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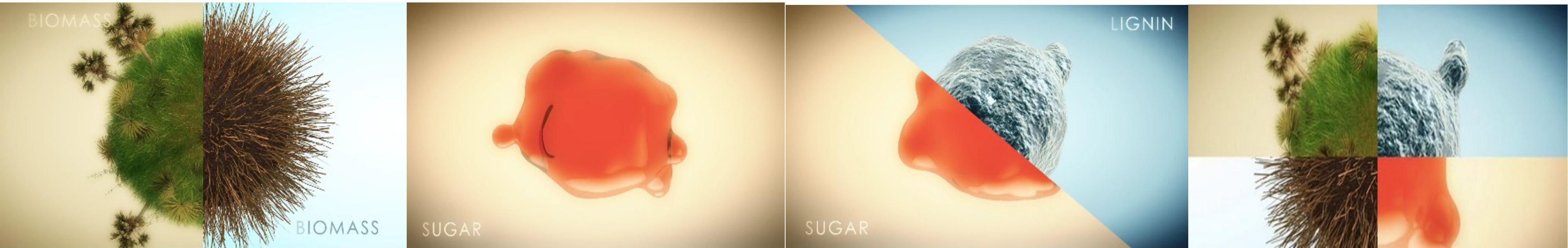
Eco Industrial Technology

Cellulosic Sugars Technology



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Agenda

- Executive Summary
- Technology
- Market
- Proven Technology Born in 1st Gen Corn Ethanol
- Bolt-On Technology
- Partners
- Eco's Technological Capabilities
- Technology Development & Demo Plant
- Technology Comparison
- Budget
- Technology Processes
- Technology Documentation
- Enzyme Strategy
- Scale Up
- Business Model
- Supporting Data

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Executive Summary

- Eco proposes to introduce in Brazil it's bolt-on, low capex system to convert bagasse and other biomass products into high purity sugars from which 2nd generation ethanol (2G Ethanol) can be produced. The system can be attached to existing sugar and ethanol mills to increase their ethanol productivity by 20-40% without additional cane plantation, and with an additional capex of only 5-10% when compared to the mill's capex. More than 70% of the equipment can be produced in Brazil.

- The goal is to achieve 10% of the potential market (40 mills of an average crushing capacity of 3 million tons per year, each) within 15-20 years. This business plan conservatively models 22 units to be installed in the next 10-15 years.

- Eco, is a Licensee of Edeniq, Inc., a privately held United States corporation founded in 2008 for development and commercialization of technology for the conversion of biomass to ethanol and intermediate cellulosic sugars. Edeniq, Inc., principle shareholders are the venture capital firms of Kleiner Perkins Caulfield Byers, Draper Fisher Jurveston, The Westly Group, Cyrus Capital, The Angelo Group, I2BF, Element Partners, and Flint Hills Resources, a US refining, chemicals, and biofuels company. Edeniq has invested about $100 million in the development of its biomass conversion technology, which forms the basis of its bagasse to ethanol process. Edeniq has already commercialized its pretreatment and cellulosic ethanol technology in first generation, corn-based ethanol plants in the United States, a business that is generating over $20 million per year in revenue. In addition to its development efforts mentioned above, Eco has an ongoing business in Brazil (Eco) to optimize the mainstream processes in sugar-ethanol plants, which are also potential clients for the proposed process. Eco has a lab and an experienced staff with full knowledge of the sector and fully trained during the past years on the proposed new process.

- Eco's main business model is to invest in the bolt-on units and sell the resulting additional ethanol, sharing a portion with the mill owner (i.e. not necessarily sell the equipment). Eco plans to be flexible in its negotiations with the mill owners, as some may want to partner and others just share in the offtake and some purchase the equipment. The model conservatively focuses on local market sales of ethanol.

- Two Bolt-On's module sizes
  - Large bolt-on modules have capacity to process 50 ton/hour (1,200 ton/day) of biomass producing 38 MM

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Executive Summary

- Eco has already signed an agreement with the leading sugar-ethanol industry supplier, Simisa, to manufacture equipment in large scale when possible and provide EPC packages to be commercialized.
- Eco has already tested and proven the operationality of Edeniq's technology at its complete pilot plant in the USA using Brazilian bagasse as feedstock. The investments in Brazil have already started with the shipment of equipment for a Demonstration Plant in the State of São Paulo a totaling $3.0 MM, additional $2.5 MM is required to complete, operate which shall serve as a basis to develop the project for the commercial-size plant. After that, the business plan goes directly to the commercialization phase.
- Eco is in the process to form a solid structure in Brazil through Joint Ventures with strategically important Brazilian partners (Eco Brazil JV). Negotiations are advanced with Gávea Investimentos, and BNDES-backed investment fund where Gávea will be the equity arm and BNDES the debt (20-80%).
- Some of these partners plan to capitalize the JV before, and after the start-up of the Demonstration Plant
- Eco has retained key employees of Edeniq, Inc. and Edeniq Brazil to continue construction of demo plant.
- Eco has 70% of the necessary equipment in place to complete demo plant; an additional $1.5 MM (Year 1) to complete demo plant construction and $1.0 MM to run the plant and scale up.

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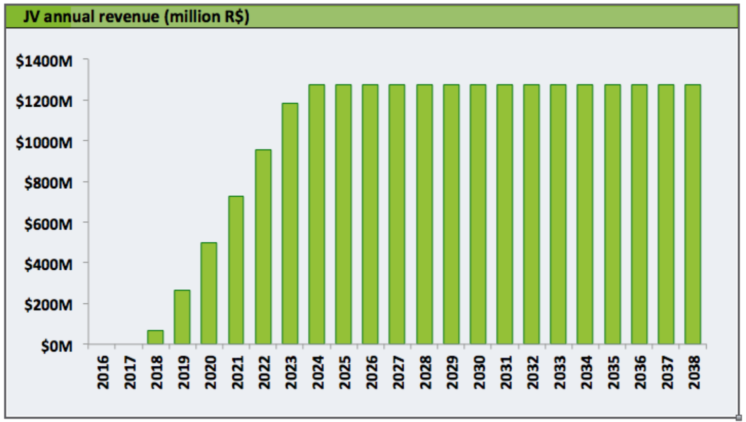
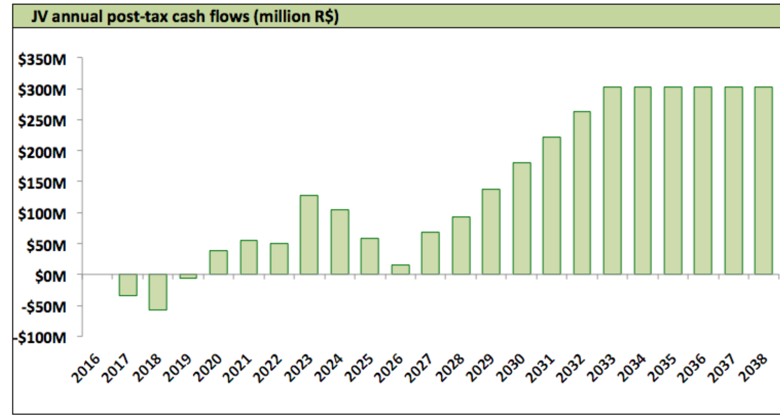
Executive Summary

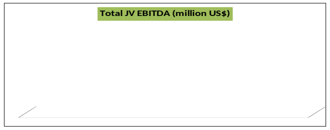
Projected investment and results table:

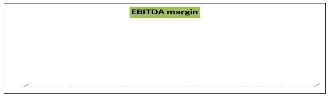




Summary (million R$)	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
New plants under construction	-	2	4	4	4	4	-	-	-	-	-
New plants online	-	2	4	4	4	4	4	-	-	-	-
Cumulative plants online	-	2	6	10	14	18	22	22	22	22	22
Cumulative capacity (MGPY or MLiters)	-	85	255	425	594	764	934	934	934	934	934
JV Revenue	-	-	R$ 68	R$ 263	R$ 500	R$ 727	R$ 955	R$ 1,182	R$ 1,273	R$ 1,273	R$ 1,273
JV EBITDA	-	(R$ 20)	R$ 11	R$ 83	R$ 175	R$ 259	R$ 344	R$ 428	R$ 468	R$ 468	R$ 468
EBITDA margin	nm	nm	16%	31%	35%	36%	36%	36%	37%	37%	37%
BNDES funding	-	R$ 134	R$ 268	R$ 268	R$ 268	R$ 268	-	-	-	-	-
Equity funding	-	R$ 34	R$ 67	R$ 67	R$ 67	R$ 67	-	-	-	-	-
Total capital outlay	-	R$ 168	R$ 335	R$ 335	R$ 335	R$ 335	-	-	-	-	-
JV cash flow	-	(R$ 35)	(R$ 57)	(R$ 7)	R$ 38	R$ 54	R$ 49	R$ 127	R$ 104	R$ 59	R$ 15
Cumulative JV cash flow	-	(R$ 35)	(R$ 92)	(R$ 99)	(R$ 60)	(R$ 6)	R$ 43	R$ 170	R$ 274	R$ 333	R$ 348

Summary (million R$)	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
New plants under construction	-	-	-	-	-	-	-	-	-	-	-	-
New plants online	-	-	-	-	-	-	-	-	-	-	-	-
Cumulative plants online	22	22	22	22	22	22	22	22	22	22	22	22
Cumulative capacity (MGPY or MLiters)	934	934	934	934	934	934	934	934	934	934	934	934
JV Revenue	R$ 1,273	R$ 1,273	R$ 1,273	R$ 1,273	R$ 1,273	R$ 1,273	R$ 1,273	R$ 1,273	R$ 1,273	R$ 1,273	R$ 1,273	R$ 1,273
JV EBITDA	R$ 469	R$ 470	R$ 470	R$ 470	R$ 470	R$ 470	R$ 470	R$ 470	R$ 470	R$ 470	R$ 470	R$ 470
EBITDA margin	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%
BNDES funding	-	-	-	-	-	-	-	-	-	-	-	-
Equity funding	-	-	-	-	-	-	-	-	-	-	-	-
Total capital outlay	-	-	-	-	-	-	-	-	-	-	-	-
JV cash flow	R$ 68	R$ 93	R$ 137	R$ 180	R$ 222	R$ 263	R$ 303	R$ 303	R$ 303	R$ 303	R$ 303	R$ 303
Cumulative JV cash flow	R$ 416	R$ 509	R$ 646	R$ 826	R$ 1,048	R$ 1,312	R$ 1,615	R$ 1,918	R$ 2,221	R$ 2,524	R$ 2,827	R$ 3,130


Total JV EBITDA (million US$)


EBITDA margin

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Technology

Unlocking the Sugar Conversion Process

Mechanical Processes	Technologies for Producing Lower Cost, High Purity Sugar	Biological Processes

Enable Biorefineries to Become
More Profitable and More Competitive

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Technology has Far-Reaching Commercial Applications

>$100B Addressable Market

Business **Up**

Continued Optimization for Existing Ethanol Plants

Scale in the U.S. and Brazil

Joint Venture Model

Sugars and Product Partnerships

Uses Edeniq Technology Platform

Cellulosic Sugars

Cellulosic Sugars

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Brazil: A Compelling Location

Well Established Ethanol Industry

- **World's 2nd Largest Ethanol Producer**
- **Ethanol is up to 75% of Fuel Use (vs. ~9% in the US)**
- **Natural Advantage in Producing Ethanol from Cane**

Supportive Environment

- Policies in Place to Stimulate the Supply of Sugar Based Biofuels & Biochemicals
- Incentives to Support Crops Dedicated to Biofuels & Biochemicals

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Brazilian Ethanol is a Successful Story

Compelling Characteristics

- Necessary Part of Fuel Stream for Refineries
- 25% Mandated Blend In Gas Sold
- Value for Octane and Oxygen
- Largest Flex-fuel Fleet E0-100%) With Over 4.5 MM Vehicles
- Healthy Demand and Supply Expansion without Subsidies

Brazil **>400 Plants**
>7 Billion Gallons

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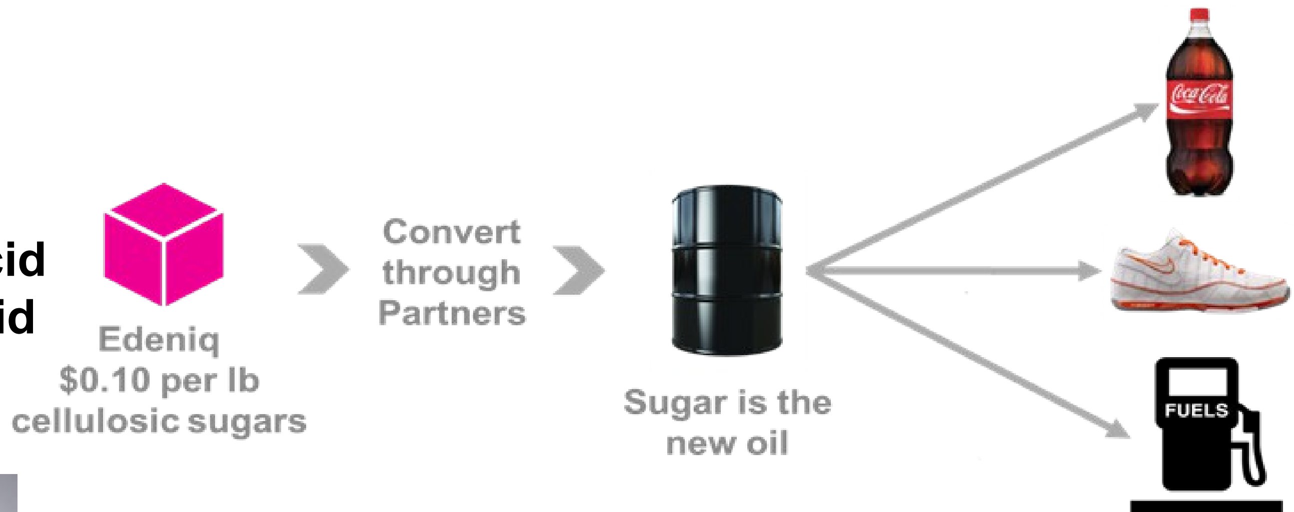
Low-Cost Sugars Expand Market

Biochemicals / Biofuels likely to achieve 10% of $1 trillion/year market

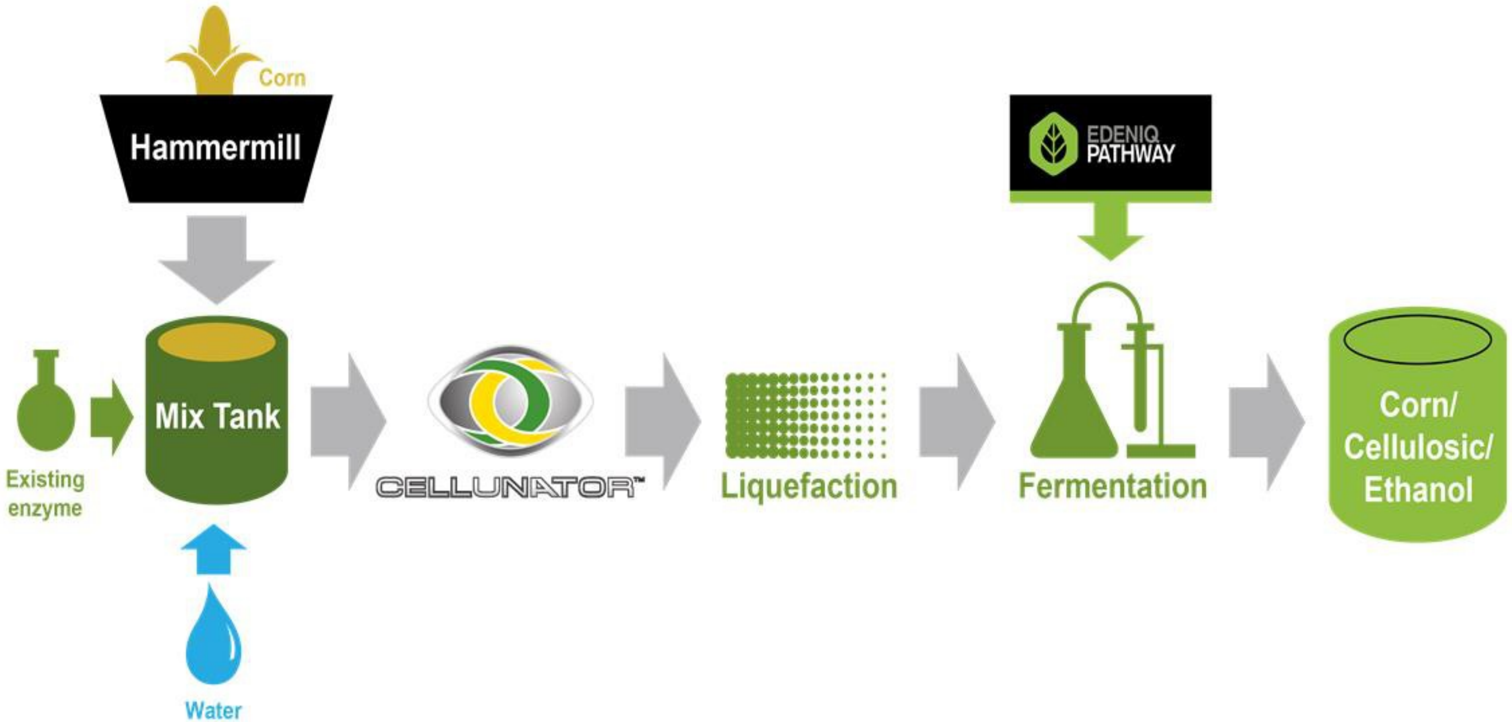
- **Expand market through maximizing C5 and C6 sugars**
- **Mechanical pretreatment delivers higher purity / lower cost**
- **Edeniq has supplied sugars to leaders for validation testing**
  - **Butanol**
  - **Aromatics**
  - **Farnesene**
  - **Acetic Acid**
  - **Lactic Acid**
  - **Levulinic Acid**
  - **Succinic Acid**
  - **Diesel**
  - **Jet Fuel**



Proven Technology Born 1st Gen Corn Ethanol

Low Capex and provides 1 - 4% boost in plant performance

Integrated platform of particle sizing & cellulase enzymes



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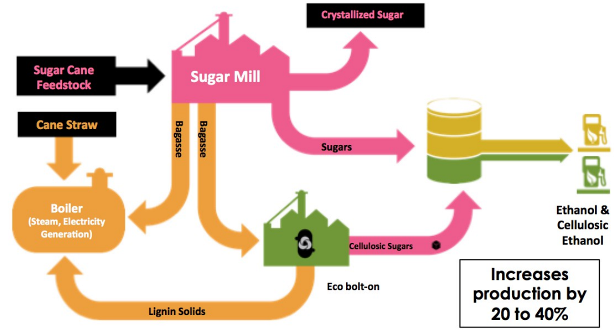
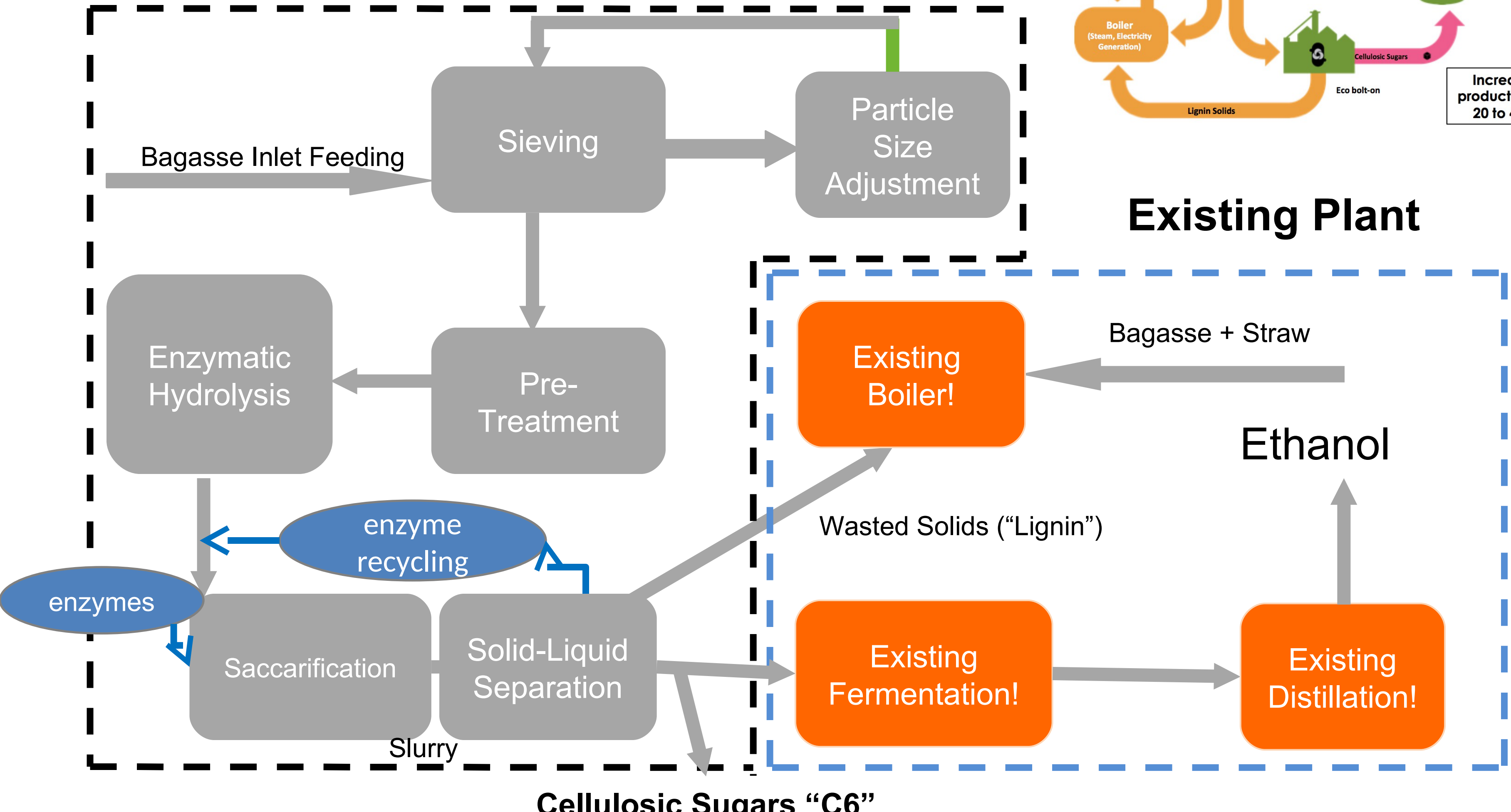
Bolt-On Technology



Bolt-on System: Uses existing infrastructure of 1G Plant



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Low Capex, Modular & Flexible process

Technology Platform

Easy Integration

Thermo-Mechanical Process

Pre-Process & Pre-Treatment

Biochemical Process

Enzymes Hydrolysis & Solid-Liquid

Existing Mills

Main Advantages

- Good Yield Sugars Conversion (no acids)
- Modular & Flexible
- Low Capex (standard equipment)
- Bolt-On System (easy integration existing mills)

Partners

Feedstock, Yeast & Enzymes

Solid-Liquid Separation

Equipment & EPC

Pilot Plant Corn Stover & Bagasse

Engineering & process

Enzymes Filtration Technology

Automation

Biomass cleaning and grinding

Agitation & Homogenization Technology

Yeast, Enzymes & Additives

Sieving technology

Engineering

Logistics

Equipment Manufacturer

Equipment Manufacturing

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Usina Vale

Technology of Cellulosic Sugars in Brazil

Demo Plant in Brazil allows a fast scale-up

- 190,000 L / year Pilot Plant in Visalia, CA
- -$ 25 M investment - DOE and California
- -Flex Plant - diversity of biomass

320,000 L / year Demo Plant in Brazil
-Investment in partnership with Usina Vale
-LOIs signed for 6 commercial plants

Agreement with Usina Vale

- Plant 20 tons/day of bagasse to produce cellulosic sugars & EtOH 2G.
- Located at Usina Vale- São Paulo State.
- Agreement includes plans for a commercial unit thereafter installation and operation of the demo plant.

