

- **Maintain technological leadership in transition to CBP**
  - Launch of *T. saccharolyticum* and development of CBP organisms

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