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Technological Capabilities

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Laboratory




Fermentation





Chromatography

Microbiology

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Machine Shop












<u>Boiler Shop</u>:
- Guilhotine
- Folding
- Radial drilling machine
- Lathe
- Calender

<u>Machining</u>:
- Boring
- Lathe 8-10 meters
- Table lathe
- Welding
- Overhead travelling crane 10 tons

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Manufacturing Solutions

- Reception and Cane preparation

- Extraction of Broth (Crusher or Diffuser)

- Evaporation and treatment of broth

- Sugar factories

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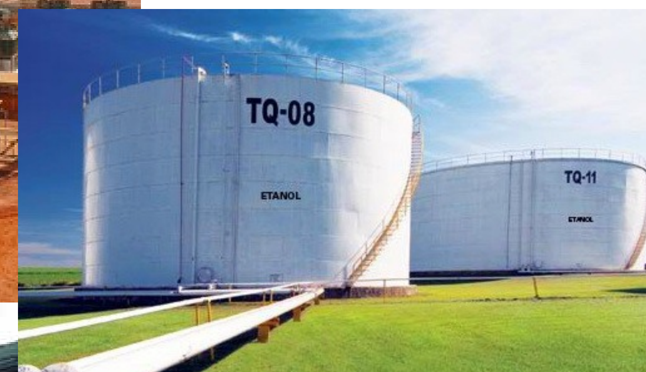
Manufacturing Solutions

- Fermentation
- Distillation and Dehydration
- Storage Tanks
- Boilers and Pressure Vessels
- Pipes and Interconnections



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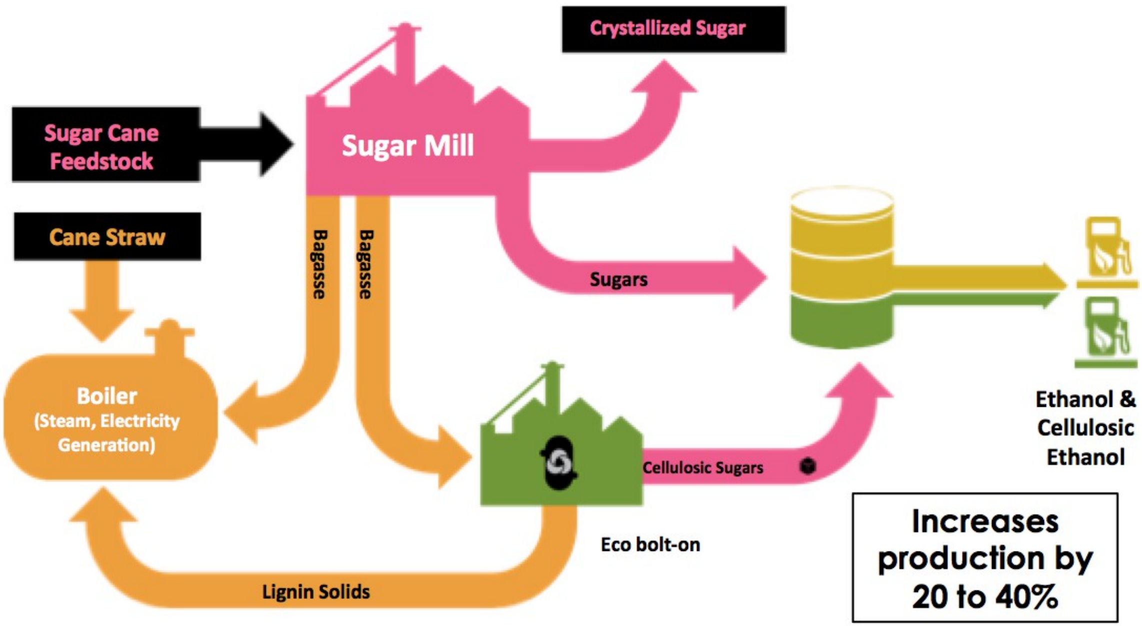
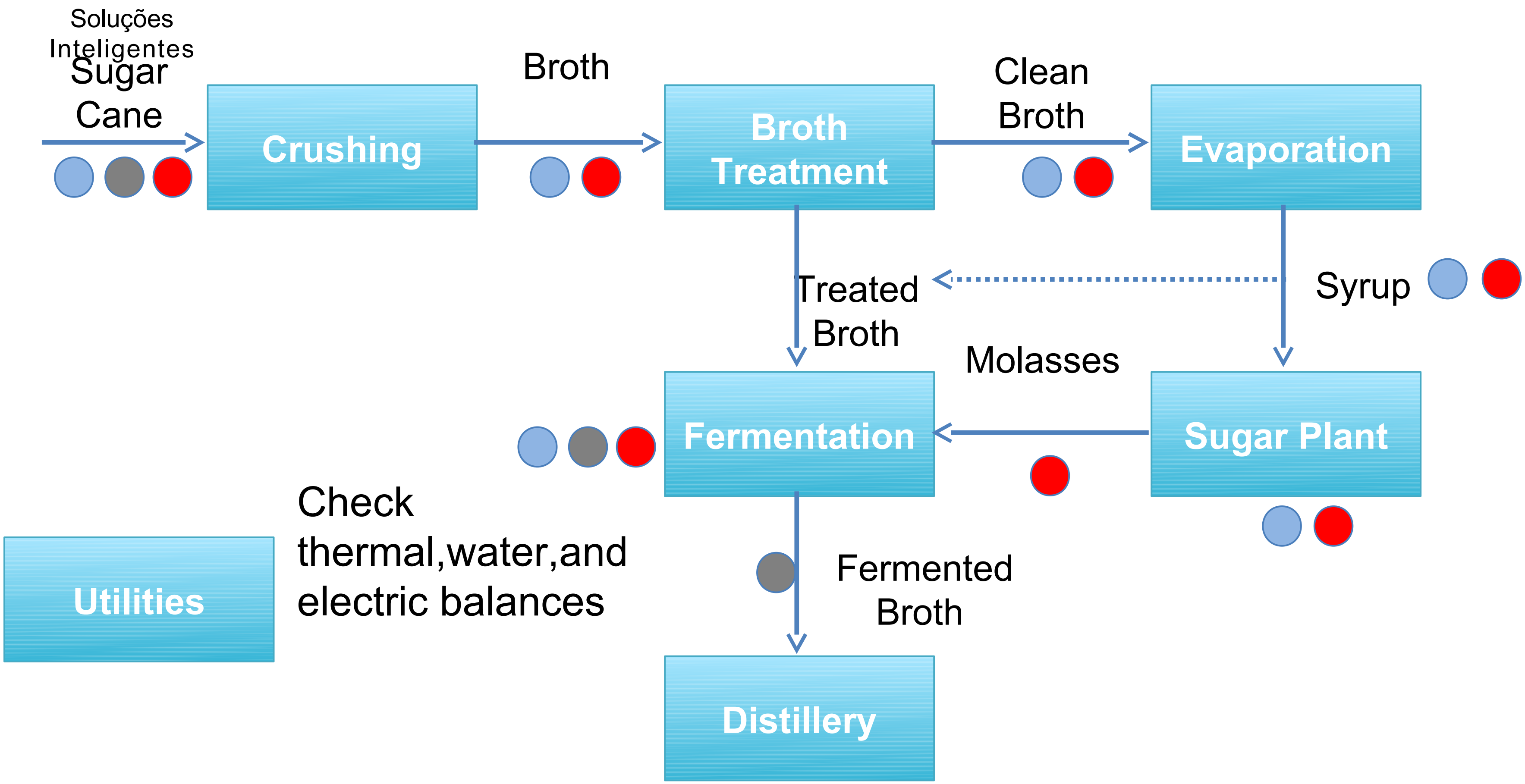
Sugar Mill Retrofit



Retrofit Steps

1. Monitor losses of Etoh 1G plant
2. Check thermal,water,and electric balances
3. Check biomass consumption vs. thermoelectric efficiency
4. Measure sugars: sucrose (glucose and fructose); total sugars throughout the process
5. Measure ethanol, methanol, glycerol, and vinasse
6. Measure acids: succinic, lactic, and acetic
7. Monitor via Statistical process control (SPC) process parameters
8. Analyze data and implement necessary measures to bring process into control
9. Engineering design
10. Procure equipment
11. Construction and commissioning
12. Training

Monitoring losses of Etoh 1G plant



HPLC Results

- Measure sugars: sucrose (glucose and fructose); total sugars
- Measure ethanol, methanol, glycerol, and vinasse
- Measure acids: succinic, lactic, and acetic

Monitoring losses of Etoh 1G plant

MC Rapid Diagnostic Kit. Uses chromogenic technology measured by fixed plating's offers fast bacterial contamination response in the fermentation process, allowing quick decision making.

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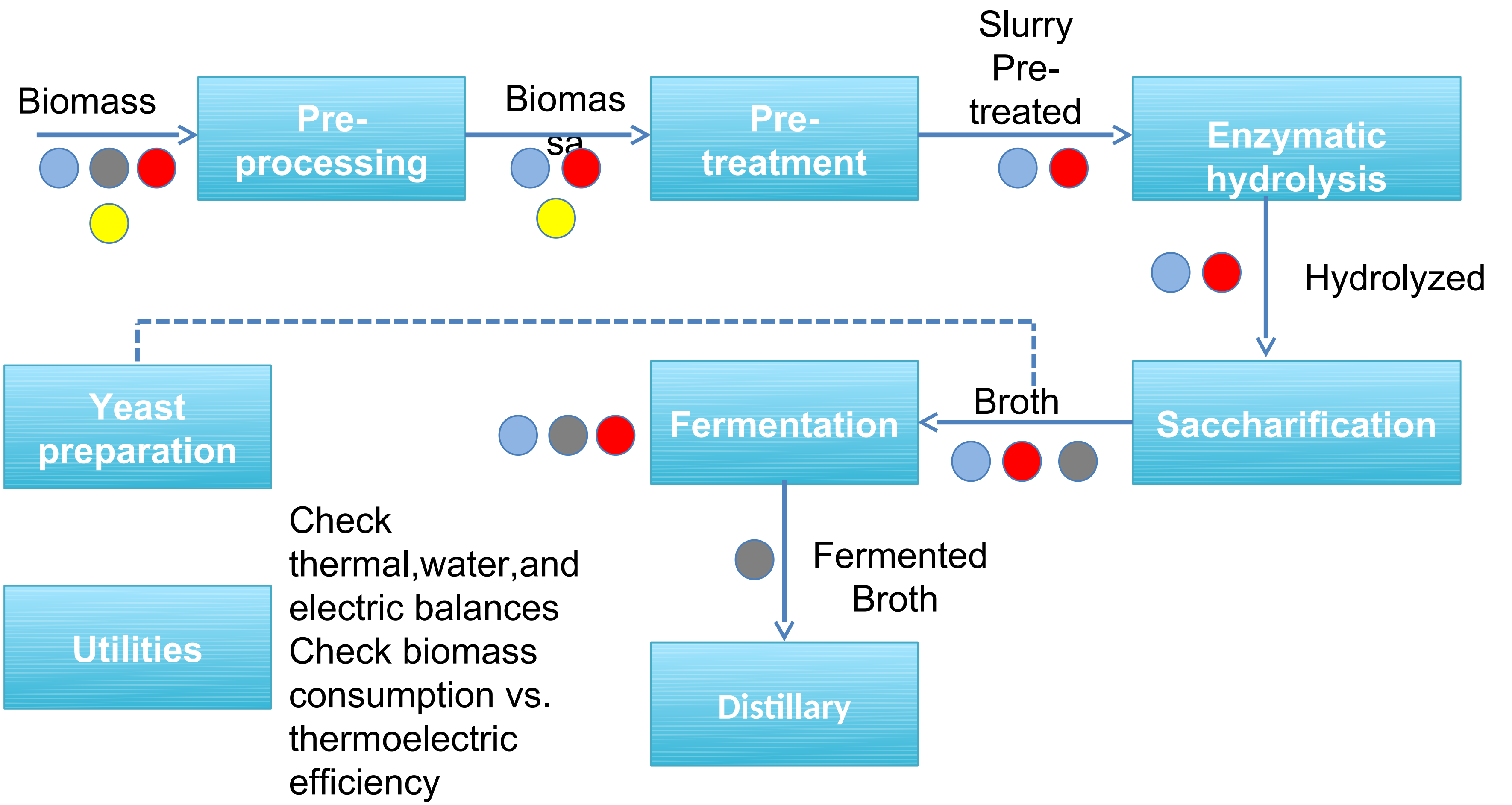
Monitoring losses of Etoh 2G plant

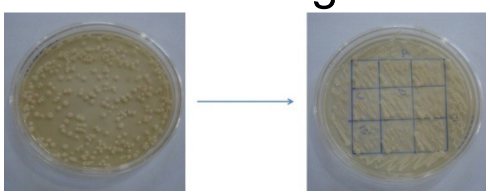


- (blue) Measure sugars: cellulose ("Glucose"), hemicellulose (xylose, arabinose, etc.)
- (grey) Measure ethanol, methanol, glycerol, and vinasse
- (red) Measure acids: succinic, lactic, acetic, and furfural
- (yellow) Measure Impurities vegetables, minerals (earth, silica, ash, etc.)

Yeast Optimization

- Yeast optimization using DNA analysis
  - Quantitative analyses of yeast strains
  - Best yeast strains identified for future utilization

Plating



Yeast Pellet DNA

Electrophoresis

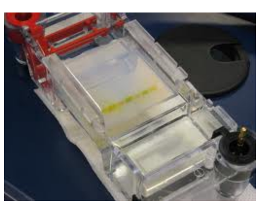
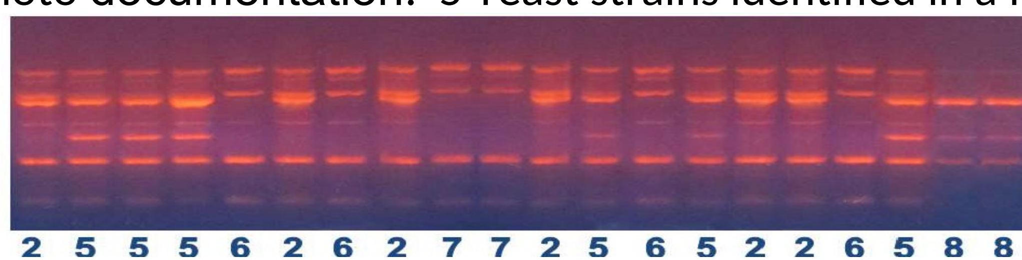


Photo documentation: 5 Yeast strains identified in a fermenter



Brazil Services:

Process Optimization

1. **Process Diagnosis**: Identify and mapping the plant bottlenecks and propose solutions

   Deliverables:

   - Mass Balance, steam, energy and water
   - Report of technical recommendations

2. **Industrial Planning for Season**: Study of industrial processing for next season

   Deliverables:

   - Simulation scenarios and balances month to month
   - Report of technical recommendations
   - Worksheet with needed investments based on technical recommendations

3. **Master plan for capacity expansions**:

   Deliverables:

   - Simulation of scenarios to expand capacity (Feasibility Study)
   - Report and presentation of the master plan
   - Worksheet of total investment (estimated cost)

· 4 . Plant Savings

Plant A

Fermenters: ~3.9 MLY EtOH

Vinassse: ~0.2 MLY EtOH

~ 4 million R$/year

Plant B

Fermenters: ~1.74 MLY EtOH

Vinassse: ~0.2 MLY EtOH

~ 2 million R$/year

Plant C

Fermenters: ~1.44 MLY EtOH

Vinassse: ~0.1 MLY EtOH

~ 1.5 million R$/year

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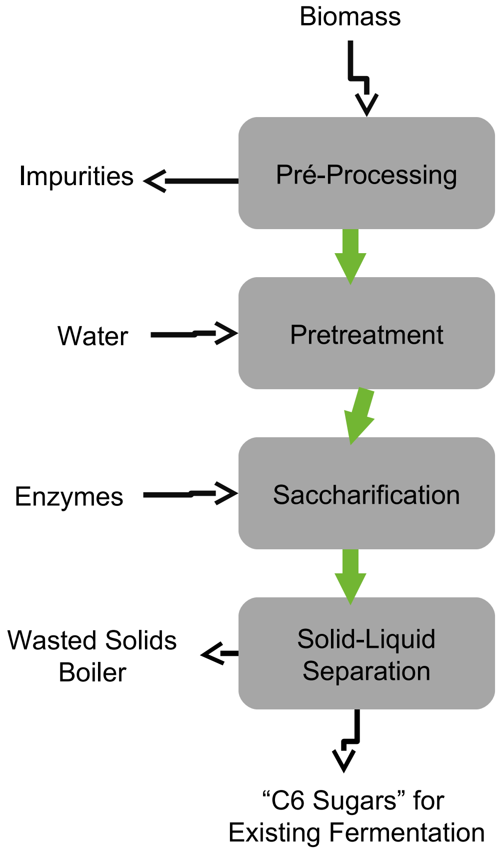
Technology Development

~$100MM US of process development

- Pre-treatment thermo-mechanical to avoid the high cost of chemicals (acids and others) producing high quality fermentable sugars.
- Exclusivity of continuous reactor, a continuous saccharification process, separation and recycle system enzyme and enzyme technology.
- Easy integration with existing power plants - "Bolt-On"
- Partnerships (with suppliers of equipment, enzyme suppliers) – development of the process with application equipment and commercial enzymes.
- Systemic Scale-up: flexible and modular to reduce the risk of scaling.



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Technology Development

Operational Units

Pre-Processing: Sieving & Particle Size Reduction:

Sieving to remove biomass impurities (ash, silica and sand) and Crusher to reduce the particle size. It is essential to have cleaning biomass to avoid the waste of equipment and sanitary conditions for the plant. Also, it is necessary to adjust the particle size to increase the contact surface for enzymes reaction.

Pre-Treatment:

Essentially continuous, with two alternatives depending on the plant and biomass characteristics

Batch on a continuous operation (Sugarcane Bagasse & Straw)

Brazilian equipment operating in batch cycle. 35 years running with bagasse in Brazil.

This is a reactor which promotes the steam explosion in biomass through application of pressure and cooking time. A composition batch equipment in parallel allows to operate in a continuous way. (similar of Batch Vacuum in sugar Factories). High pressure and temperature promotes the increase of % glucan availability.

Fully Continuous (Corn Stover)

Hydration biomass under conditions of temperature and pressure to create a slurry via disperser MHD developed with IKA;

Colloidal mill biomass with Cellunator developed with IKA; Opening of the pulp fibers and homogenization of the particles

Continuous reactor from the high pressure and temperature application allows the cooking of slurry. (Continuous steam explosion) to maximize glucan availability.

Enzymes Hydrolysis & Saccharification

There is a reactor project property to add enzymes and provide residence time for enzymatic hydrolysis; process has features to reduce the residence time and increase the efficiency of enzyme additives property.

Solid/Liquid Separation (Including Smart Flow Membranes)

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Demo Plant

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Demo Plant (Layout)

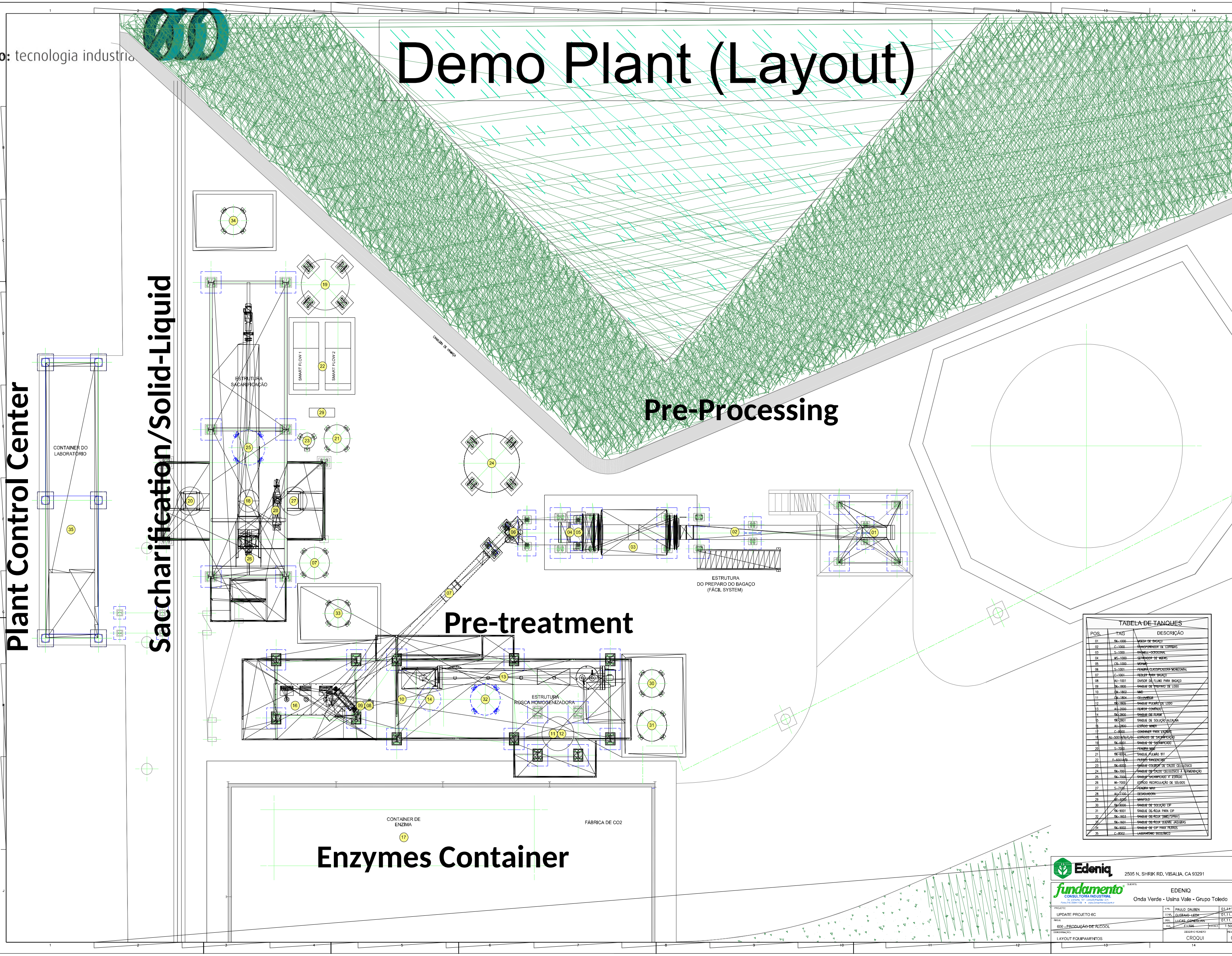

TABELA DE TANQUES

POS.	TAG	DESCRIÇÃO
01	TK-1000	MOEGA DE BAGAÇO
02	C-1000	TRANSPORTADOR DE CORREIAS
03	S-1000	TROMELL-OCTOGONAL
04	MS-1000	SEPARADOR DE METAIS
05	CR-1000	MOINHO
06	S-1001	PENEIRA CLASSIFICADORA HORIZONTAL
07	C-1001	REDLER PARA BAGAÇO
08	AU-1001	DIVISOR DE FLUXO PARA BAGAÇO
09	TK-1800	TANQUE DE PREPARO DE LODO
10	CM-1802	MMD
11	CM-1804	CELUNATOR
12	TK-1805	TANQUE PULMÃO DE LODO
13	AU-2000	REATOR CONTÍNUO
14	TK-2800	TANQUE DE FLASH
15	TK-2801	TANQUE DE SOLUÇÃO ALCALINA
16	AU-2800	ESTÁGIO MIXER
17	C-8000	CONTAINER PARA ENZIMAS
18	AU-5001A/B/C/D	ESTÁGIOS DE SACARIFICAÇÃO
19	TK-6001	TANQUE DE SACARIFICADO
20	S-7000	PENEIRA MAVI
21	TK-6004	TANQUE PULMÃO TFF
22	F-6001A/B	FILTROS TANGENCIAIS
23	TK-6003	TANQUE COLETOR DE CALDO CELULÓSICO
24	TK-7001	TANQUE DE CALDO CELULÓSICO À FERMENTAÇÃO
25	TK-7000	TANQUE SACARIFICADO 4° ESTÁGIO
26	MI-7000	ESTÁGIO RECIRCULAÇÃO DE SÓLIDOS
27	S-7100	PENEIRA MAVI
28	AU-7100	DESAGUADORA
29	MF-6000	MANIFOLD
30	TK-9000	TANQUE DE SOLUÇÃO CIP
31	TK-9001	TANQUE DE ÁGUA PARA CIP
32	TK-1603	TANQUE DE ÁGUA (MMD/SPRAY)
33	TK-1601	TANQUE DE ÁGUA QUENTE JAQUETAS
34	TK-9002	TANQUE DE CIP PARA FILTROS
35	C-8002	LABORATÓRIO BIOQUÍMICO

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Technology Development

Mass Balance

#	Fluid/Material	Description	Mass Flow	Volume Flow	Temp.	Pressure	Solids Level	Specific Gravity	Viscosity
			kg/hr	m3/hr	C	Barg	%	m3/hr	cP
a	Bagasse	Hopper TK-1000	1360	5.44	25	1	53	250	-
b	Bagasse	Raw bagasse in C-1000	1360	5.44	25	1	53	250	-
c	Bagasse	After Tromell S-1000	1088	4.35	25	1	53	250	-
d	Bagasse	After Crusher C-1000	1074	4.30	25	1	53	250	-
e	Bagasse	Bagasse after S-1001	1006	4.03	25	1	53	250	-
a*	Bagasse	Bagasse inlet R-1900	2700	10.80	25	1	53	250	-
b*	Pre-treated bagasse	Bagasse after R-1900	675	9.00	180-220	1	55-60	75	-
c*	Pre-treated bagasse	Bagasse for demo plant	1350	18.00	50	1	55-60	75	-
01	Bagasse	Thur Fossel System	833	3.33	25	1	47	250	-
02	Bagasse Slurry	Thur MK Line-up to AU-2000	2800	2.95	25	1 to 18	15	950	2000 - 5000
03	Bagasse Slurry	From AU-2000 To TK-2800	4200	4.42	210 to 100	18 to 1	10	950	2000 - 5000
06	Bagasse Slurry	To AU-2800	4100	4.32	50	1	10	950	2000 - 5000
07	Bagasse Slurry	To Sacc Augers AU-5001	4100	4.32	50	1	10	950	2000 - 5000
08	Bagasse Slurry	Sacc Auger Flow	32800	34.53	50	1	15	950	2000 - 5000
09	Bagasse Slurry	Recyle Solids	27470	28.92	50	-	15	950	2000 - 5000
10	Bagasse Slurry	Purge Solids	410	0.43	50	-	40	950	2000 - 5000
11	Liquor	Liquor Drain - To TK-6001	4920	4.69	50	-	12	1050	500
12a	Liquor	Recyle Liquor	22000	20.95	50	-	12	1050	500
12b	Liquor	Recyle Liquor	1230	1.17	50	-	12	1050	500
12c	Liquor	Recyle Liquor	6000	5.71	50	-	12	1050	500
13a	TFF Loop	Filtered Liquor (P-6002A/B)	0	0.00	50	-	15	1050	500
13b	Sugar Solution	Product out	3690	3.51	50	-	8	1050	500
W01	Plant Water	From Mill thru P-1602	10000	10.00	30	-	-	1000	1
W02	Plant Water	To AU-2800 Jacket	3000	3.00	30	-	-	1000	1
W03	Plant Water	Thru P-1603	5000	5.00	30	-	-	1000	1
W04	Plant Water	To AU-2800 Spray Cool	3000	3.00	30	-	-	1000	1
W05	Heated Water	Thru H-1400	4000	4.00	90	-	-	1000	1
W06	Heated Water	To TK-1800/CM-1802	2000	2.00	90	-	-	1000	1
W07	Heated Water	To AU-2800	2000	2.00	90	-	-	1000	1
W08	Jacket Water	Thur P-1601	40000	40.00	70	-	-	1000	1
W09	Drain Water	To Mill Cooling Pond	3000	3.00	70	-	-	1000	1
S1	Steam - 21 Barg	Caldema Feed	8000	1111.11	300	18	-	7.2	0.02
S1*	Steam - 21 Barg	Caldema Feed	4050	562.50	300	18	-	7.2	0.02
S2	Steam - 21 Barg	Demo Plant Feed	2700	357.14	300	21	-	8.4	0.02
S3	Steam - 21 Barg	To AU-2000	3000	333.33	300	15	-	6	0.02
S4	Steam - 4 Barg	To TK-1601	2000	312.50	300	4	-	1.6	0.02
S4	Steam - 4 Barg	To H-1600	500	312.50	300	4	-	1.6	0.02
			500						
B1	pH Buffer - NaOH 50%	To TK-2800 or AU-2800		0.013	30	-	47	1500	2
			19.6						
EZ1	Enzyme Solution	Recirc Pump		0.090	30	-	10	1050	100
EZ1	Enzyme Solution	To AU-2800	94.0	0.030	30	-	10	1050	100
EZ2	Enzyme Solution	To AU-6001	31.3	0.030	30	-	10	1050	100
			31.3						

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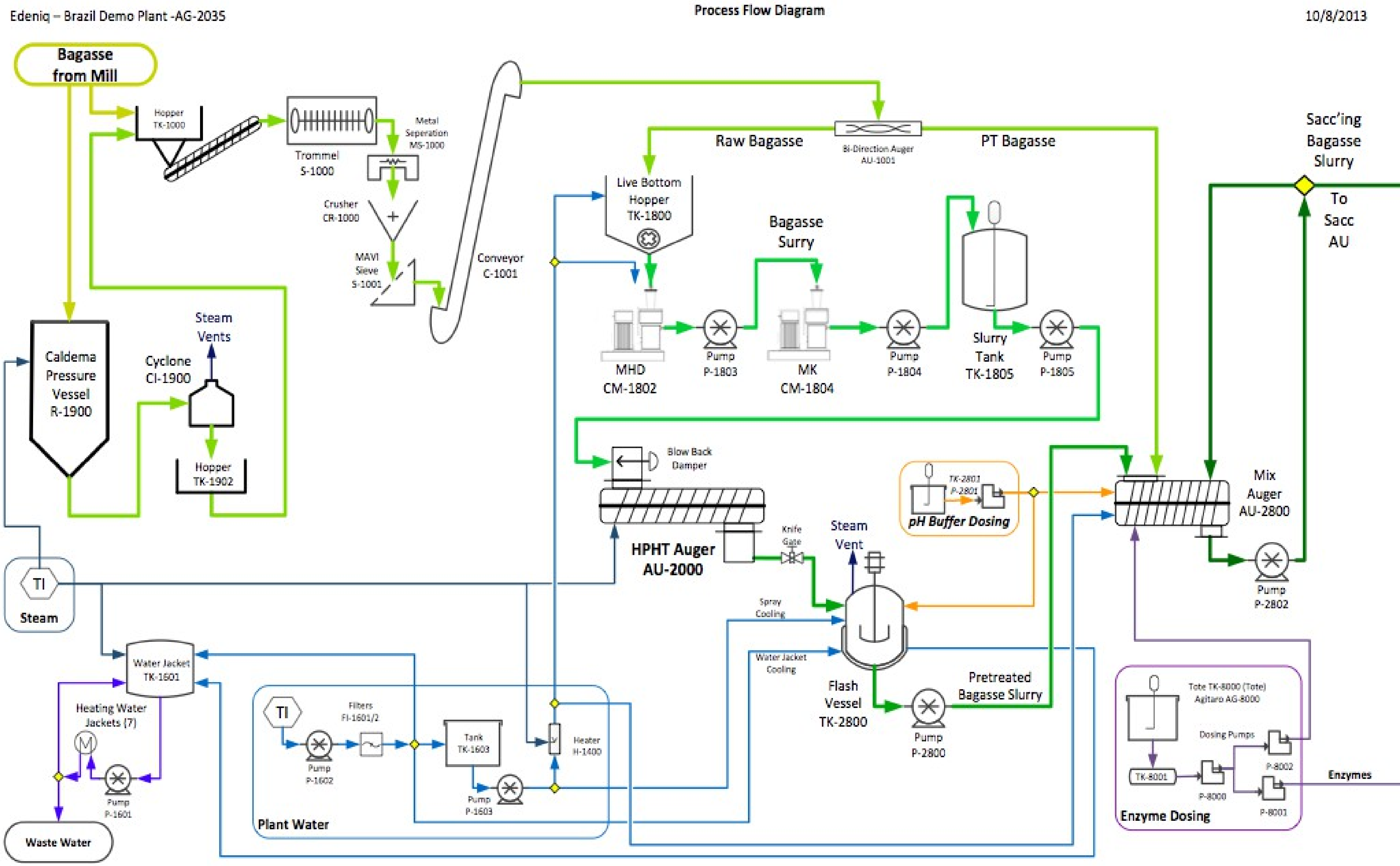
Process Flow Diagram



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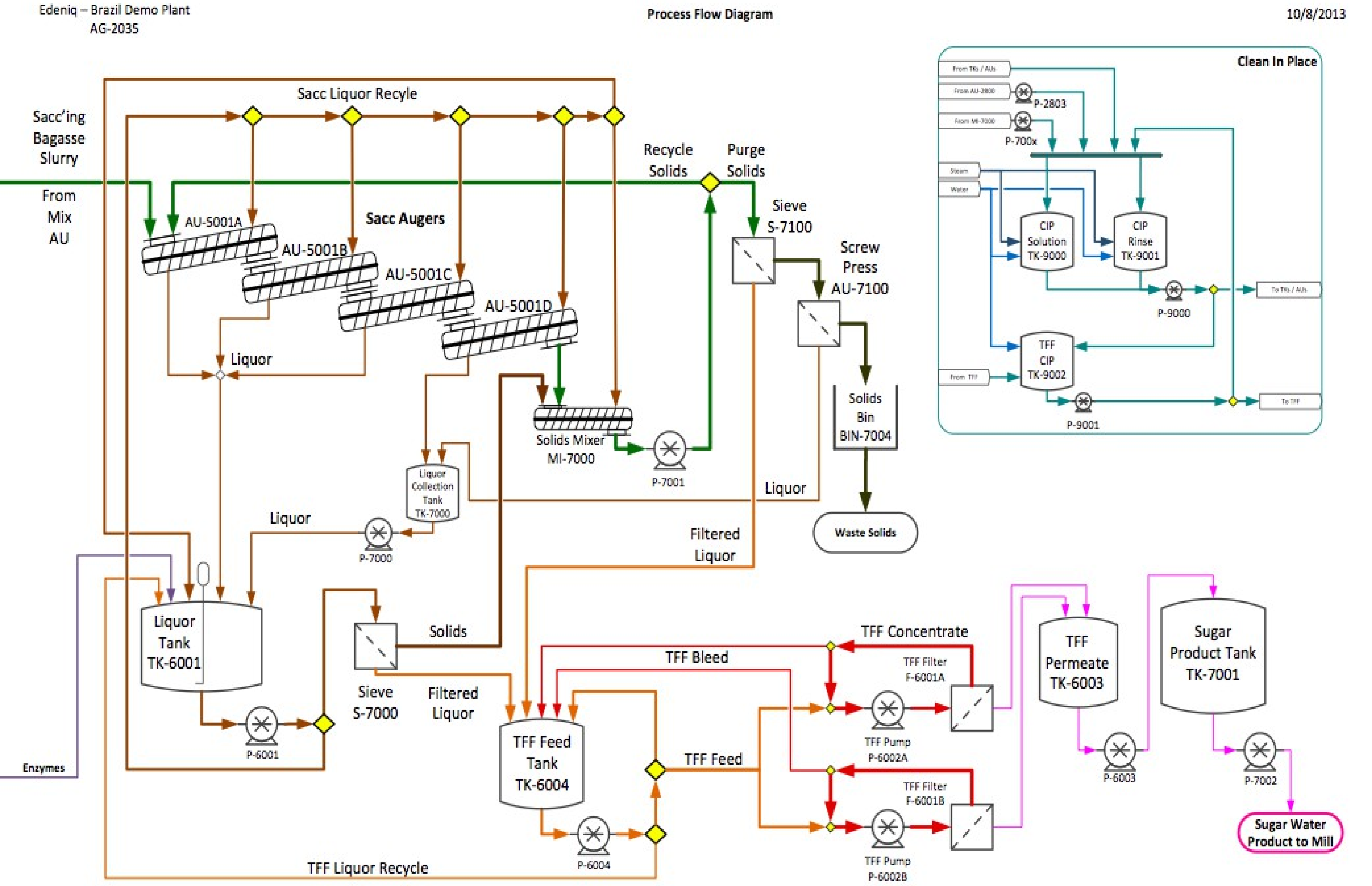
Process Flow Diagram



Pre-Processing

Bagasse "natural"

Bagasse Sieved & Crushed

Impurities

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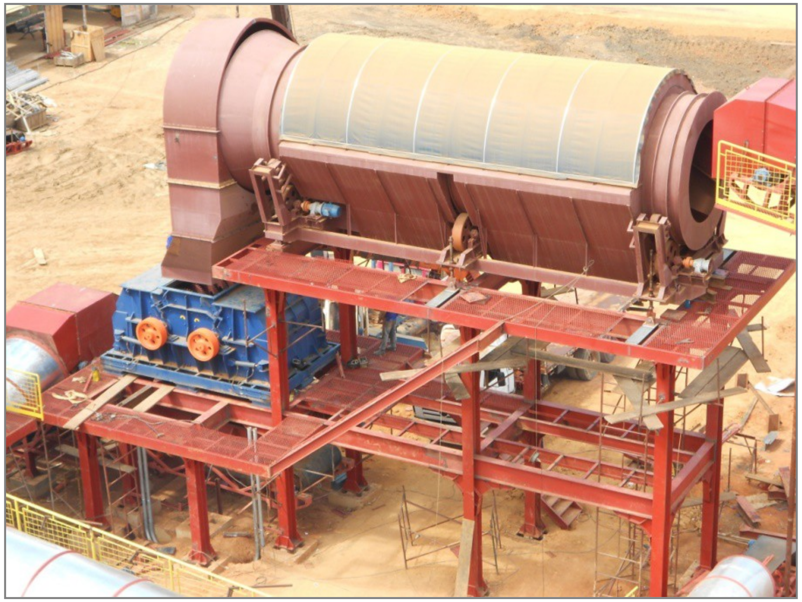
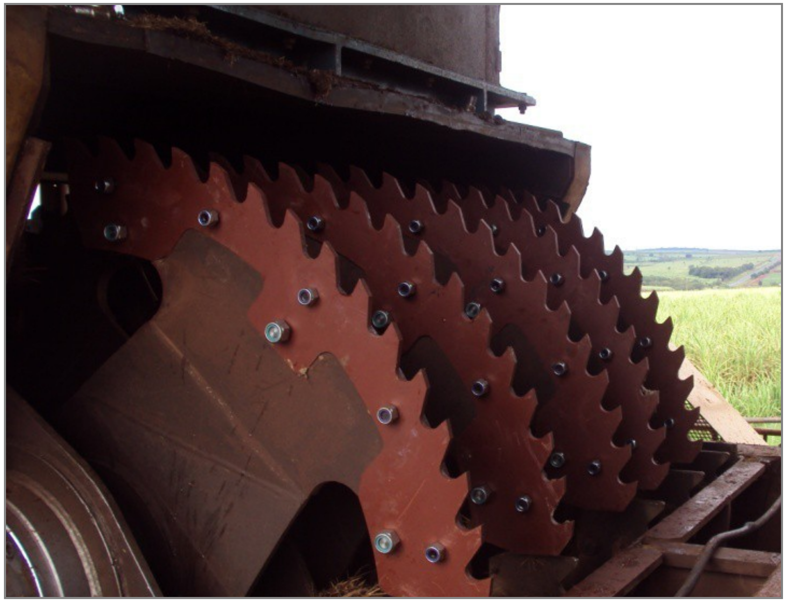
Pre-Processing

- Separation of mineral impurities (cleaning).
- Particle size reduction promoting the enzymatic reaction.
- Flexible sy

Pre-Processing

- Trumell & Crusher in Commercial Scale





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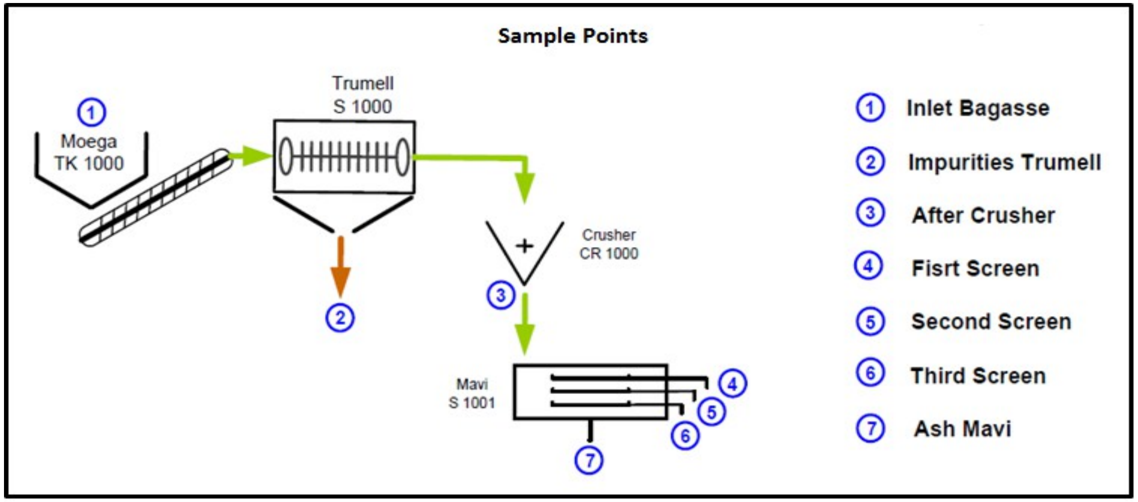
Pre-Processing

Key Assumptions		
Capacity	1,200	kg/h
Moisture	53%	
Fiber	47%	
Impurities	3%	
Trumell losses	20%	
Cleaning efficiency	63%	
Mavi 1st screen	66%	
>850uM	49%	
<=850uM	51%	
Mavi 2nd screen	21%	
>850uM	5%	
<=850uM	95%	
Mavi 3rd screen	12%	
>850uM	2%	
<=850uM	98%	
Ash Mavi	1%	



#Point	Flow(kg/h)	Impurities	% Mass	PSD			
				>850uM		<=850UM	
				kg/h	%Mass	kg/h	%Mass
1	1,200	2.8%	100%				
2	235.2	1.8%	20%				
3	965	1.0%	80%				
4	633.9	1.0%	66%	309.3	49%	324.5	51.2%
5	206.5	1.0%	21%	10.3	5%	196.1	95.0%
6	117.7	1.0%	12%	2.7	2%	115.0	97.7%
7	5.8	1.0%	1%	**322.4**	**33.4%**	**635.7**	**65.9%**

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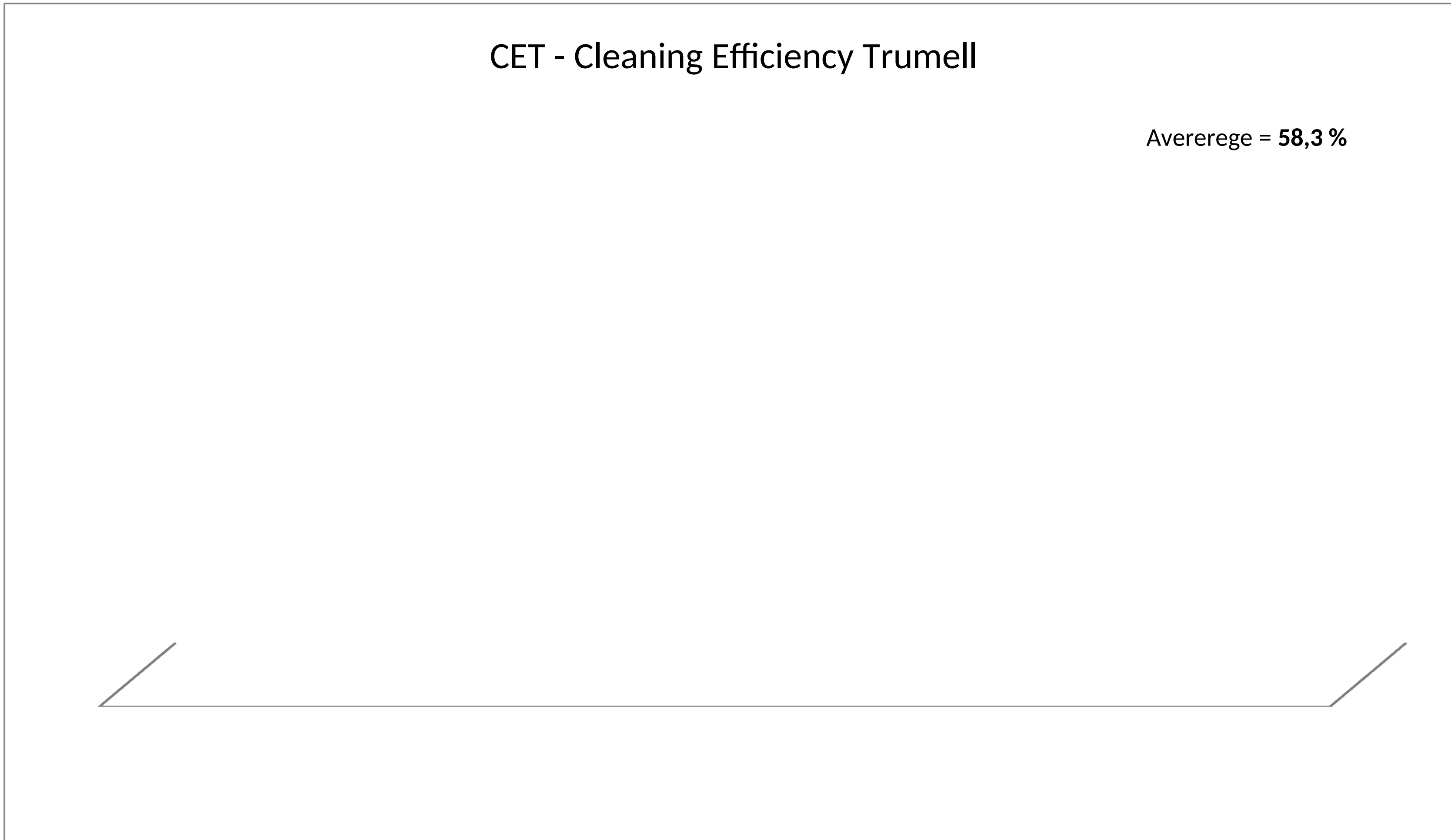
Pre-Processing



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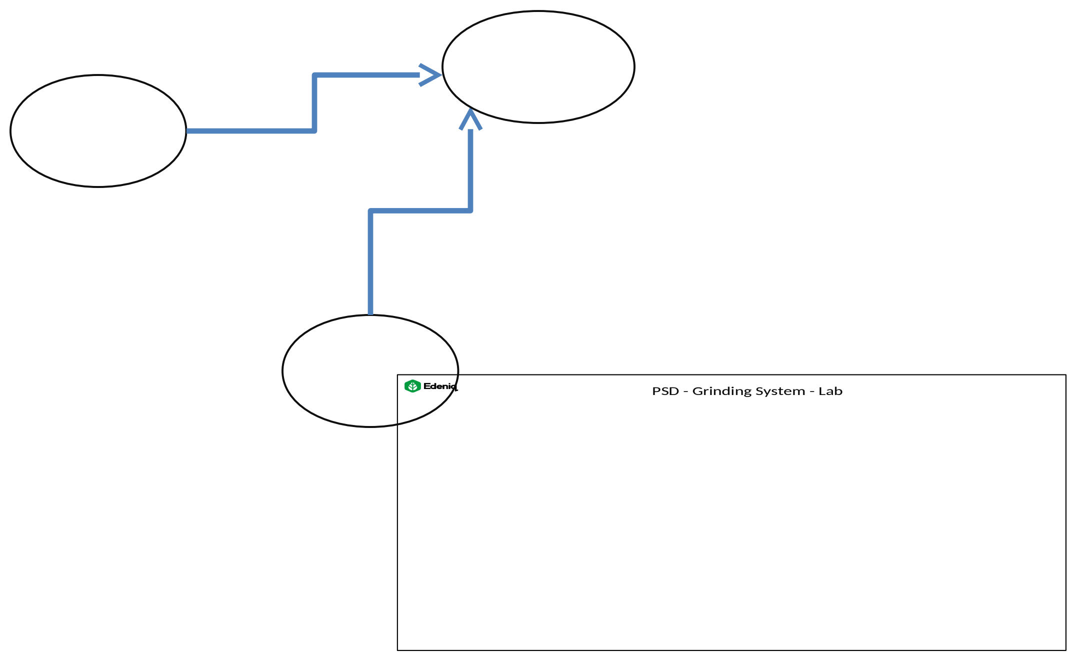
- Pre-Processing



Pre-Processing

- The cleaning efficiency is 58.3%, but if moisture% bagasse increases this number will be higher. This mean that less mineral impurities and ash in demonstration plants. Calculating the amount of impurities in days and extend almost 30 times means a gain of 1 hour of operation.
- After the mill, 65.9% (average of all runs) of the particle are <= 850uM, very close to the 66% target project. Improved after Run # 7, because it changed the mill grid size to # 6 mm. If considerer a range between the Tests 7 and 12, increases in average 82.8%. Still, we are being conservative assuming 65.9% in the mass balance.
- We must not confuse particle size reduction with uniform particle size. The target is easy to operate as preprocessing to reduce the particle size of aiding the step of pre-treatment.

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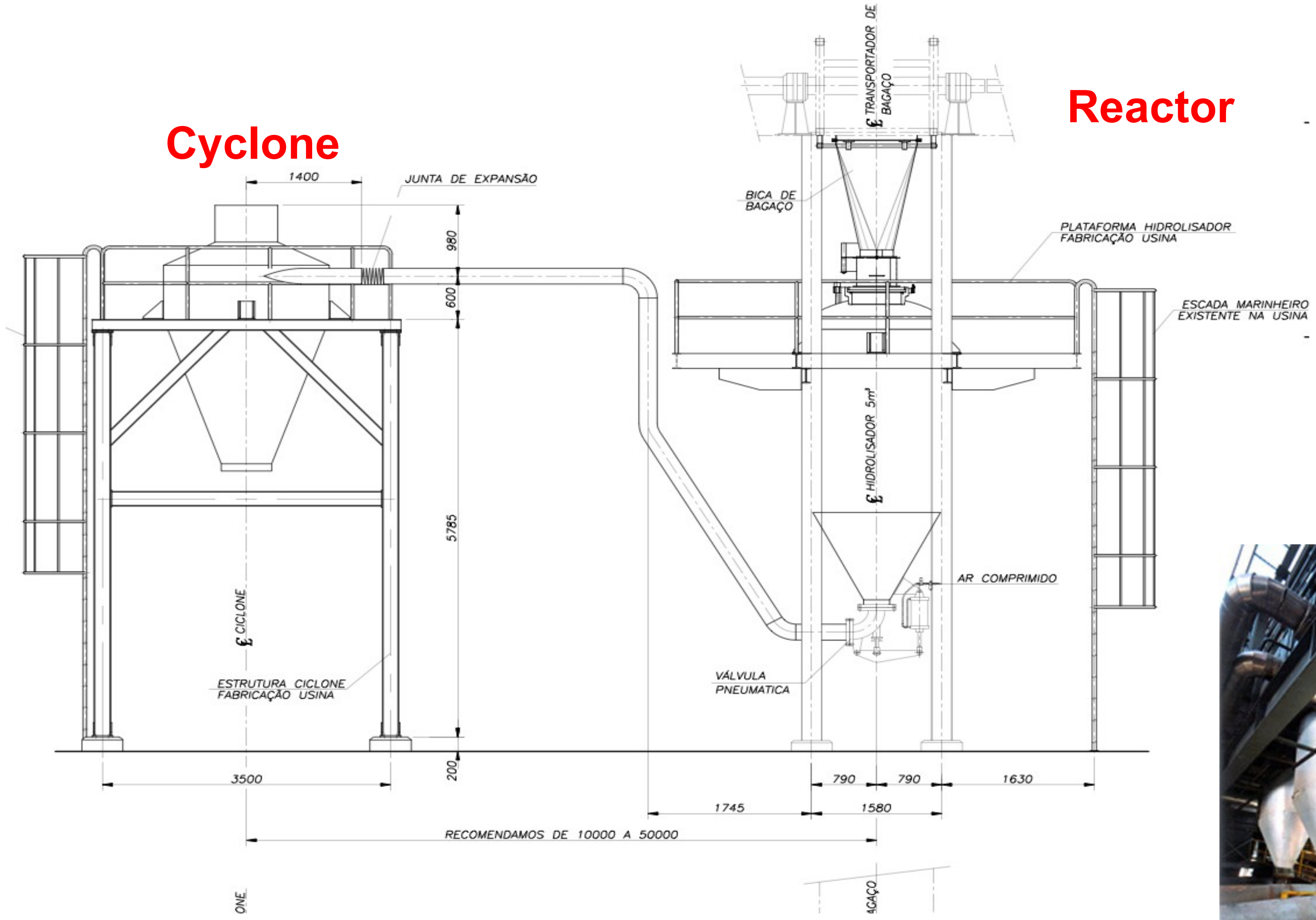
Pre-treatment

- Caldema is a company of Boilers and Pressure Vessels in Brazil. They are very knowledgeable in sugarcane and other markets. It is considered a big company.
- Caldema Pre-Treatment System is a batch system have being used in Brazil for 30 years. It is a steam explosion system similar then Batch CCM. Caldema's main application is preparing bagasse to feed cows and oxes.
- In this steam explosion it is possible to separate fibers and sugars as other current pre-treatment. In a Reactor the bagasse is cooking applying pressure and temperature with steam in a cycle time. The material is discharged in a shot for a Cyclone where it is cooled ~25oC. The fresh bagasse feeds Caldema with moisture 50-58% and output 60-65%.
- The pressure can vary between 10-20barg, generally operates 17barg. The cycle time can vary between 5-20 minutes. The best results of Eco process were ~62% in C6 conversion (18barg;16minutes).Operation tests were done in Usina Estiva in Brazil and Lab tests were done in Visalia.
- Caldema has low capital cost compared other systems. Eco is including a Caldema unit existing in Usina Vale to test in Demo plant. The goals are test Caldema working with Continuous Pre-Treatment and Facil System to evaluate the targets for Scale-Up.
- Caldema can work in continuous operation, but it would be like a cookers used in sugars factory in Brazil. It needs some equipment in parallel.

Pre-Treatment



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- # Pre-Treatment

Bagasse “natural”

P>=18barg

5min	10 min	16 min

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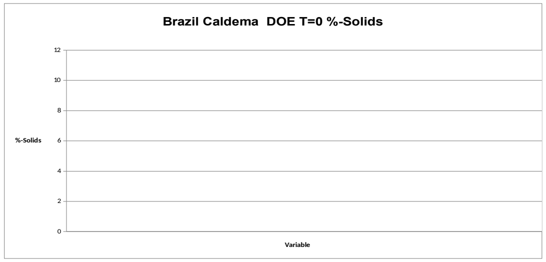
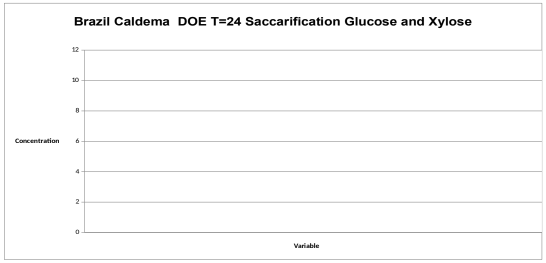
Brazil Caldema DOE

%-Solids of Samples



Brazil Caldema DOE

Glucose and Xylose at T=24 Saccharification



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Brazil Caldema DOE

C6 & C5 Conversion at T=24 Saccharification

Brazil Caldema DOE T=24 Saccarification C6 and C5 Conversion

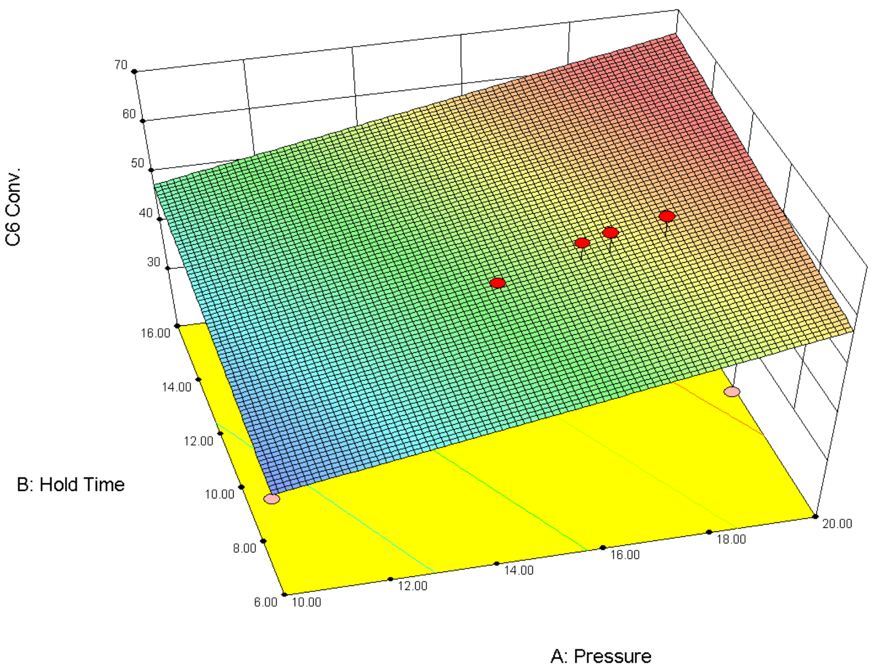
Brazil Caldema DOE

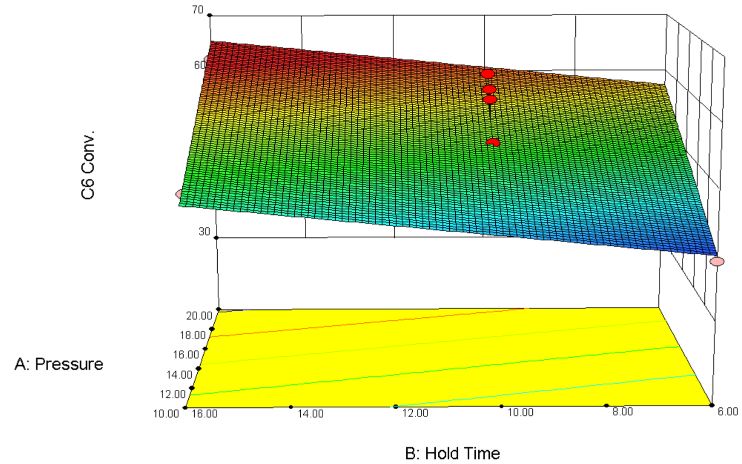
Furfural and 5-HMF at T=0 Saccharification

Brazil Caldema DOE T=0 Furfural and 5-HMF

Brazil Caldema DOE

Design Expert





Brazil Caldema DOE

Summary Points

- Highest C6 Conversion (C5)
  - 62.26 (17.79) – 16min at 20 Bar [212˚C] (Test #1)
  - 61.18 (35.21) – 10min at 18 Bar [206˚C] (Test #4)
  - 59.36 (42.45) – 10min at 17+ Bar [203˚C] (Test #5)
- Highest C5 Conversion (C6)
  - 57.63 (48.60) – 16min at 11+ Bar [184˚C] (Test #7)
  - 54.17 (48.39) – 6min at 18 Bar [206˚C] (Test #2)
  - 54.11 (52.24) – 10min at 15 Bar [198˚C] (Test #3)

Saccharification & Solid-Liquid Separation

- The continuous Saccharification & Solid-liquid separation is a mirror of the work in the pilot plant of California, logically to process improvements suggested by Brazil team.
- The difference in the disposition of Augers vertical structure, recycles at strategic points and optimizations of residences times are significant contributions that affected much of the C6 sugars conversion efficiency.
- In tests with bagasse, it was possible to obtain a maximum conversion of 81.4% C6% in 48 hours and 70.4% at 24 hours. The enzyme additives developed and improvements mentioned were responsible for this result, which can be improved with the advent of continuous pretreatment.
- By stoichiometric reaction conversion in% C6 or hexoses expected yield is 85-90 liters of ethanol per ton of bagasse at 50% moisture. It is the same Yield of sugarcane 1G Plant.

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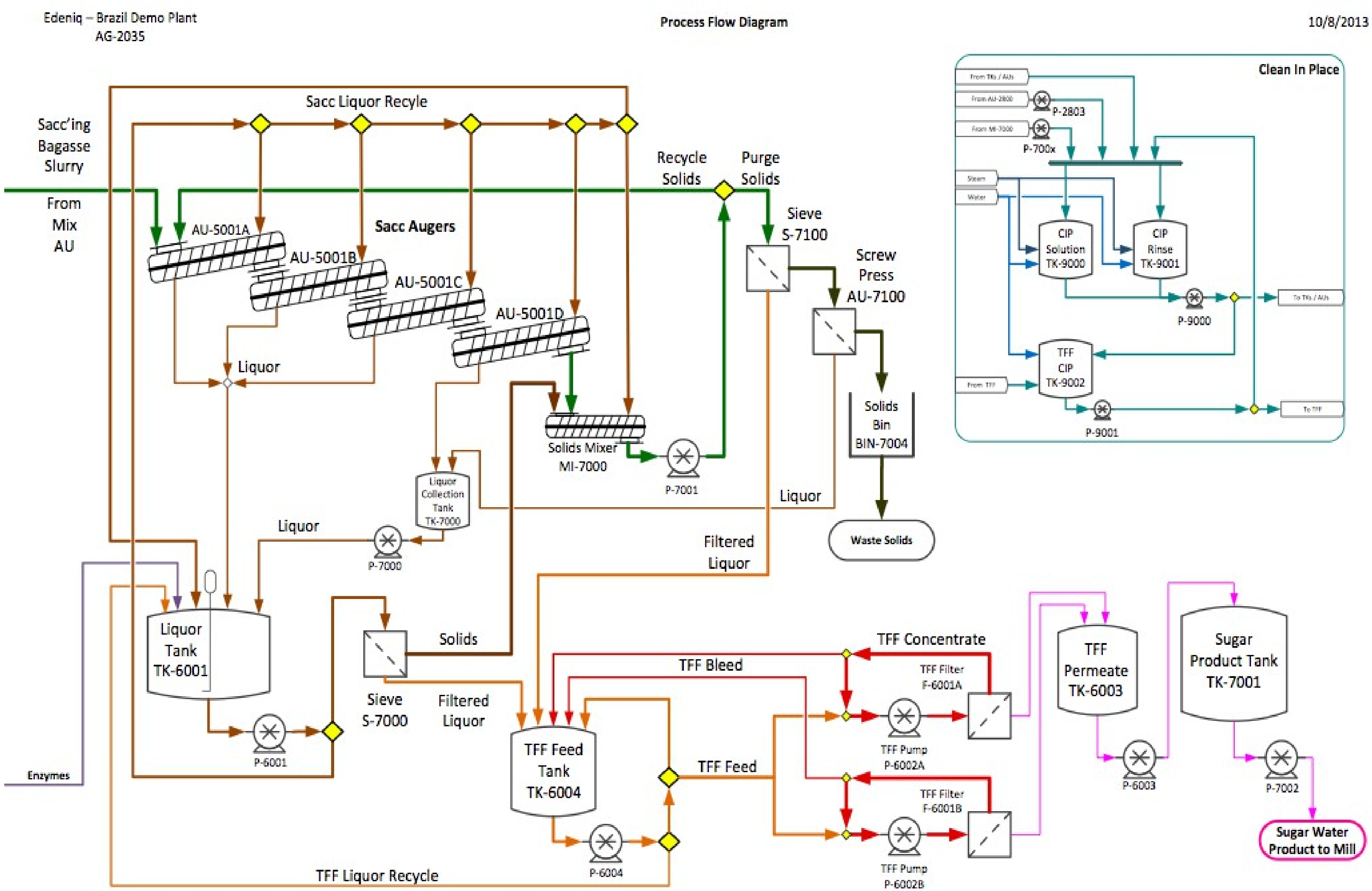
Saccharification & Solid Liquid Separation



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Saccharification & Solid-Liquid Separation

Mix Auger

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Saccharification & Solid Liquid Separation

Sacch Augers

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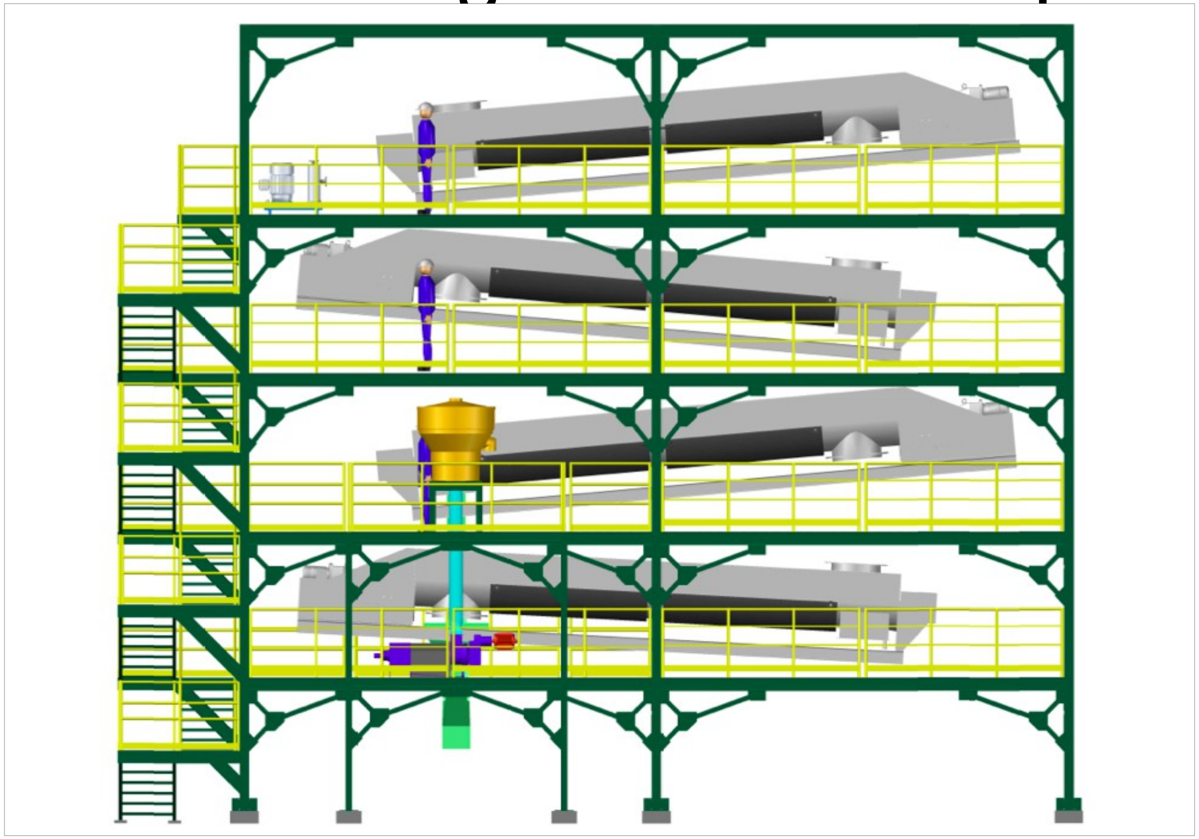
Saccharification & Solid Liquid Separation

Sacch Augers & Solid Liquid



- # Saccharification & Solid-Liquid Separation

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Saccharification & Solid-Liquid Separation

Table 1: Sugar yield values for shake flasks over time. Each value represents an average of three shake flasks.

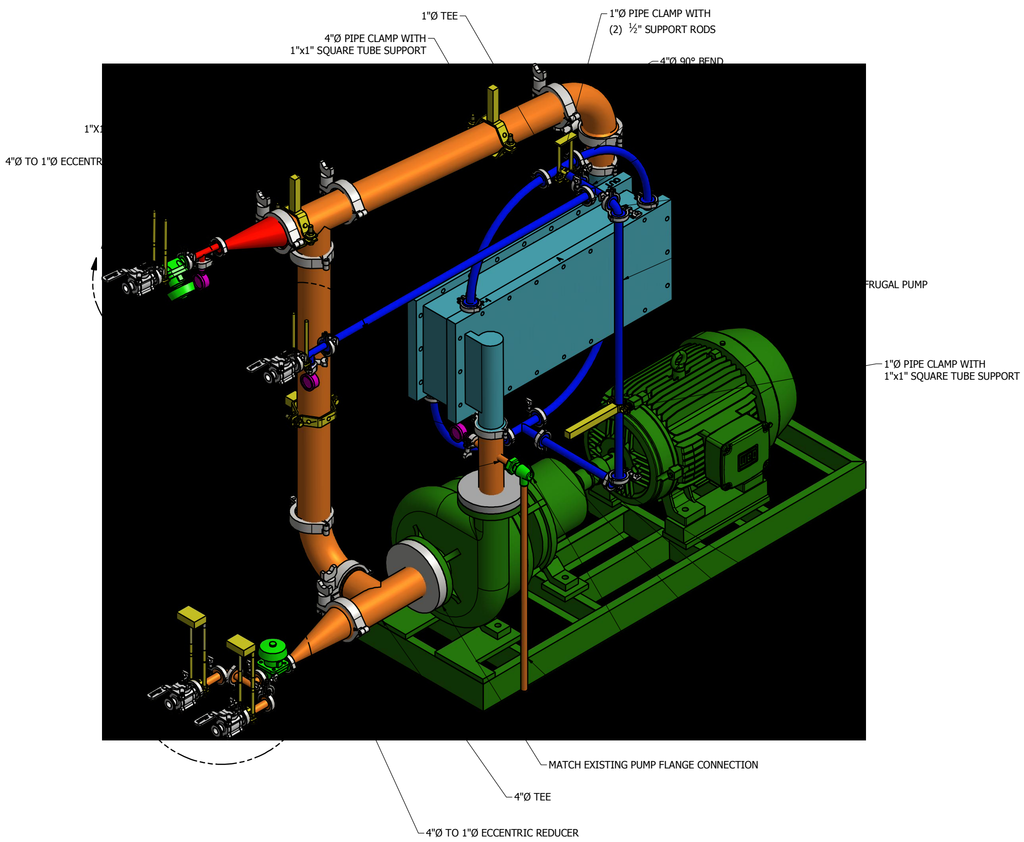
YIELD

C6	CONTROL	0.5X Enzyme	1X Enzyme	0.5X Enzyme + 1X Additive	1X Enzyme + 1X Additive
0	0.6%	0.6%	0.6%	0.6%	0.6%
4	0.6%	15.1%	22.5%	21.1%	31.2%
24	0.7%	31.7%	47.7%	47.4%	70.4%
48	0.7%	37.5%	56.0%	55.0%	81.0%
C5	CONTROL	0.5X Enzyme	1X Enzyme	0.5X Enzyme + 1X Additive	1X Enzyme + 1X Additive
0	27.5%	27.5%	27.5%	27.5%	27.5%
4	26.3%	47.4%	52.3%	50.0%	55.2%
24	26.3%	56.3%	60.6%	60.3%	66.1%
48	26.4%	58.5%	63.2%	63.1%	69.0%

Saccharification & Solid-Liquid Separation

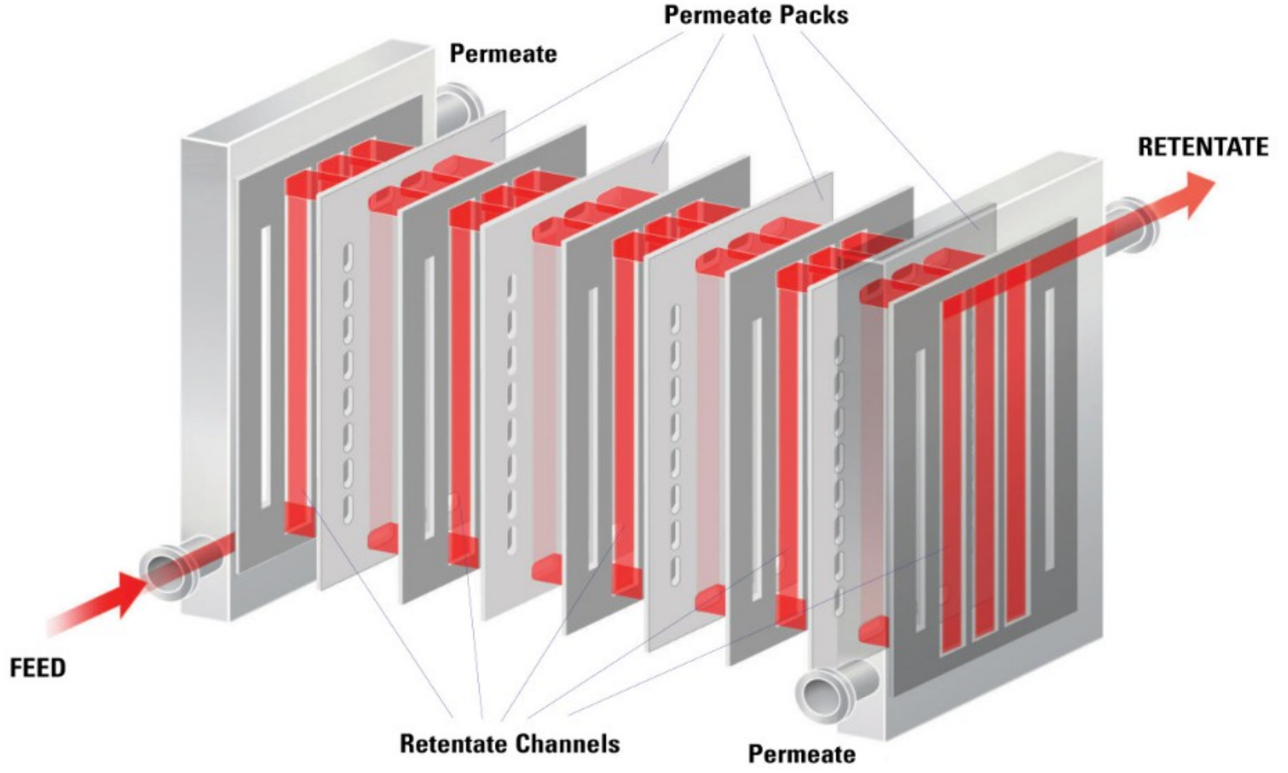
Enzymes Recovery – Smart Flow

Smart-Flow Filter (Skid TFF)



Enzymes Recovery – Smart Flow

TFF : Tangential Filter



SmartFlow Samples

Feed

Permeate

Concentrate

- Samples

Feed

Solids (69% solids)

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Technology Comparison

Process	Eco Technology	2G Plants Installed (Brazil)
Concept	Bolt-on in the existing mills. Enjoy existing potentialities of Fermentation & Utilities.	Plant 100% autonomous, assumes all risk investment.
Pre-Processing	Clean and Crusher of biomass without high risks	Clean and Crusher of biomass without high risks High CAPEX in large conveyors.
Pretreatment	Continuous or Batch nationalized (~ 35 years) both low Capex.	Continuous (large reactors) imported equipment, high Capex.
Enzymes Hydrolysis	Continuous process (low Capex) with lower sugar conversion time.	Batch process (high CAPEX) with higher sugar conversion times.
Fermentation	Standard fermentation (existing) and yeast.	Investment in a new fermentation (C5 sugars) and GMO yeast.
Distillation & Dehydration	Standard Process.	Investment in special equipment: vacuum columns and high performance trays.
Boiler	Potential use of Standard Boilers	Investment in Fluid Bed Boilers.
Enzymes	Concern enzyme consumption: Reuse of enzymes and enhances the use of nationalized enzymes.	Imported enzymes with high cost.
Chemical Inputs	No special chemicals.	Use special chemicals, acids, nutrients and bases in large amount.
Molasses	Do not use molasses for multiplication of yeast.	Using large amount of molasses yeast to multiply. Molasses purchase.
Additional Biomass	Not use	Need extra biomass (limitation Bed Boilers Fluidized).

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Demo Plant Completion Budget

Step-I Demo Plant Construction & Initial Operation	2016
Capex - Demo Plant Installation	
Equipment/Construction	$1,171,588.82
Laboratory	$68,965.52
Sub-Total Capex	**$1,240,554.33**

Opex - Operations Cost	
Materials/Services/Inputs	$119,068.25
Maintenance	$47,586.21
Sub-Total Opex	**$166,654.46**

Administrative Expenses	
Employees	$706,551.72
General expenses (Travel, Taxes, etc)	$289,655.17
Sub-total Administrative	**$996,206.90**

Total Budget	**$2,403,415.68**

Demo Plant Completion Budget

Step-II - Operation Full	2016
Capex -Demo Plant Installation	
Upgrade of equipment	$100,000.00
Laboratory	$-
Sub-Total Capex	**$100,000.00**

Opex - Operations Cost	
Materials/Services/Inputs	$293,970.37
Maintenance	$103,103.45
Sub-Total Opex	**$397,073.82**

Administrative Expenses	
Employees	$706,551.72
General expenses (Travel, Taxes, etc)	$289,655.17
Sub-total Administrative	**$996,206.90**

Total Budget	**$1,493,280.72**

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Technology Processes

Quality Tools

- Statistical Process Control
- Design Of Experiments
- Six Sigma

Statistical Process Monitoring/ Control

Design Purpose; Basic Components

Purposes

- Determine if a process or measurement process is out of control
- Determine if data are statistically distinguishable
- Determine if process is statistically capable of meeting objectives
- Understand the process; minimize additional costs (e.g., by pooling data)

Basic Steps

- measuring important inputs and outputs of the process
- eliminating special causes of variation in the process to make it consistent
- reducing the magnitude of common causes of variation
- improving the process to its best target value
- monitoring the process continually

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Processes: Quality

Additional *Six Sigma* tools have been successfully applied

- Risk Matrix Analysis
- Gap Analysis
- Resource Mapping (implications)
- SIPOC Analysis

Technology Organization

Matrix Design Aims Multidisciplinary Resources at Business Priorities

- Functional Organization; Integrated Location
- CSP Steering Team; Brazil Demo Project Focus
- Technical Action Teams
- Documentation Standard

Technology Groups

Organization provides functional expertise for technology deployment

Edeniq

- Lab Services
- Commercial Applications
- Enzyme Tech & Analytical Sciences
- Process Synthesis & Applications

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- Lab Services
- Operations
- Engineering
- Manufacturing

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- Process Design Engineering
- Mechanical Technology
- Instrument, Controls and Electrical

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Technology Documentation

Documentation Standard implemented to ensure archiving consistency, quality

- Strategic Development Plans (SDP)
- Campaign Test Plans (CPT)
- Experimental Run Plans
- Interim Reports
- Technical Progress Reports
- Field Trial & Trip Reports
- Process Flow Diagrams (PFD)
- Piping & Instrumentation Diagrams (P&ID)
- Standard Operating Procedures (SOP)
- Lab Records / Notebooks

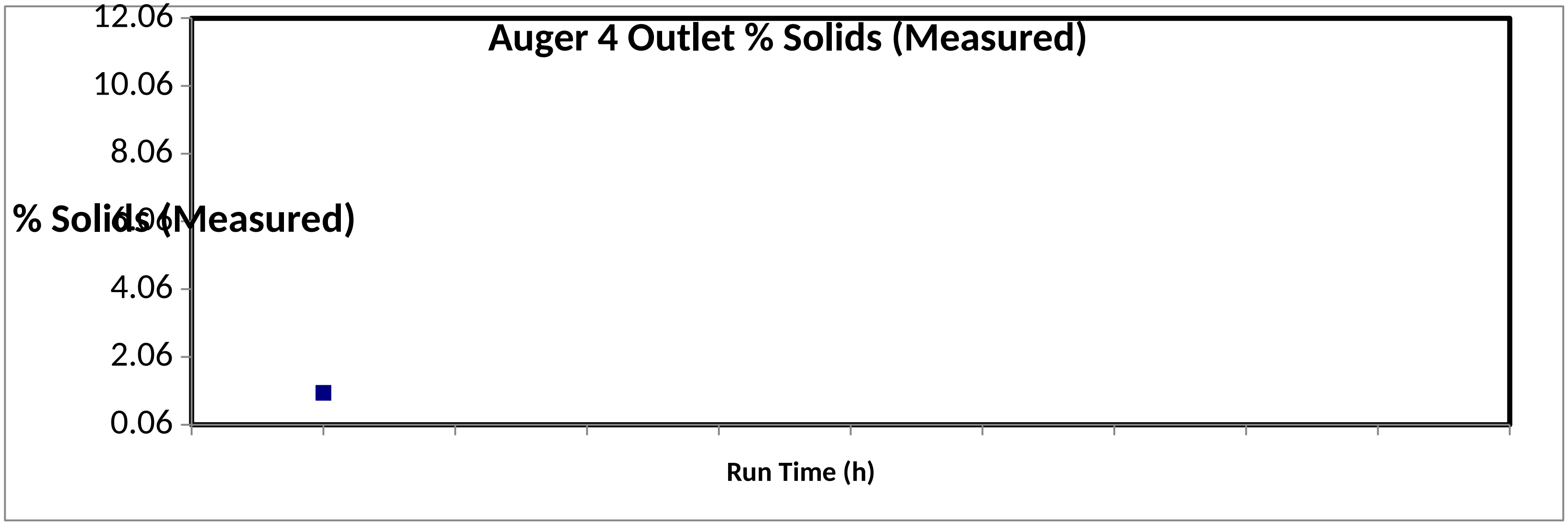
Documentation Standard Norms

Formalized protocols for preparation, content, review, archiving expectations

- Sharepoint used for document archival
- Documentation will be a key performance objective of all PI's
- Review/ Approval requirements (by authority level) specified by document type
- Strategic Development, Campaign Test & Experimental Run Plans to be reviewed with appropriate team prior to implementation
- Results of Experimental Runs to be reviewed with appropriate teams prior to report being written

Control Chart – Solids

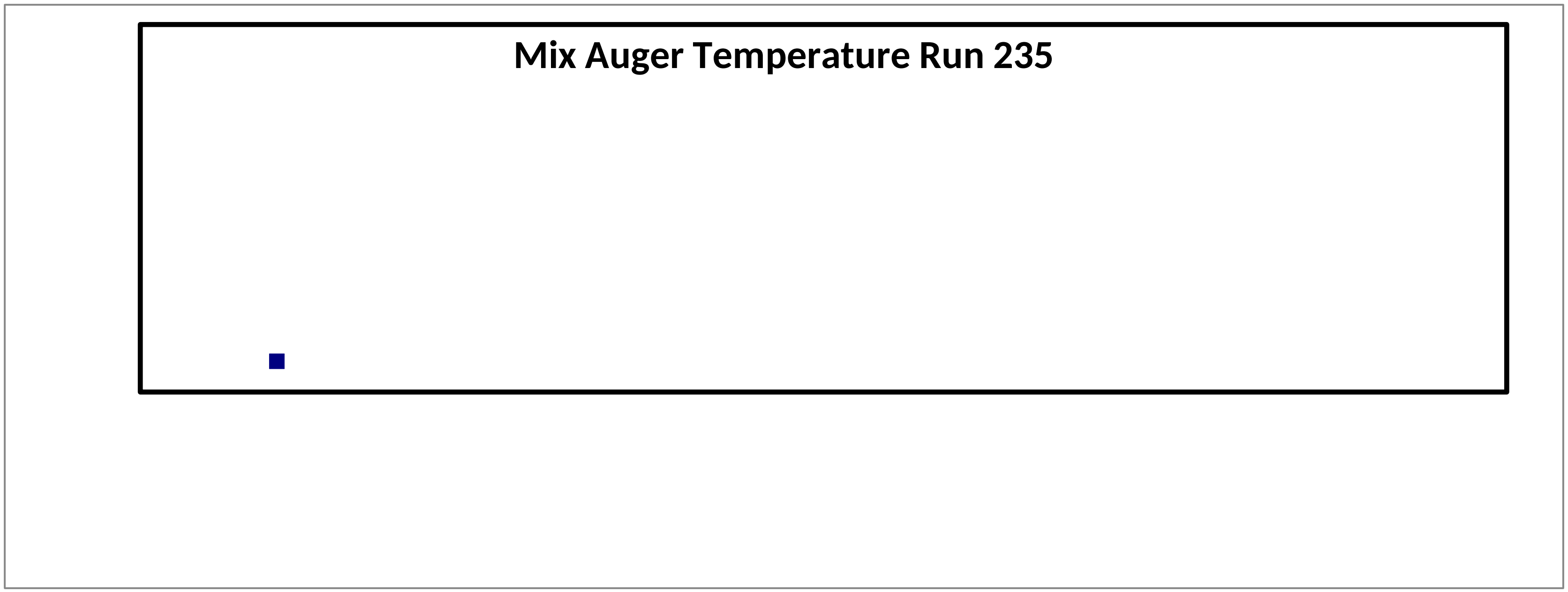
Solids level – control and monitoring example



- Observed good control of auger solids concentration with all points in control
- Initial commissioning work focused on understanding auger pitch and solids.
    - Increased pitch increased the solids in the system.

Control Chart – Temperature

Temperature - control and monitoring example

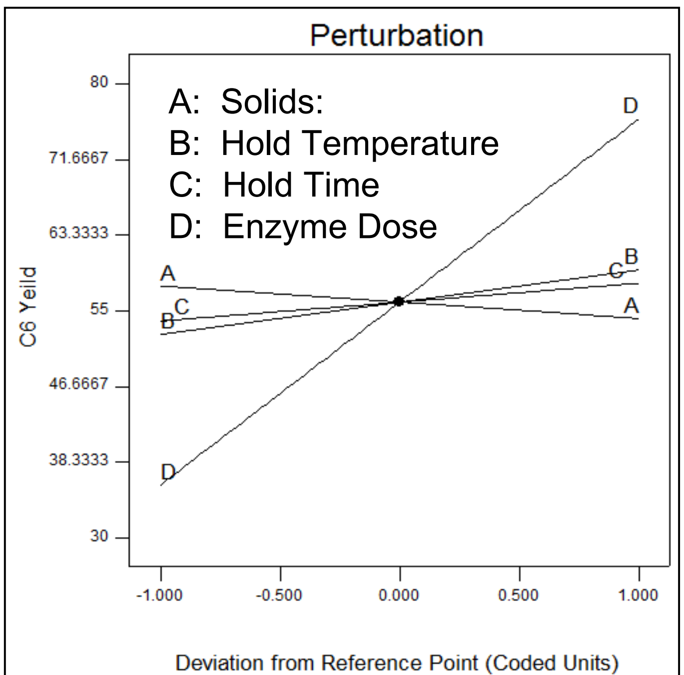


- Observed excellent control of auger temperature with most points within 1 degree of target temperature.

Corn to Cellulosic Migration (CCM) Optimization -Using DoE Pilot Plant

Integrated Pretreatment & Saccharification

- Statistical approach to characterize PT & Sacc on CCM pilot plant
- Use to further refine computational models for development of next generation plants



C6 Conversion vs. Severity Factor at Fixed Dosing

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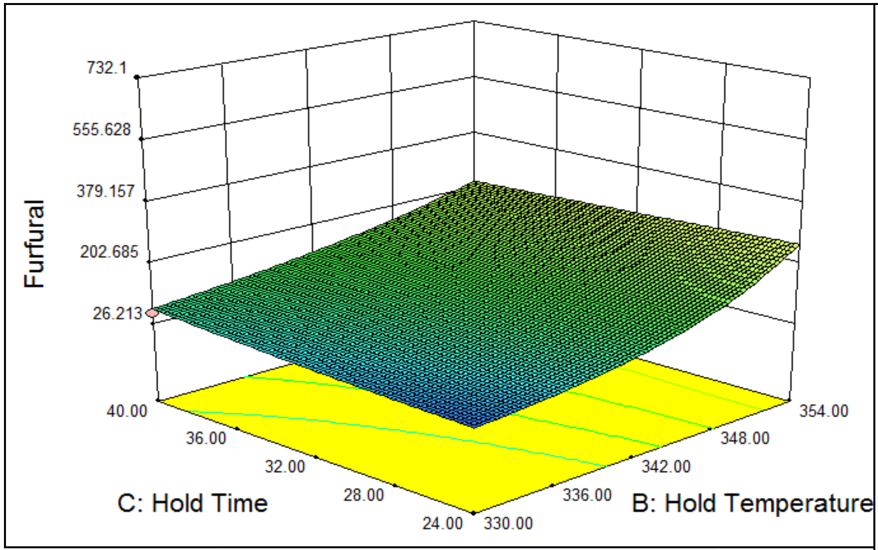
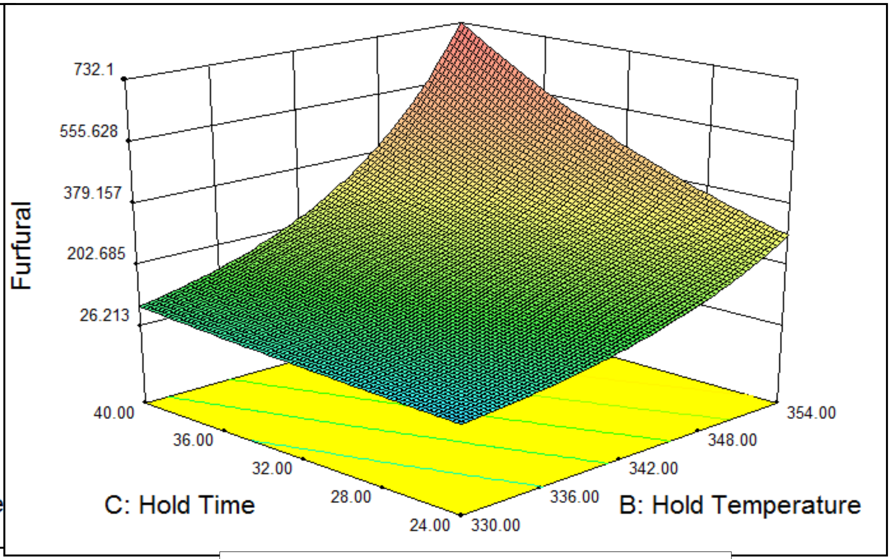
CCM Pre-treatment

Design of Experiment Example: Inhibitor Levels with Corn Stover

- PT Cook conditions on inhibitor formation
- Map operational domain to maximize Sacc conversion while remaining below inhibitor thresholds



Low Biomass Solids



High Biomass Solids

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Enzyme Strategy

1. **Third party relationships**
2. **Eco proprietary enzymes augments performance**

Enzyme Technology Strategy

Evolution of supply options for improved business security

- Collaborate with wide range of partners and suppliers
  - Broaden technology offerings
  - Maximize sourcing options and enhance economics
- Complement external technology with internal R&D
  - Auxiliary enzymes to improve commercial cocktail performance
  - Chemical additives to enhance enzyme efficiency
  - Enzyme and process stream recycle to improve economics
  - Identify optimal enzyme properties under use

Novel Cellulase from Partner

Excellent tolerance of high bagasse solids

Auxiliary Enzymes

Approach:

- Screen candidate genes for applicability.
- Express selected genes in *S. cerevisiae* for preliminary evaluation.
- Express better candidates in *P. pastoris* for bench scale and pilot testing.
- Commercially produce best candidates in fungal host (partner collaboration).

Examples:

Beta-Glucosidase (BG).

CBHII-Beta-Glucosidase Fusion Protein.

Auxiliary Enzyme Identification

Increasing the pool of candidate proteins

Source	Type	Application	Size	Status
In-House, synthetic genes	Fungal plant-cell degrading enzymes	Pathway; CSP	~ 20 (enzymes)	Expression and screening ongoing; Application testing pending
	➢ Cellulases (CBHs; EGs; BGs)		8	Tested in *Saccharomyces*, moving to *Pichia* expression
	➢ Hemicellulases (Xylanases, Xylosidases, FAEs etc)		6	Tested in *Saccharomyces*, moving to *Pichia* expression
	➢ Expansins, Swollenins, Ligninases		6 to 8	Selection, moving to *Pichia* expression
Stanford University	Fungal plant-cell degrading enzymes	Pathway; CSP	~ 80 (enzymes)	Expression and screening ongoing; Application testing pending
	➢ Glucan- active enzymes		24	
	➢ Xylan-active enzymes		8	
	➢ Mannan-active enzymes		9	
	➢ Pectin-active enzymes		25	
	➢ Miscellaneous enzymes		10	

Eco Beta-Glucosidase

Successfully engineered and expressed

Goal

- Increased activity on cellobiose
- Decreased inhibition by glucose
- Increased catalytic efficiency

Random Mutagenesis

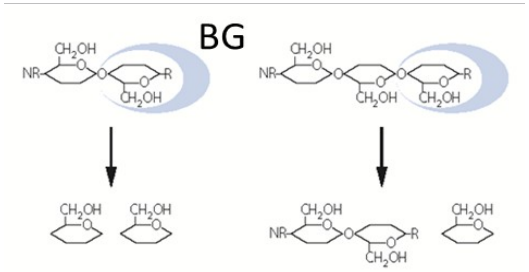
- Entire gene
- Targeted regions

Fungal gene target

- *Aspergillus niger* wild type

Target expression strain

- *S. cerevisiae* yEdQTR3



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Beta-Glucosidase with Enhanced Catalytic Efficiency

Random mutagenesis of *A. niger* gene – Patent Pending

Cellobiose Substrate

Cellobiose substrate	Vmax (units/mg)	Km (mM)	Ki (mM)	Kcat (min-1)	Kcat/Km (min-1mM-1)	Km/Ki
Desired feature	**High**	**Low**	**High**	**High**	**High**	**Low**
Comm-BG 1	51.89 ± 2.53	6.56 ± 0.89	5.20 ± 0.63	4068.18	620.15	1.26
Comm BG 2	7.77 ± 0.56	1.59 ± 0.41	3.13 ± 0.76	932.40	586.42	0.51
WT (745) BG	4.36 ± 0.24	1.45 ± 0.29	1.56 ± 0.29	523.20	360.83	0.93
Mut (885) BG	11.57 ± 0.59	1.45 ± 0.26	1.11 ± 0.19	1388.40	**957.52**	1.31

Protein Conc.	A-BG mg/mL	S-BG mg/mL	yEdQ745-BG (WT) mg/mL	yEdQ885-BG mg/mL
Bradford method	35.95 ± 1.22	90.52 ± 1.41	1.30 ± 0.06	1.20 ± 0.04

High Kcat/Km on cellobiose substrate demonstrates superior catalytic efficiency on cellobiose.

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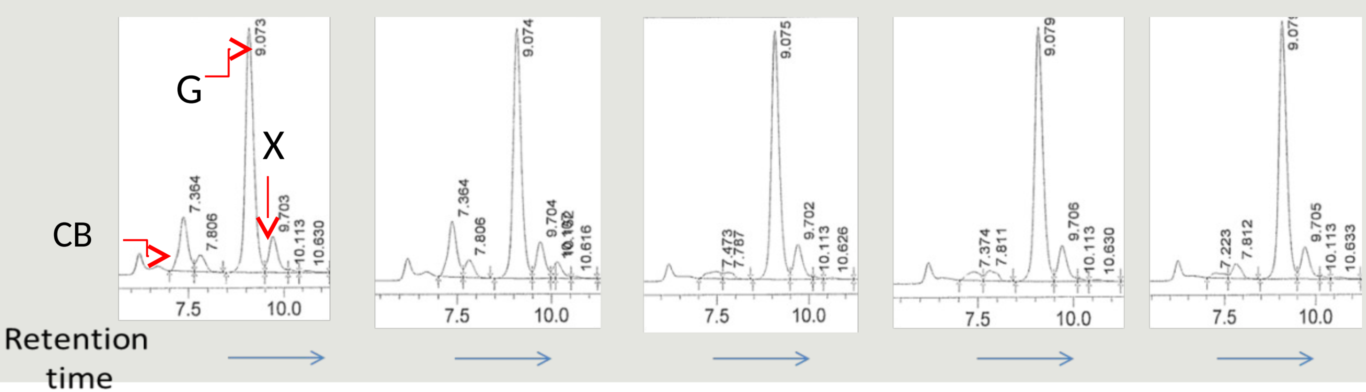
Eco BG Improves Partner Cocktail

Glucose Conversion



20% additional sugars using Edeniq BG

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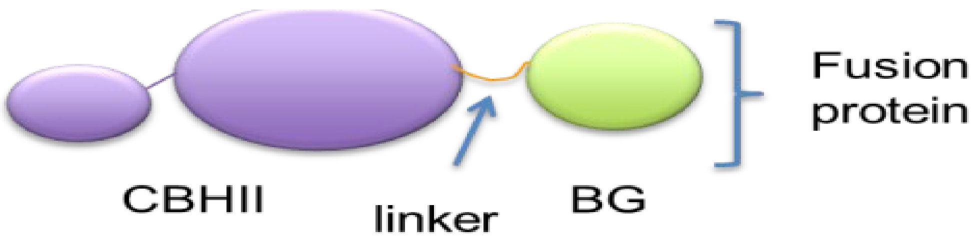
Eco Fusion Protein

Combined enzyme functionalities for enhanced activity



Advantages:

- Enhanced saccharification kinetics via substrate channeling.
- Improves BG stability via association with CBHII.
- Single component for process supplementation of both labile Exo and BG.
- Simplified recycle of BG by binding to solid phase via CBM of CBHII.

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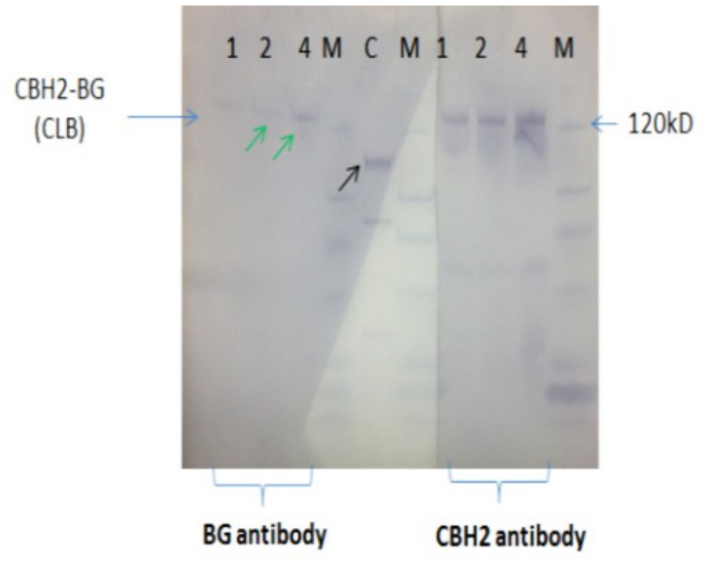
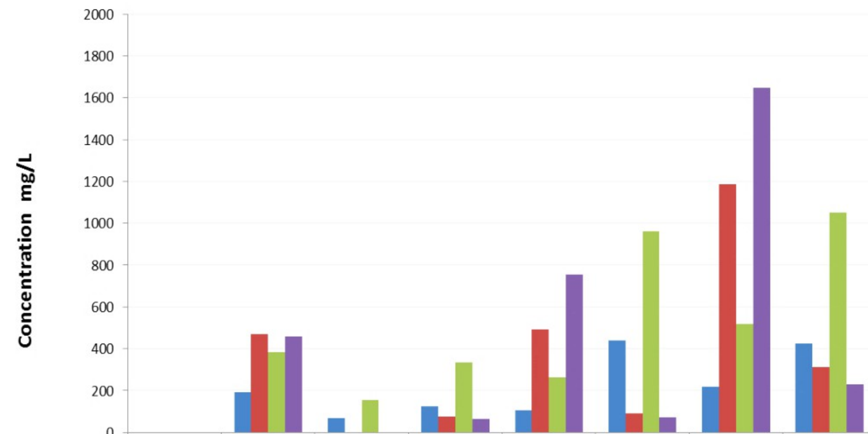
CBH II-BG Fusion Protein

Successful expression of intact protein in *S. cerevisiae*

CBHII-BG fusion is intact and both enzymes are active in the chimeric cellulase



Western blot detection of proteins in media broth supernatants (CLB in lanes 1, 2, 4) using BG antibody on the left side and CBHII antibody on the right side of the blot. M is the prestained size markers. Control (lane C) shows BG (*A.niger BglA*) secreted by yeast. Green arrow: CLB fusion protein; Black arrow : intact BG



	PASC	EG	BG	CLB	CBHII	EG+BG	EG+CBHII	EG+CLB
Glu 6 h (mg/L)	0	191	67	125	105	441	218	426
Cellobio 6 h (mg/L)	0	471	0	76	491	91	1188	311
Glu 24 h (mg/L)	0	382	153	333	263	963	519	1050
Cellobio 24 h (mg/L)	0	458	0	63	756	74	1649	228

Digestion of PASC substrate by individual and combined enzyme components.
CLB = CBHII-BG fusion protein

Glc 6 hr
Glc 24 hr
Cellobiose 6 hr
Cellobiose 24 hr

Enzyme Technology Strategy

Summary and conclusions

- Extensive group of suppliers and partners established to broaden technology offerings, provide sourcing flexibility and improve economics
- Focused internal R&D program used to develop proprietary, complementary technology to further improve process economics
    - Auxiliary enzymes
        - Engineered beta-glucosidase has superior catalytic efficiency – used to supplement commercial cocktail
        - Engineered CBHII-BG fusion protein expressed – exhibits activity of both partners
    - Chemical additives
    - Enzyme recycle

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Scale-up

Scaling of Process

Unit	Feedstock Scale	Scope	Location
Pilot Plant	1-2 dry tons/day	Semi-continuous Feedstock to ethanol production	Visalia, CA
Pilot Plant	2 dry tons/day	Continuous Feedstock to sugars	Visalia, CA
Demonstration (under construction)	10 dry tons/day	Continuous, integrated with Brazil mill, bagasse to sugars	Usina Vale Sao Paulo State Brazil
Commercial (target 2018)	Not announced	Continuous, integrated with Brazil mill, bagasse to sugars	Usina Vale Sao Paulo State Brazil

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Business Model

- Build and operate commercial scale bolt-on plants after successful scale of demo plant.
- Bolt-On technology is modular; modules can be added to increase production over time.
- Bolt-On have low opex and capex in addition to much lower technology risks.
- Bolt-On is focused on C6 sugar using existing fermentation capacity of sugar mill but provides process flexibility for future separate dedicated C5 fermentation.
- Very simple and robust process with small plant footprint.
- At this stage we are focusing in ethanol production but pure sugars have a much higher upside.
- Two Bolt-On's module sizes:
  - Large bolt-on modules have capacity to process 50 ton/hour (1,200 ton/day) of biomass producing 38 MM liters of ethanol operating 300 days of the year at a cost of $34 MM USD.
  - Smaller bolt on modules have capacity to process 30 ton/hour (720 ton/day) of biomass producing 22 MM liters of ethanol operating 300 days of the year at cost of $21 MM USD.

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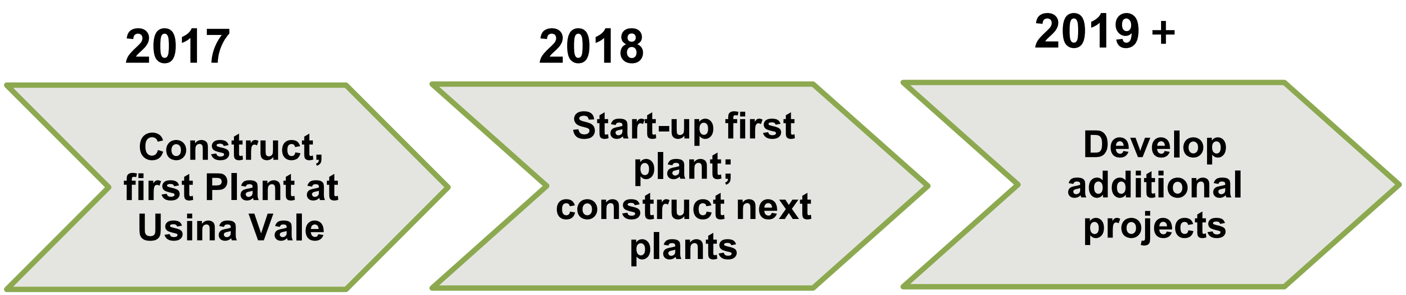
Business Model

- Eco's bolt on projects will be funded by an equity partner and BNDES (Brazilian Development Bank) (http://www.bndes.gov.br/SiteBNDES/bndes/bndes_en/) funds 20-80%.
- Eco had The Gávea Group (http://www.gaveainvest.com.br/en/empresa) validating business model and group is interested in becoming the JV partner once demo plant is operational.
- Eco via its predecessors has had R$ 80 MM project finance approved by BNDES, lack of guarantees did not move financing forward but BNDES is aware of the project transition and will revise loan when guarantees can be provided by equity partners.
- A full financial model for roll out of 22 bolt is included.

Business Plan

Implementation Timeline



2017

Continue demo plant operations to optimize process

Engineering on first commercial

Start construction on first Usina Vale plant

2018

Start-up first Usina Vale plant; start constructing next plant(s)

2019+

Operate second plant; additional bolt-on units with other sugar/ethanol producers

Ethanol target: 22 JV plants operating by 2027; ~ 1 billion liters/year production capacity, based on 70 mm tons/year of cane crush capacity (< 10% of forecast cane crush capacity)

Sugars target: 10 JV plants (2 per year 2020 to 2024)

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Continuing to Scale-Up Cellulosic Sugar Capacity

2012

Demonstrate Technology

Pilot Plant

Corn Stover, Bagasse

- Visalia, CA
- 1-2 mt/day
- Funded by DOE & CEC

$0.15/lb (R$0.74/kg)

2017

Prove Economics

Demonstration Plant

Bagasse

- Usina Vale, São Paulo State, Brazil
- 10 mt/day
- Co-Funded by Partner

$0.12/lb (R$0.59/kg)

2018

Scale Commercially

First Commercial Plant

Bagasse

- Usina Vale, Brazil
- 750 mt/day*
- 4 LOIs in Brazil

$0.10/lb (R$0.50/kg)

* Dry basis

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Executive Team

Claude Breyvogel-Chief Executive Officer
Mr.Breyvogel is President of Luzverde S.A. , renewable energy development company . Was Country Manager and Director of Strategy and New Business Development CMS Energy Brazil S.A. Mr. Breyvogel been in the organization of CMS since 1998 and has 30 years of experience in the electricity sector. He served as development manager for BHP Power and has held other positions in oil companies , and generation, transmission and distribution of electricity. Mr. Breyvogel holds a degree in Aerospace Engineering from the University of Southern California , Master in Oceanic Engineering from the Rosenstiel School of Marine Science and Amospheric and M.B.A. the University of Miami, Florida. Mr. Mylla is fluent in English, Spanish and French.

Paulo Mylla-Chief Operations Officer
Mr. Mylla has over 30 years of experience as an Executive in operations and new business development in the areas of Agribusiness, Information technology, Industrial Production and renewable energy. He was the responsible to develop Edeniq's presence in Brazil since inception in 2009, as well as being operations liaison of the bolt-on technology development in between the the US and Brazilian teams. Before joining Edeniq Mr. Mylla served as consultant responsible for implementation of new projects and business in the Americas and Europe. He worked with several national and international groups such as Caterpillar, Dana Corp., Bolthouse Farms, and Votorantim. Mr. Mylla holds a Bachelor's degree in metallurgical engineering and production at FAAP (Fundação Armando Alvares Penteado) and has a master's degree in International Business (MBA) by Nova Southeastern University (NSU). Mr. Mylla is fluent in English, Spanish and Italian.

Gustavo I. Miletto- Chief Technology Officer
Mr. Miletto is a former Edeniq's project director where he was responsible for transfer of technology of production of cellulosic ethanol from sugar cane biomass between the United States and Brazil. He is also responsible for the creation of the modular bolt-n technology allowing fast, standardized , and cost effective bolt-on deployment. Has 12 years of experience in sugar ethanol market always acting in the fields of project engineering and consulting of operation for improvement of industrial yields. Has extensive experience in the design, conduct and management of multidisciplinary teams with focus on results. Holds a Bachelor of mechanical engineering from UNESP, MBA in production engineering from UNESP and specialization in Corporate Strategy from UNICAMP and MBA in project management from FGV. He served in large companies like Raízen, Dedini and Zilor.

Rodrigo Basso-Director of Laboratory and R&D
Mr. Basso is also a former Edeniq's lab director where his focus was on the monitoring of technical services developed in Brazil and new projects coming from the United States. Has experience in conducting laboratory testing, implementation and validation of methodologies involving liquid chromatography. Passed previously by multinational companies of the chemical sector BASF and ISS services. Biochemical Engineering degree at USP, MBA in production management from UNESP and Mastering Industrial Biotechnology at USP with a focus on biomass Conversion.

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Executive Team

Fabiano Bodo-Project Manager Director
Mr. Bodo is a former Edeniq's project director now he is responsible for overseeing the construction of the demo-plant. He Is a licensed chemist with a Bachelor's degree in chemistry with Technology assignments by USC, an MBA in production engineering. He has over 17 years of experience in operating and managing people in the sugar ethanol sector. Previously worked in multinationals such as Biorigin and Zilor.

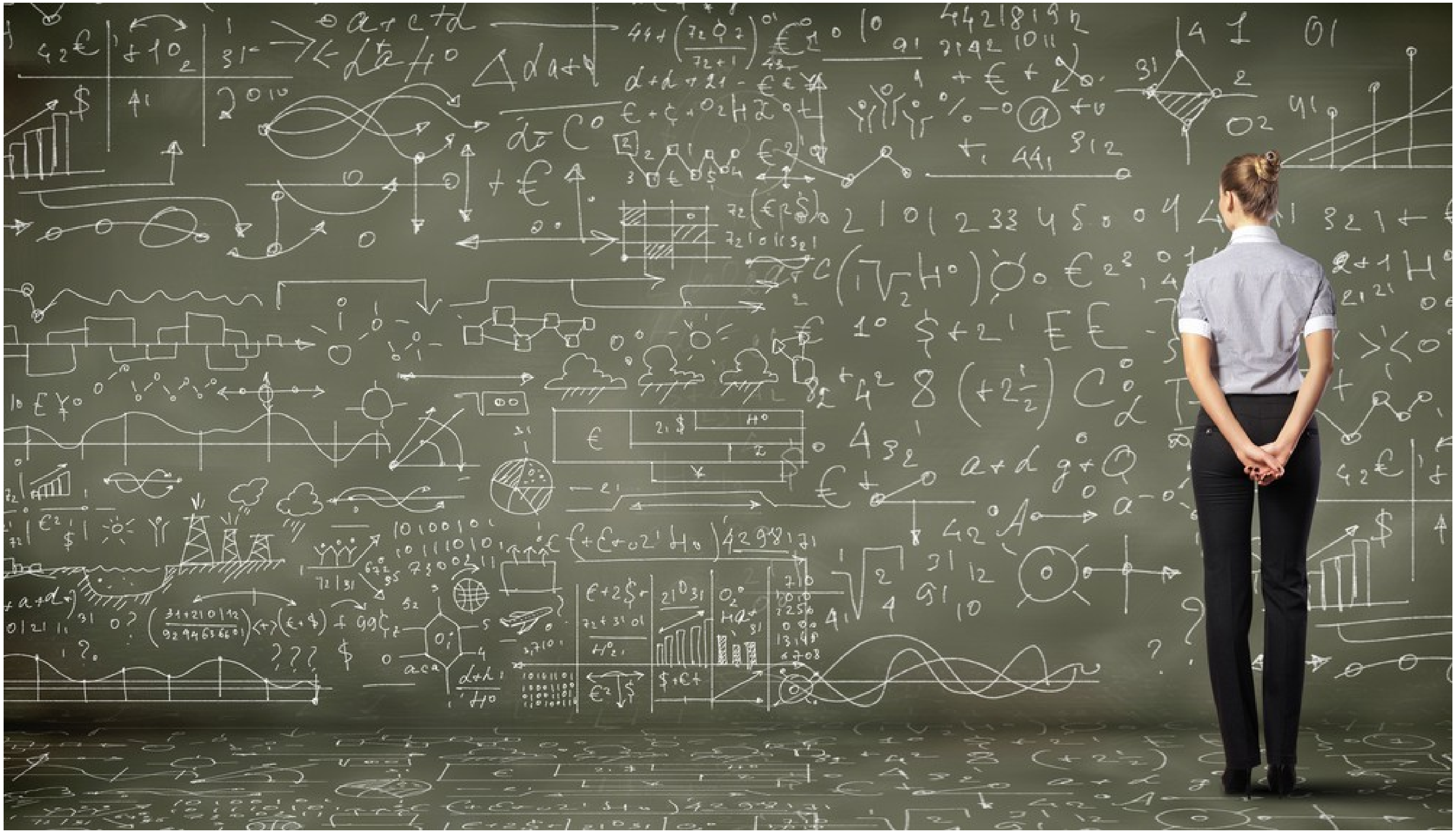
Renata K. Fernandes-Director of Operations
Ms. Fernandes is a former Edeniq's operations director she was responsible for performing hundreds of fermentation processes audits resulting in millions of cost savings to the ethanol industry. She is one of the few professionals in the world with knowledge of fermentation of sugar and corn ethanol. Has 12 years of experience in critical analysis of process and finding solutions applicable to the everyday life of our customers. Previously served in large companies like Rohm and Haas and L ´ Oréal. Has a BA in Biochemical Engineering from USP and MBA in financial management from FGV. Is fluent in English.

Board of Directors

Pedro Toledo Florencio
Mr.Florecio is the ninth generation of a family of sugar producers, who make up the Toledo Group (4 plants) . He is a shareholder and CEO of Usinas Vale and California in the State of São Paulo. He graduated in economics from the University of Chicago and was called by his family to manage commercially and financially Usina Vale and California. Since then has been dedicated to technological innovations in the industry , introducing new plants that add value to the production of sugar and ethanol. He founded Eco technologia to bring innovation to the sector. Usina Vale was the first to adopt Edeniq's technologies in Brazil culminating with the JV to construct demo-plant he ultimately acquired the rights of the bolt-on technology for Brazil.

Dr.Carlos Geraldo Langoni
Dr.Langoni serves as the President of Projeta Consultoria Econômica Ltd. and has been its Chief Executive Officer. Dr.Langoni has been instrumental in validating Eco's financial model and in identifying JV partners to deploy bolt –on technology after demo plant is completed. Mr. Langoni serves as a Senior Consultant of Companhia Vale do Rio Doce. He served as the President and Chairman of Central Bank of Brazil from 1980 to 1983. He served as the Chairman of Numeral 80 Participações S.A. He served as Chairman of Santos Brasil Participações SA. He serves as Vice-President of the Board at Santos-Brasil Participações S.A. He serves as Vice-President of Numeral 80 Participações S.A. He has been an Independent Director of Marfrig Global Foods S.A. (Alternate Name, Marfrig Alimentos SA) since May 2007. He served as a Director of Aliansce Shopping Centers SA since March 2011. He serves as a Director at Santos Brasil Participações SA. He serves as a Member of the Consulting Council/Advisory Board of Guardian Industries. He served as a Director and Member of Administrative Council at Companhia Souza Cruz SA. He served on the Advisory Board for Latin America of World Bank. He serves as Director of the Getulio Vargas Foundation's Global Economics School. He was Dean and Professor of the Getulio Vargas Foundation's Post-Graduate School of Economics, Rio de Janeiro from 1973 to 1979. He has published nine books. Dr. Langoni has a degree in Economics from the Federal University of Rio de Janeiro and a PhD in Economics from the University of Chicago.

Supporting Data



Pre-treatment

Goals of Preprocessing and Pre-treatment

1. Create access to cellulose for saccharification

- Mechanical – Hydration
- Mechanical - Size Reduction
- Thermal – Batch or Continuous Reactors
- Thermal – Some impact from steam explosion

2. Optimization for Saccharification

Unit Operations

Goals: condition biomass for easy enzyme accessibility

1. Hydration of biomass
   - 1st Gen: Batch
   - 2nd Gen: MHD (Material hydration and dispersion)
     - Higher Solids
     - Stover robust; Bagasse required screw feed modification
2. Particle sizing and Shearing
   - Cellunator: Commercially demonstrated
3. Thermal Pretreatment
   - 1st Gen: Batch
   - 2nd Gen: Continuous Plug Flow Heating and Temperature

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Pre-treatment Conversions

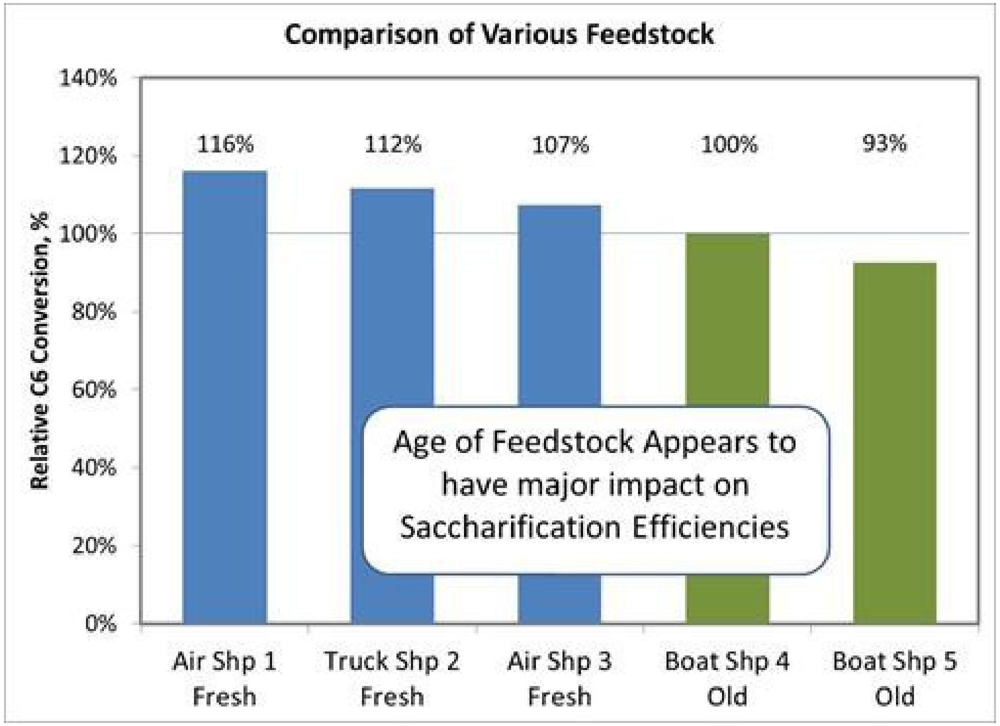
- Bagasse

Conversions usually stated in relative terms

Significant impact with bagasse aging

- Loss of moisture
- Difficulty re-hydrating
- Particle size reduction difficult
- Negative impact on conversions

- Should be less of an issue at plant



Mechanical Pretreatment

MHD Increases Hydration and Solids Level

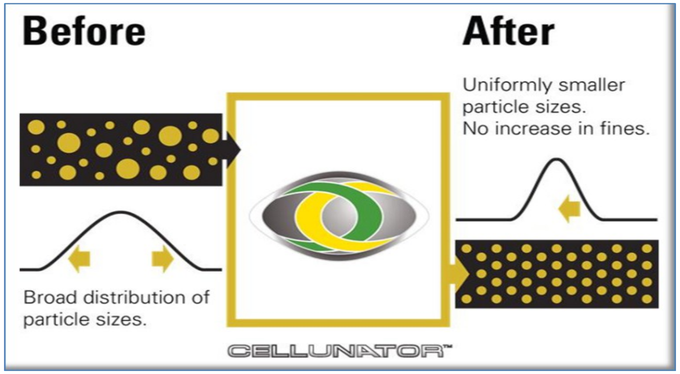
- 15% Relative increase in hydration of biomass vs. batch
- Pumpable at 20% solids versus 12% w/o
- Wide temperature operational limits
- Equipment provided by IKA Works
  - Designed mixing solids with liquids
  - Continuous In-Line process
  - Single pass hydration

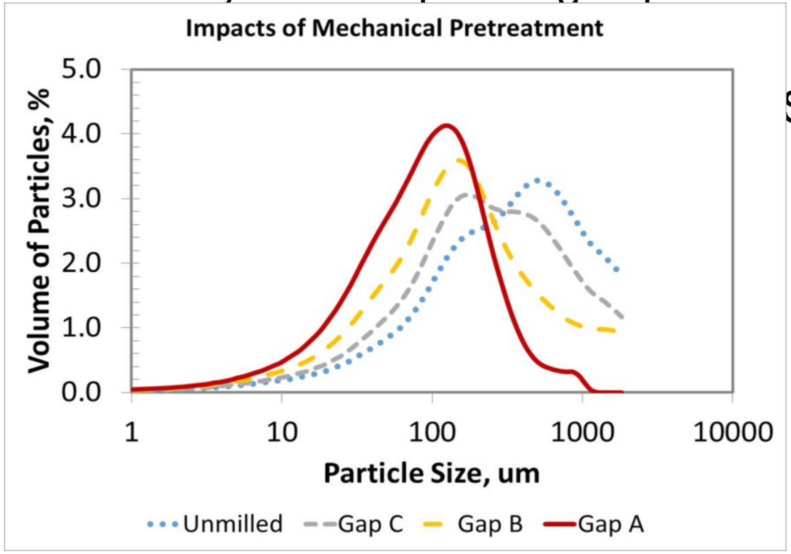
Cellunator – Particle Size

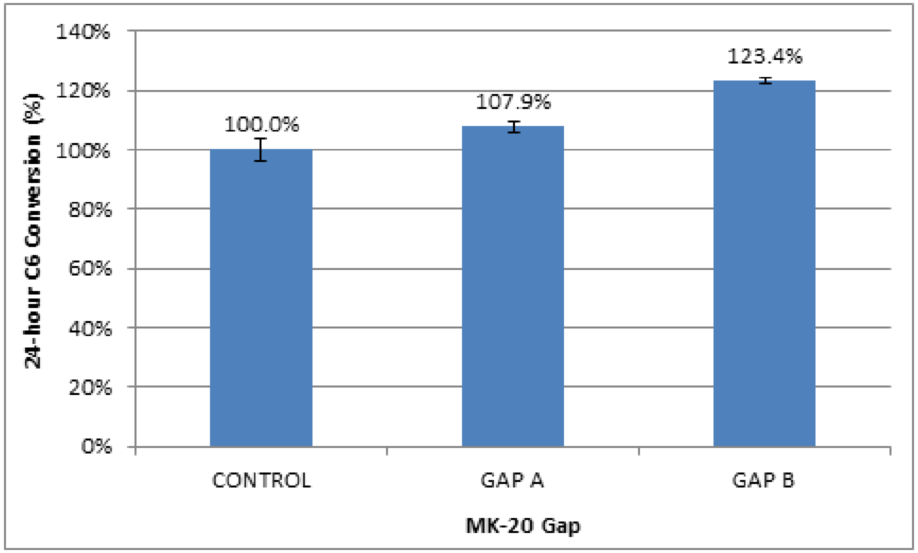
Goals: Increase enzyme accessible surface areas

- Substantial shifting of particles to optimum size
- 10% improvement in C6 Saccharification performance
- Wet processing with high solids loading
- Four years of operating experience in Corn

S.







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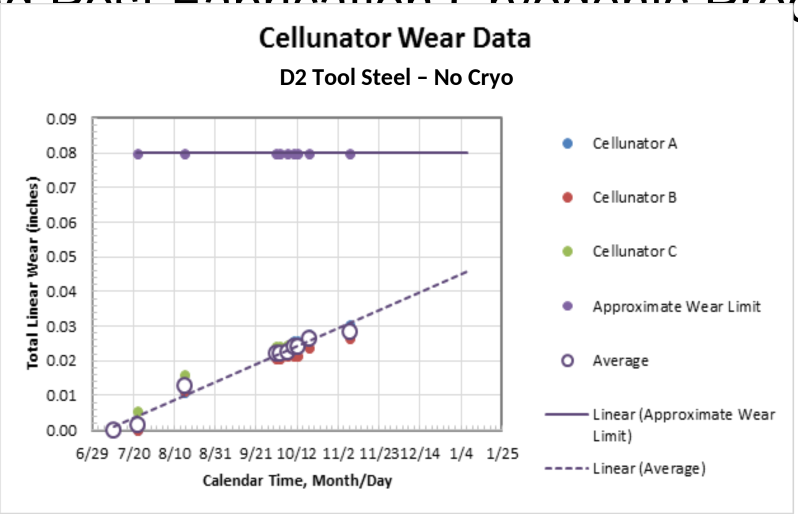
Equipment Wear

Cellunator

- In Service at Corn Ethanol Plants – Four Years
- Original heads – Duplex SS Lasted 9-12 months
- New Metallurgy – D2 installed now > 12 months
- Evaluating Post Fabrication Cryogenic Processing



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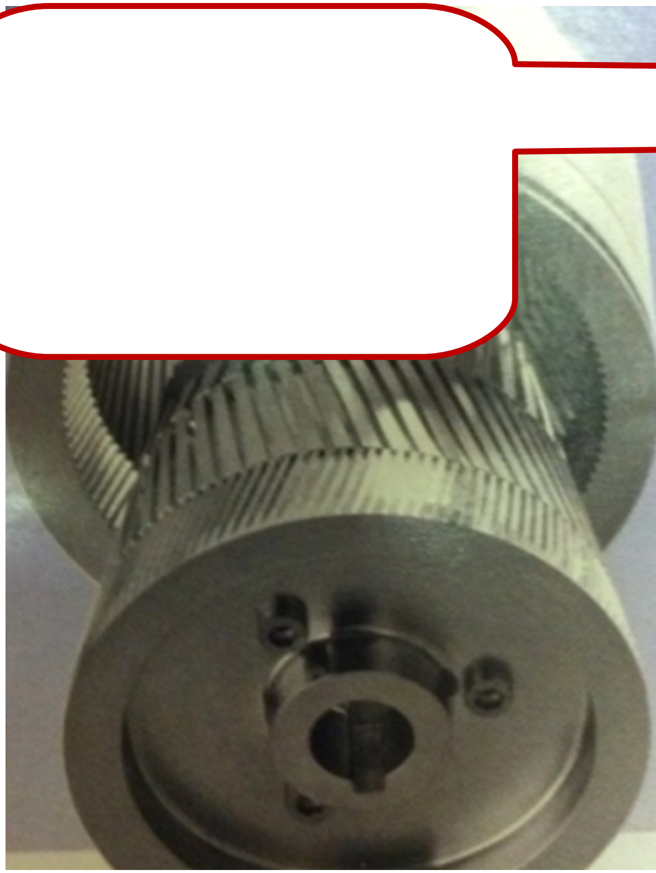
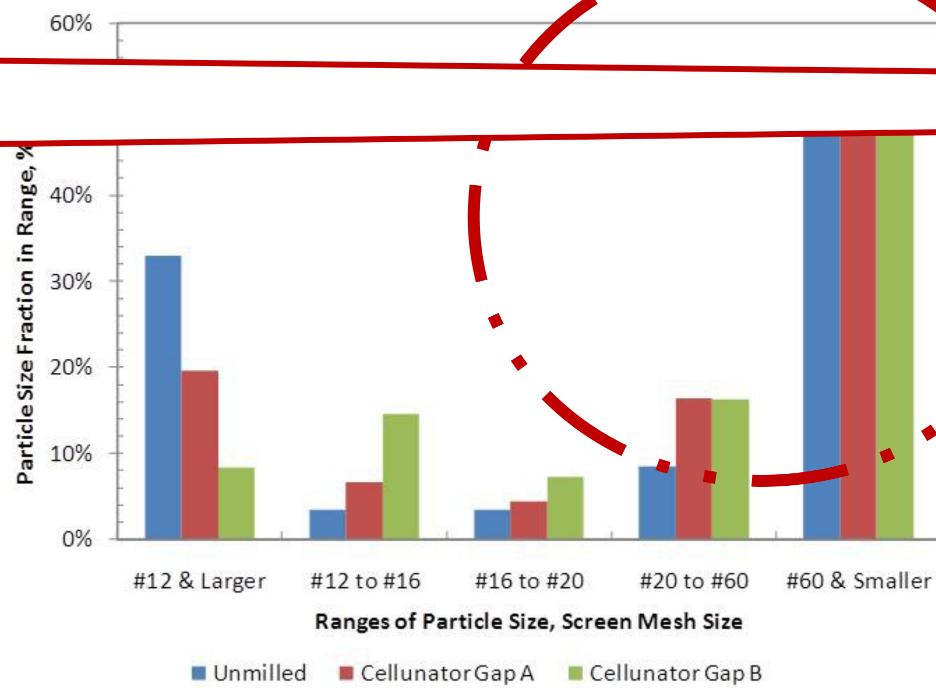
Adjustable Gap Setting

Tailor setting for target reduction and wear management





- **Reduces large Particles**
- **Does not increase fines**

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Cellunator Experience

- Operational since December 2009
- Capacity: ~1000 liters per min each @ 34% corn mash solids
- Low power draw: ~70 kw (may be 2x higher for cellulosic feeds)
- Maintenance: Replace heads annually

Installation at E Energy

Installation at Flint Hills

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Thermal Pre-treatment

History

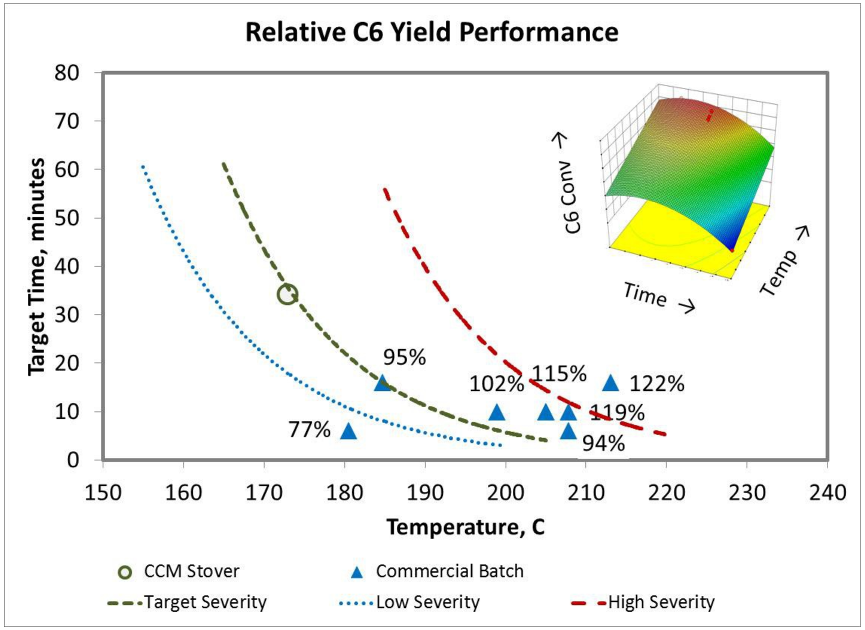
Lab Scale – One and Two Liter Batch
- Electrical Heating
- Agitation
- Cooling by Jacket Water

Bench Plant - 114 Liter Batch Pretreatment
- Jacket Steam Heating
- Agitation
- Cooling by Jacket Water

Pilot Plant – 1400 Liter Batch Pretreatment
- Steam Injection and Jacket
- Dual Agitation
- Final Conveyance by Pressure
- Cooling by Flash and Jacket

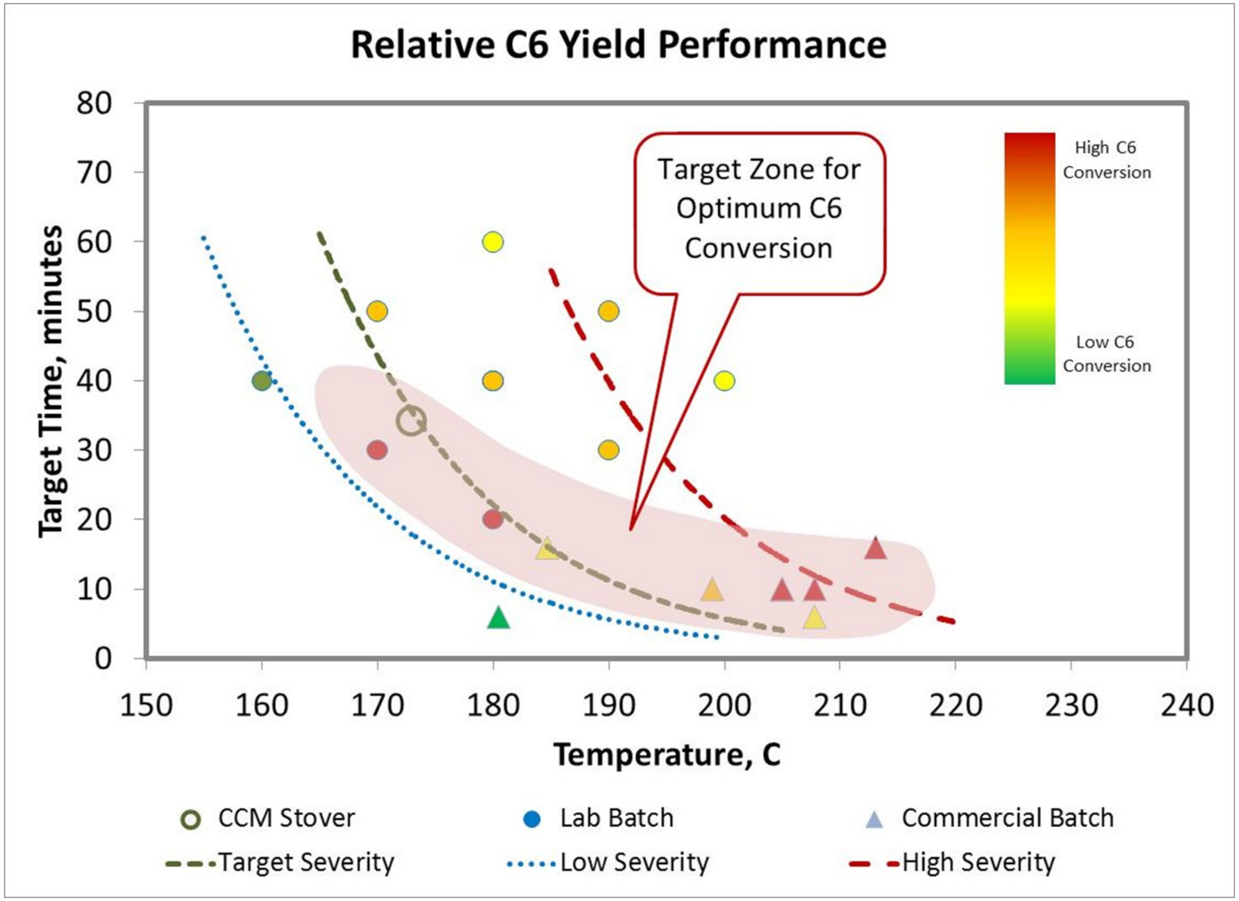
Demo - Batch (Caldema)
- Steam Injection
- No agitation
- Cooling by Flash

Pilot / Demo Continuous Pretreatment
- Integrated with MHD and Cellunator
- Steam Injection and Jacket
- Dual Agitation
- Final Conveyance by Pressure
- Cooling by Flash and Jacket



Thermal Pre-treatment

Goals: Testing indicates a wide range of effective conditions



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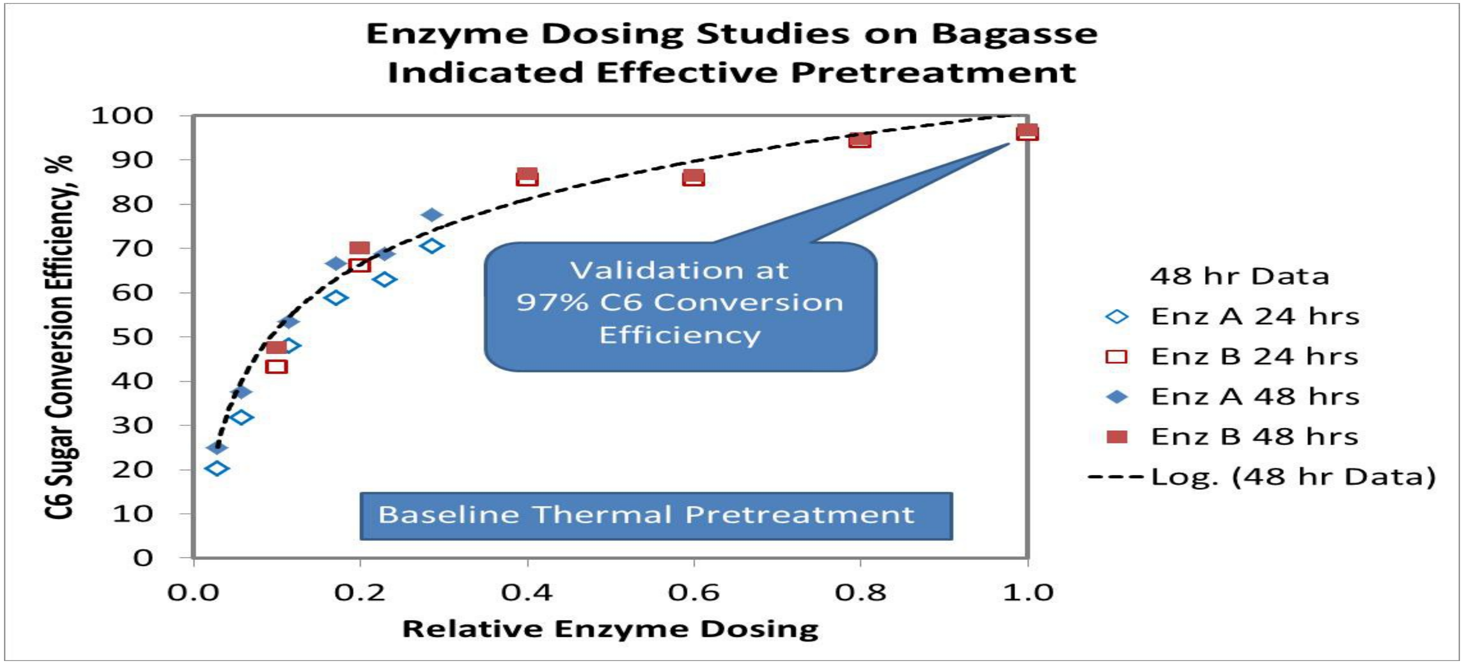
• Validated Max Pre-treatment

97% Conversion of C6 sugars validated



Batch - Thermal Pretreatment Conditions – 175C, 30 minutes

Saccharification done in batch reactors

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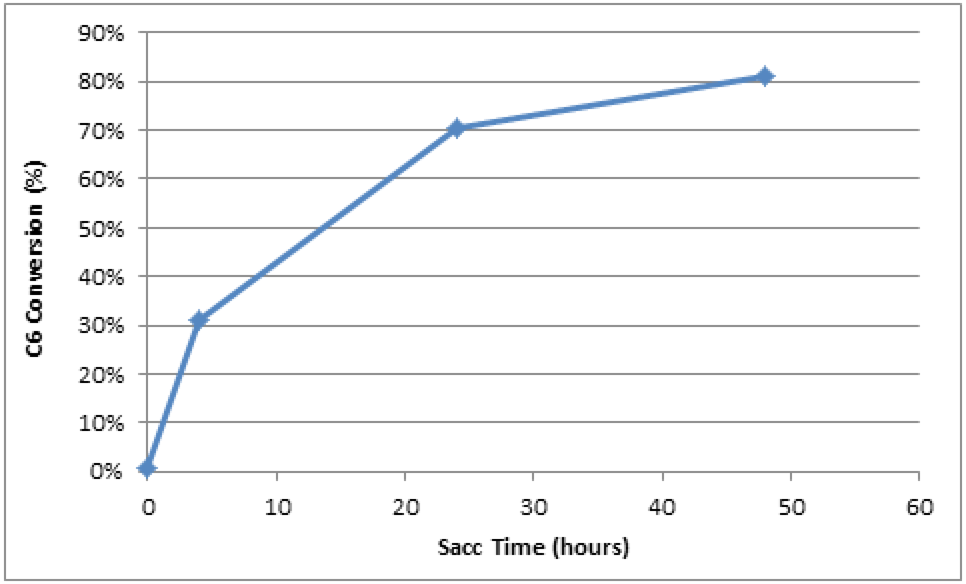
Validated Pre-treatment

81% Conversion of C6 sugars validated with Raizen Bagasse



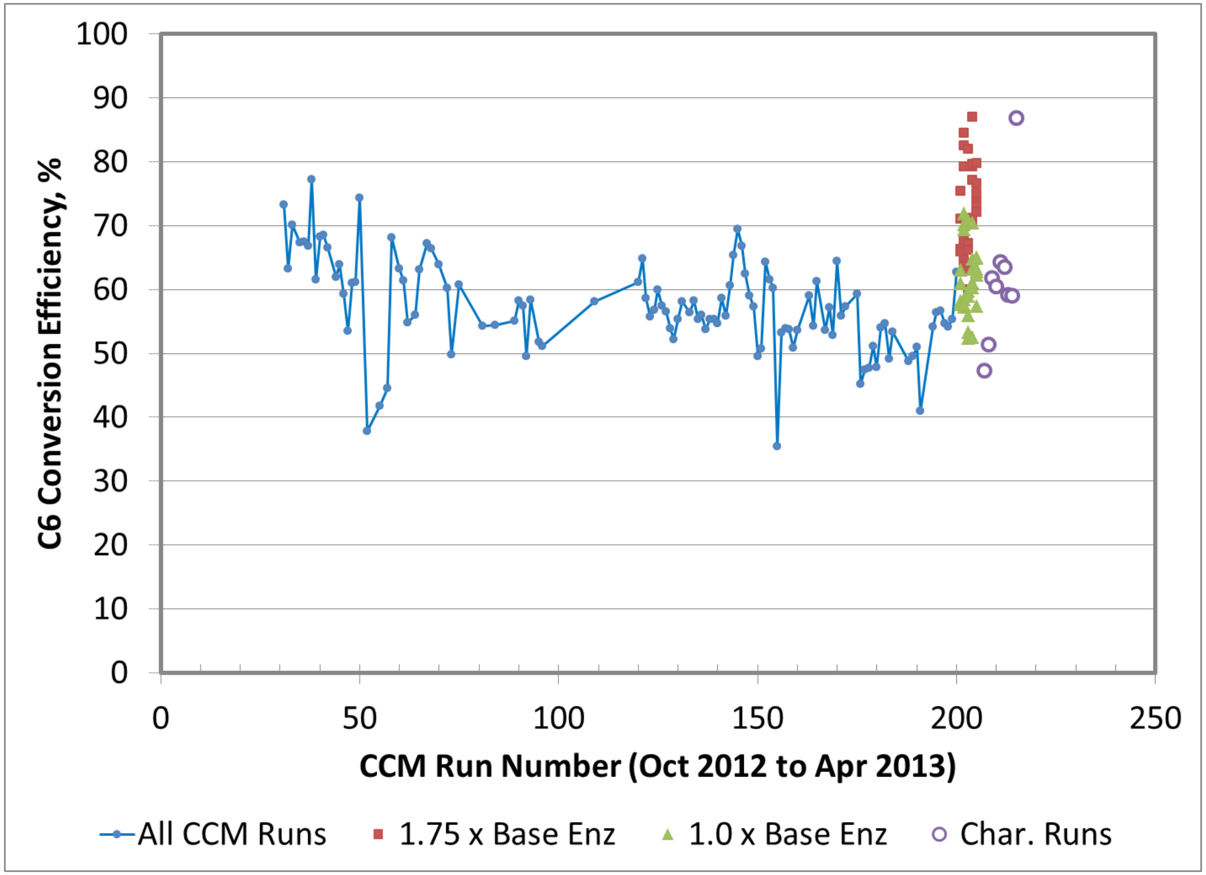
Batch - Thermal Pretreatment Conditions – 178C, 30 minutes

Saccharification done in bench scale (114 Liters)

Standard Enzyme and Additive Dosage

Validated Pre-treatment

86% Conversion of C6 sugars validated with Corn Stover



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Batch versus Continuous Evaluations

Aspect	Batch Method	CPT Method	CPT Advantages
Primary Feed Materials	50% Solids – Caldema 12% Solids - Batch	20% Solids	Complete hydration – Matches sacc. requirements
Feed Mechanism	Conveyance at ambient	Pumped in at P & T	No down-time = less reactor vol.
Mechanical PT	None	MHD and MK processing	>10% lift in conv. = less enzyme
Pressurization	Direct steam inj.	Pump	Independently controlled from T
Agitation & Mixing	Caldema = None CCM = Moderate	None. Not required, experimentally validated	n/a
Heating	Direct steam inj.	Direct steam inj. w/ homogenization (MK)	Faster and more homogenous = better reaction control and selectivity
Hold temperature	Limited to vessel spec.	Limited to piping spec.	Virtually unlimited for 300# pipe
Hold time	Heterogeneous	Homogenous	Better reaction control = higher yields and selectivity
Cooling	Additional tank is required	No additional storage required	Less tankage and footprint and fewer pumps
Steam Efficiency	25% - 50% (Batch Vessel Htg & Cooling)	80% - 90% (Continuous insulated vessel)	40% – 70% reduction in steam usage
Reactor	Custom fabricated pressure vessel	Off-the-shelf piping with instrumentation	Cost-effective, modular, no moving parts, maintenance-free

Pre-treatment

Variables Impacting C6 Conversions

- Many variable levers in pretreatment that can be used to increase C6 conversions

Pre-treatment Variable	Description	Impact
Hold Temperature	Higher Temperature to open up biomass for enzymes	Medium
Hold Time	Higher Residence Time increases C6 conversion, too long can create inhitiors and destroy sugars	Medium
% Solids	Lower solids has higher C6 conversions compared to higher	Low
Cellunator	Impact of different gap sizes on bagasse	Medium
Hydration, Water Retention, Recalcitrance	Impact on access to cellulose	High

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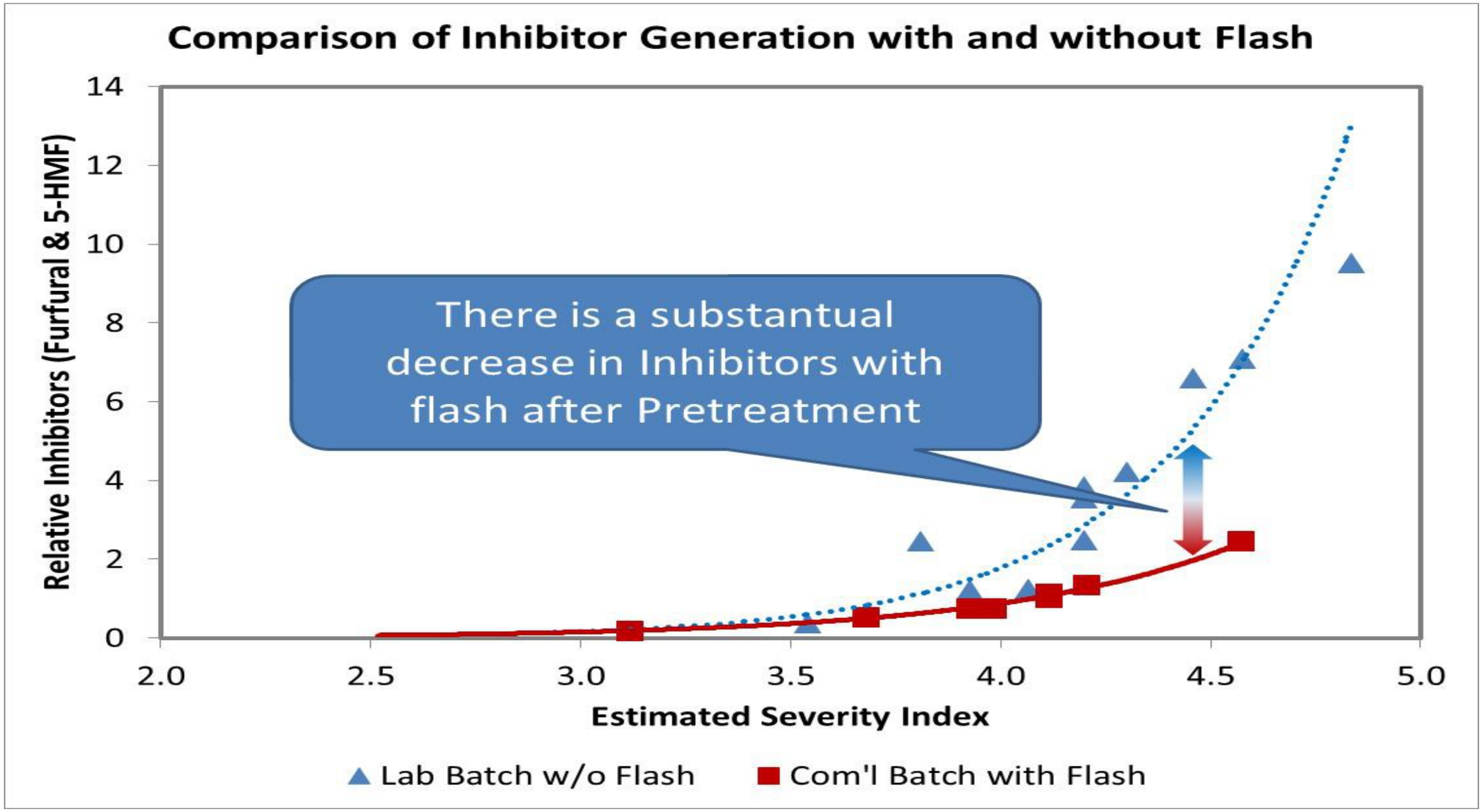
• Severity Index

Severity Relationship to Impurities and Inhibitors



Solid Separation

Solid Separation Input

Baseline

Solids From Saccharification Augers → Slurry Purge: Concentration of Solids → Boilers

Opportunities

Sugars
Enzymes
Additive
Unreacted Glucan
Lignin
(Less than 30% Solids)

→

Slurry Purge
Recover Sugars
Recover Enzymes
Recover Additive
Recover Unreacted Glucan

→

Remaining Lignin rich solids with higher heating value to Boiler

↓

Recover and Recycle Back to Liquid Separation

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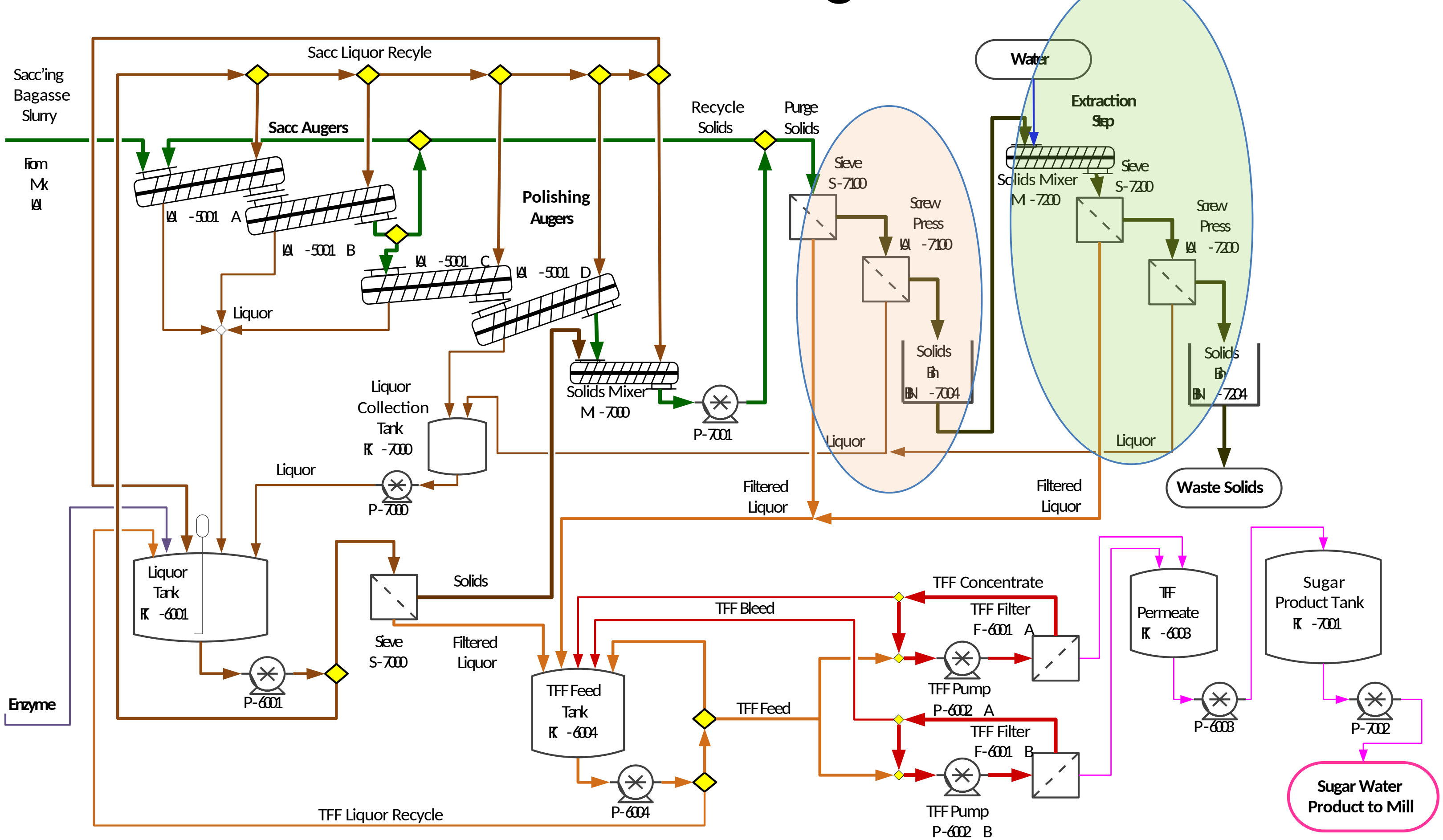
Solid Separation

Process Flow Diagram - Visalia



Solid Separation

Processed Solids

Lignin Rich Solids
is returned to the Boiler

↓

100% of lignin and must meet
Boiler specification

↓

Required for Energy

Solid Separation

Baseline Data for Cogeneration Feed Stream

	%-Solids
Purge Stream	20-30
Cake (No Steam)	38
Cake (Heated)	51

Requirements:

- Boiler Feed Specification is for ~50% moisture
- Physical Property requirements to be collaborated on with Simisa

Impacts:

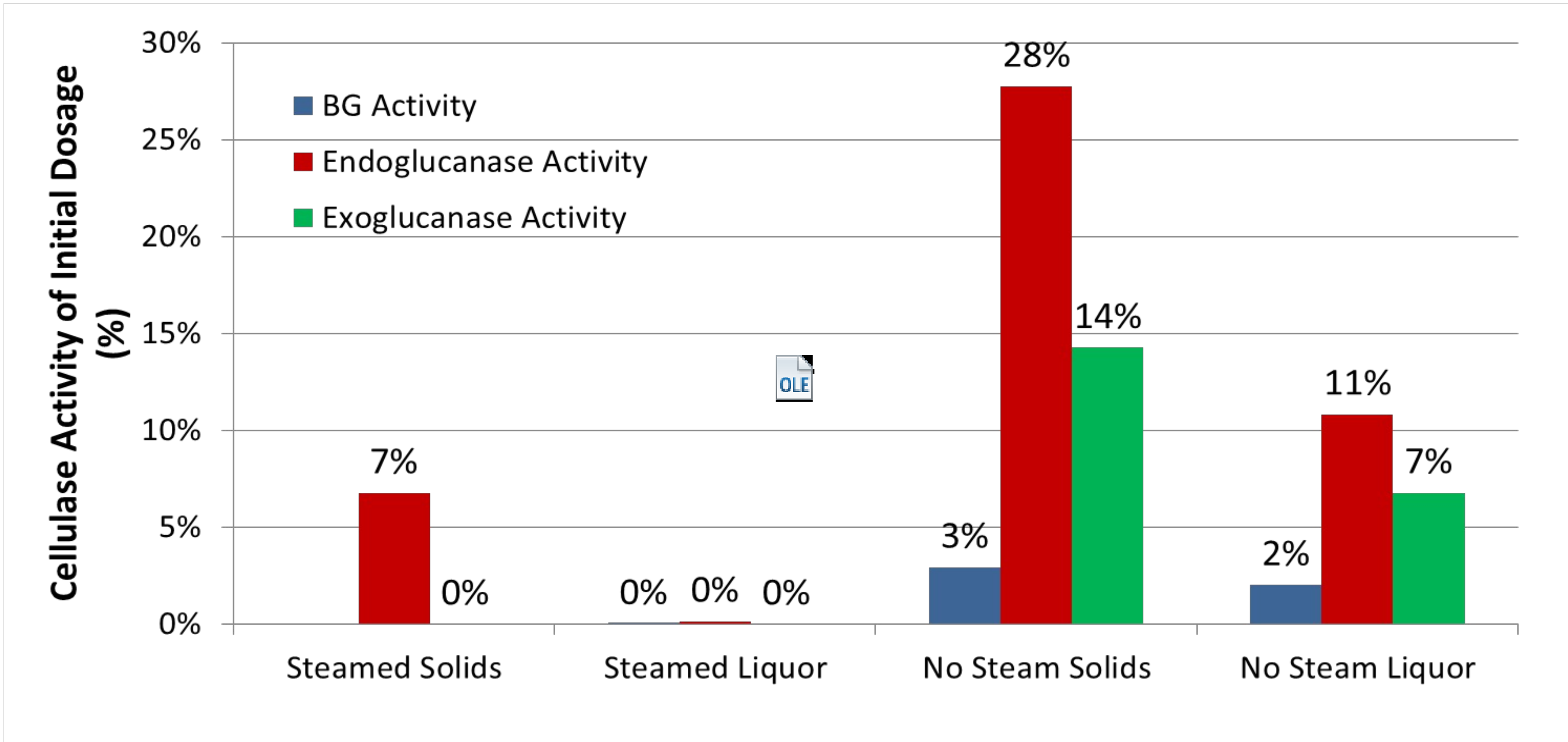
- Higher water & sugar recovery with steaming in screw press (higher cake solids %)
- 100% of unreacted glucan and 100% of lignin leaving in cake solids
- Reduced cellulosic activity with steaming
- Measured Heating Value of Lignin Rich solids is 15-30% greater than bagasse on wet basis

  Range is dependent on moisture and ash levels of bagasse feedstock

  Range is dependent on moisture, lignin, and unreacted biomass in Slurry Purge

Solid Separation

Baseline Data for Enzymes



Reduced cellulosic activity with steaming (high % of enzyme activity left in solids)

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- # Solid Separation

Reactants, Additive & Product Loss

Slurry Purge contains

↓

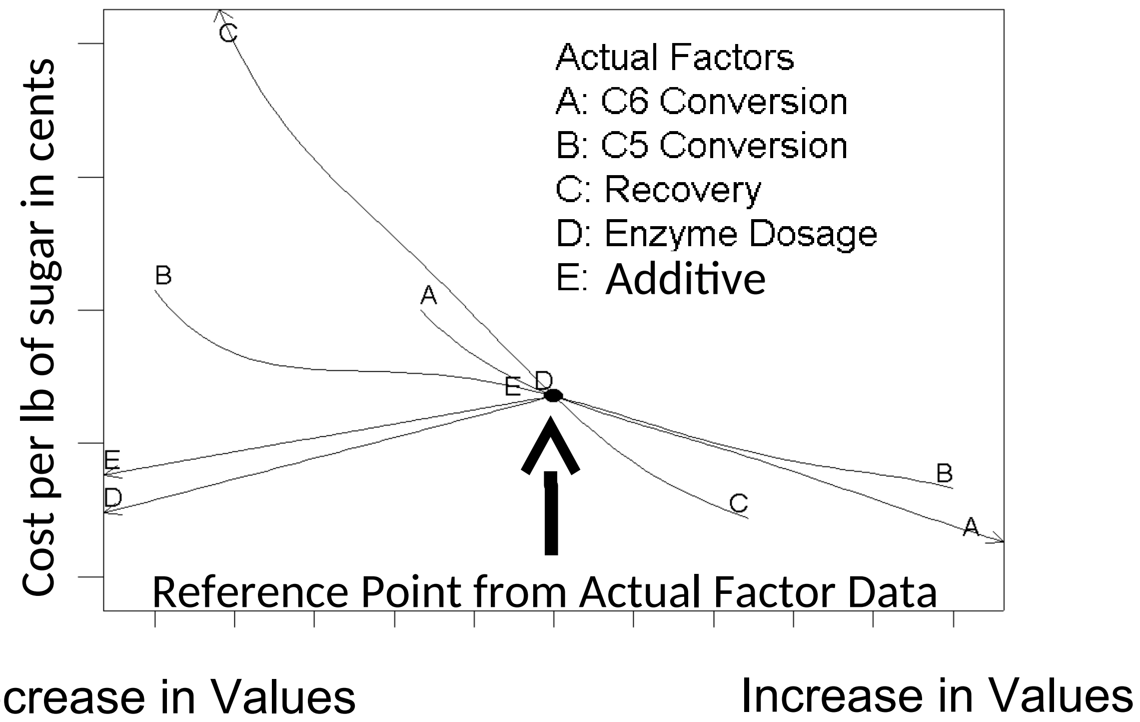
7% of produced glucose
93% of additive added to process
95% of enzyme added to process
100% of unreacted glucan

↓

High Value for Recovery

Solid Separation

Impact on Cost – Economic Cost Model



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- Solid Separation

Economic Design of Experiment

Opportunity:

Extract and/or recycle –

sugar
enzymes
additive
unreacted glucan

- Boost in recovery % numbers for sugar
- Lower additive & enzyme addition by recycling
- Reduce cost of sugar (¢/lb)

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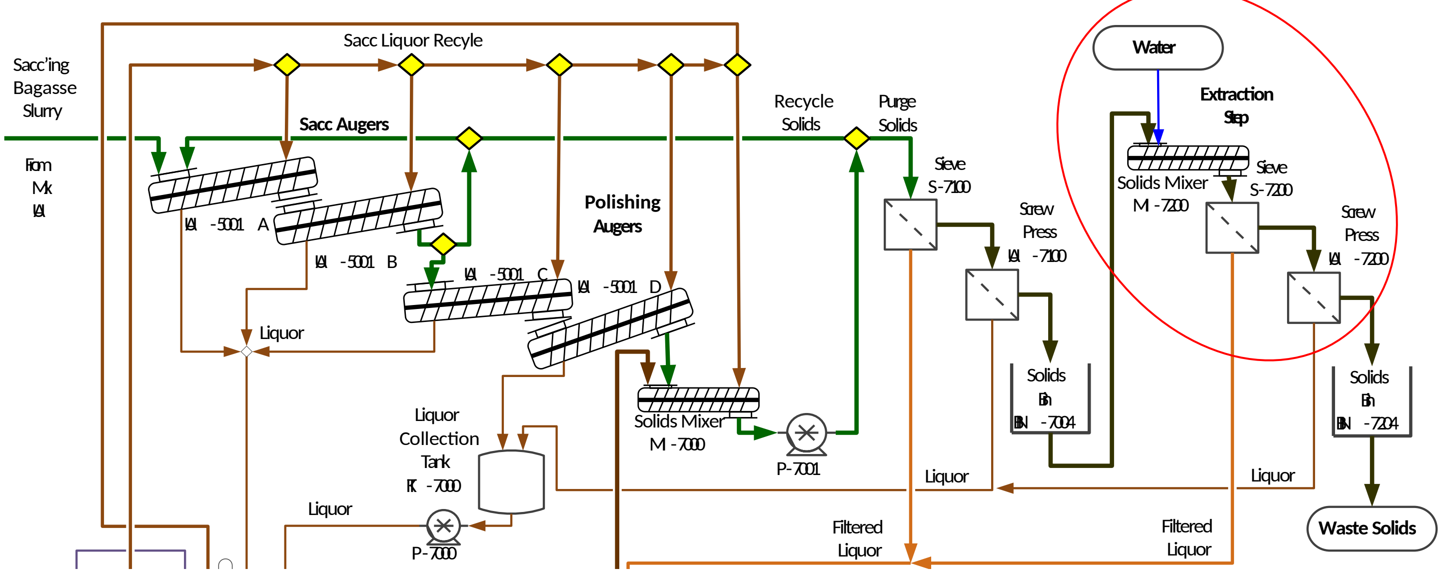
Solid Separation

Evaluating New Methodologies

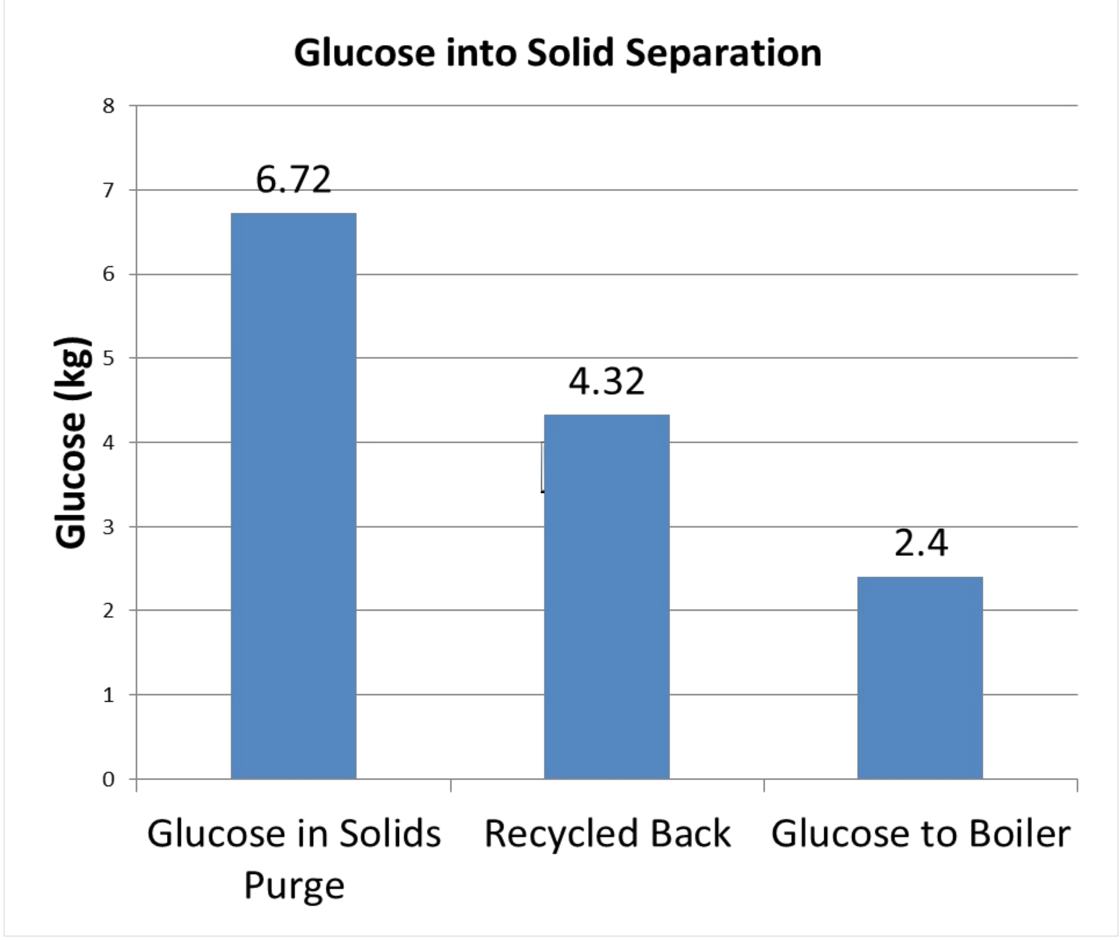
Sugar Recovery

1. Extraction Step
   - Using screw press, auger, sieving screens equipment (extra capital cost)
   - Adding water to remove trapped sugar, enzymes, & additive



Solid Separation

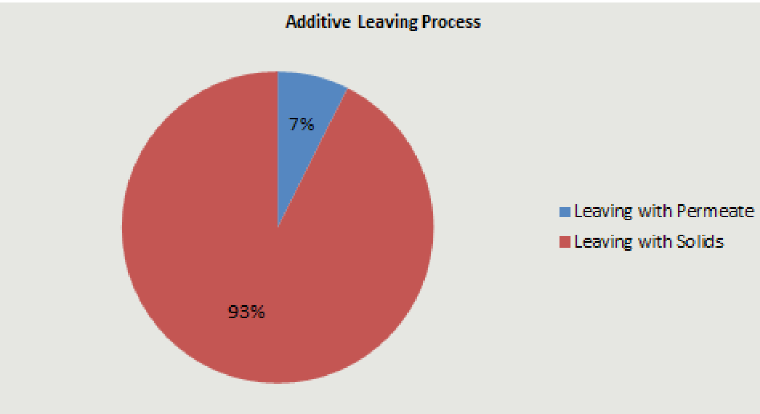
Extraction Step – 1st Pilot Plant Test



- Currently ~10% of sugar produced goes to boiler with solids
- Extraction recovered 64% of "waste sugar"
- Potential to exceed sugar yield target of 85%

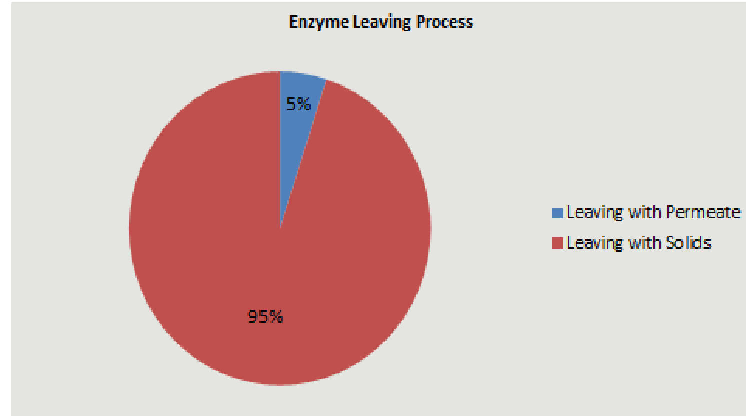
Solid Separation

Baseline Data for Additive



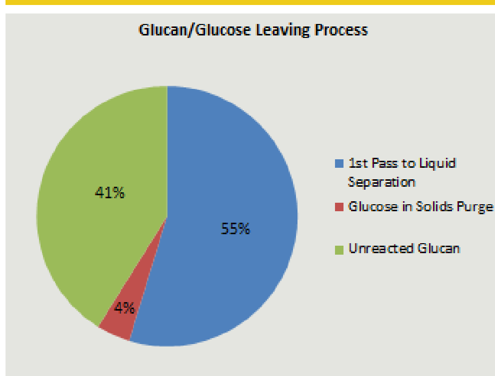
Solid Separation

Baseline Data for Enzyme



Solid Separation

Baseline Data for Sugar



- Data from run 237

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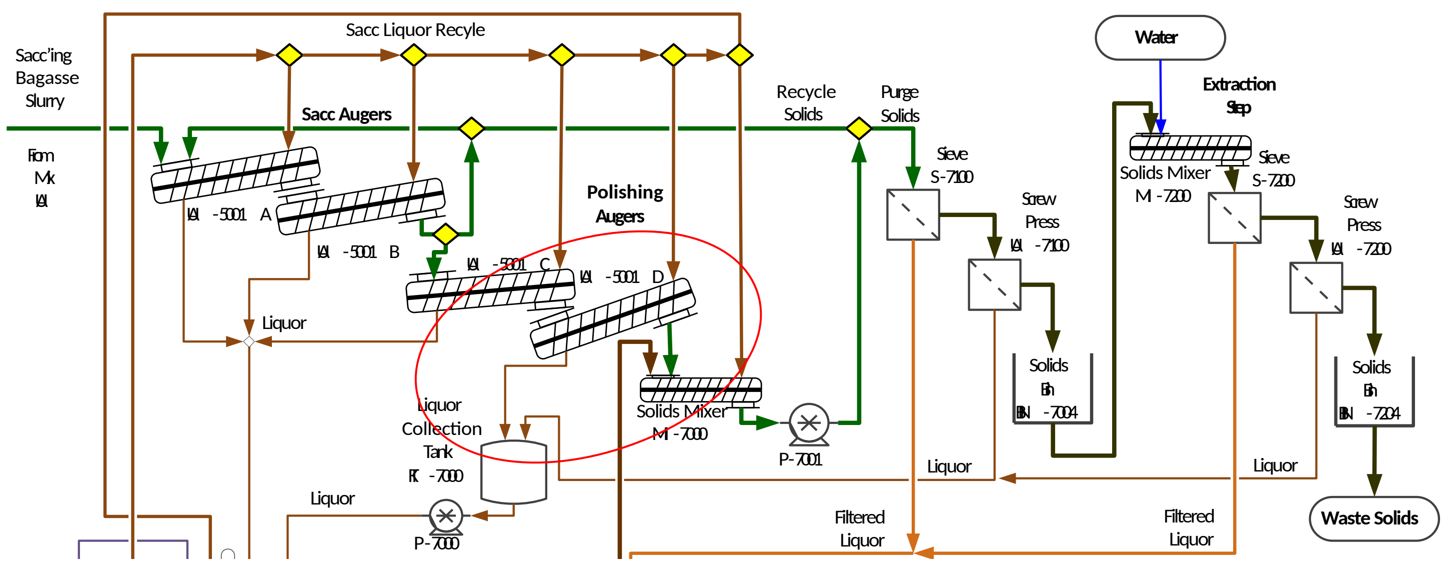
Evaluating New Methodologies

Enhanced Saccharification Slurry Purge

1. Agitating Material
   - Mixing bagasse at higher solids increases sugar concentration
   - Auger showed greater increase compared to control flasks
2. Polishing Step – smaller equipment for longer saccharification



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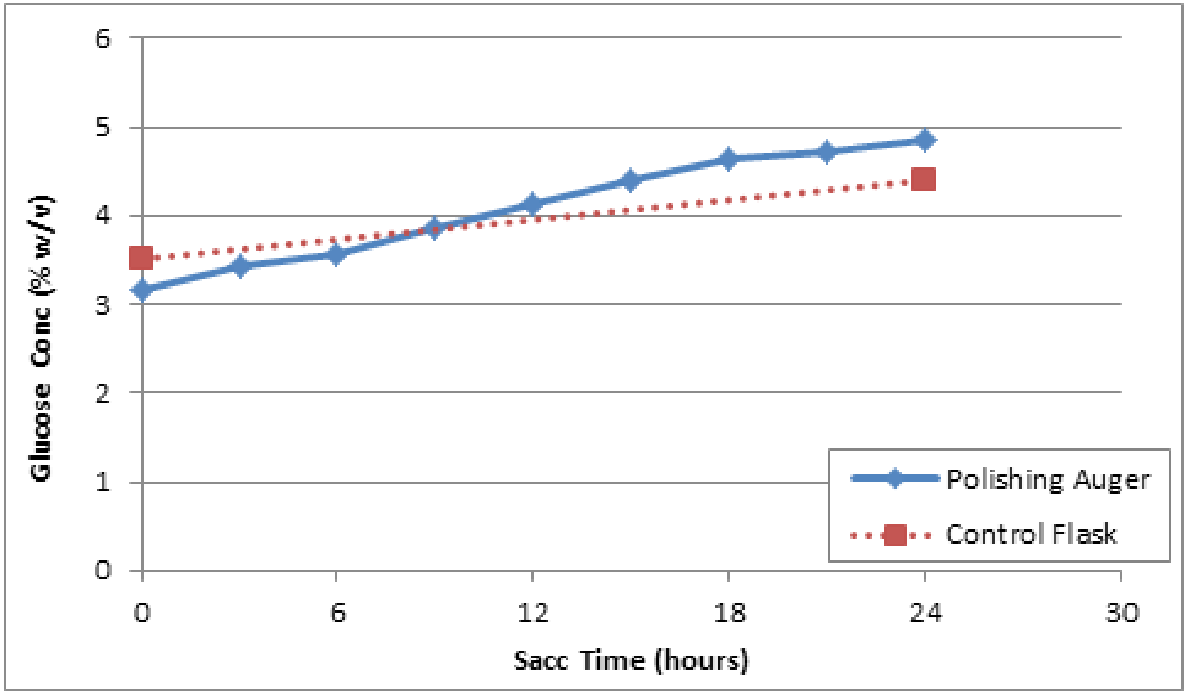
Solid Separation

Enhanced Saccharification (Agitation + Polishing Step)



- Increased agitation showed higher glucose concentration
- Glucose concentration increased with polishing auger
- Need to determine economics of additional capital versus conversion

Summary

Solids Separation Greatly Impacts Economics

- Lignin Rich Solids
- Can meet moisture specification
- Has higher heating value

- Recycle opportunities
- Recycle more additive and enzyme reducing requirements
- Recover more produced sugars
- Increase reaction conversion

Downstream Impact on Ethanol Process

Questionnaire and Discussion with Partner

- Safety and Process Hazard Analysis
- Engineering Requirements
- Utility Interface
- Downstream Processes
- - Fermentation
- - Yeast Recycle
- - Distillation
- - Boiler and Co-Generation
- Downstream Products and By-products

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Downstream Process Impact

Impacts on Other Systems

Studies Planned for Brazil Demo Plant Operation

- Sugar Liquor
  - Concentration, Specification
- Off Spec Sugars
  - Impact of C5
- Yeast Recycle -
  - Impact of Insoluble Solids
- Other Co-products –
  - Impact On…

Distillation -

Impact on Reliability

Vinasse –

Impact on Fields

Solids Waste –

Impact on Cogen

Waste Water –

Quality and Quantity

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Yeast Fermentation

Test Plan: 6-17-2013 Padma/Marie/Mike/John Zhang:

- **Bagasse solution: permeate from Visalia auger run #20.**
- **Brazil yeast adapted with 4% Molasses and 10% saccharified bagasse for 4 hours**
- **Add 10 ppm Lactrol & Allpen.**
- **Fermentation @ 34C, 150 rpm for 24hrs.**
- **At T0, T4, T8 hours take out sample for measure sugar and inhibitor levels.**

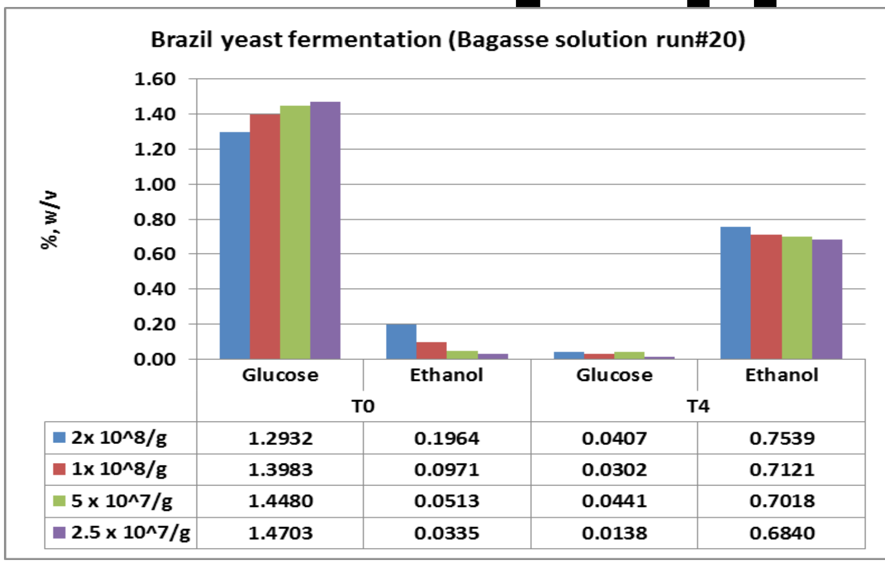
Flask#	Biomass (g)	yeast
1	100g	2x 10^8/g
2	100g	2x 10^8/g
3	100g	2x 10^8/g
4	100g	1x 10^8/g
5	100g	1x 10^8/g
6	100g	1x 10^8/g
7	100g	5 x 10^7/g
8	100g	5 x 10^7/g
9	100g	5 x 10^7/g
10	100g	2.5 x 10^7/g
11	100g	2.5 x 10^7/g
12	100g	2.5 x 10^7/g

T0 Sugar						
Glucose	Xylose	Arabinose	Lactic acid	Glycerol	Acetic acid	Ethanol
1.4703	1.3004	0.0792	0.0401	0.0158	0.2885	0.0335

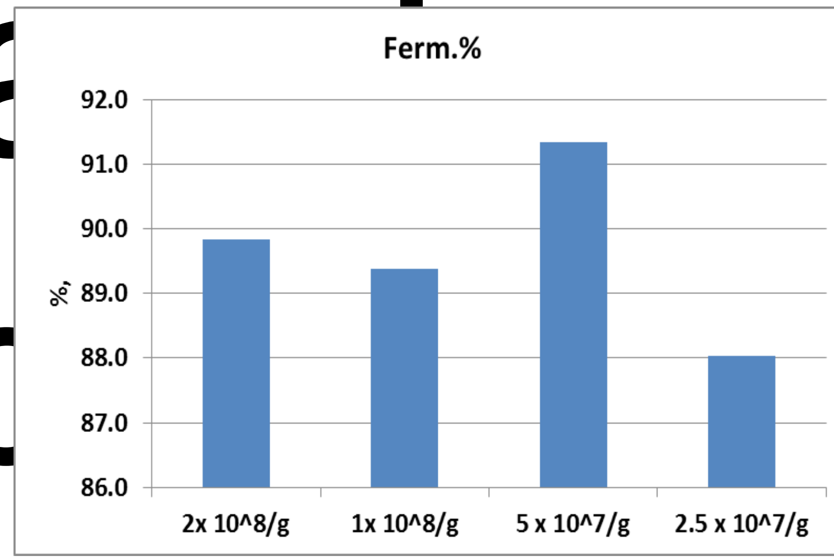
T0								
Furolic acid	5-HMF	Furfural	4HBA	Syringic acid	Vanillin	Syringaldehyde	Coumaric acid	Ferulic acid
27.7	108.9	746.2	44.9	25.4	59.7	98.3	15.8	37.4

	Acetic acid (%)	5-HMF (ppm)	Furfural (ppm)	Glucose (%)
15% solid	0.5	225.0	2250.0	4.5
30% solid	0.9	450.0	4500.0	9.0

Yeast Fermentation



	T0 Glucose	T0 Ethanol	T4 Glucose	T4 Ethanol
2x 10^8/g	1.2932	0.1964	0.0407	0.7539
1x 10^8/g	1.3983	0.0971	0.0302	0.7121
5 x 10^7/g	1.4480	0.0513	0.0441	0.7018
2.5 x 10^7/g	1.4703	0.0335	0.0138	0.6840



Glucose reduction:

Observation:

- Brazil yeast (adapted) finished glucose fermentation (permeate from 10% of bagasse saccharification) at 4 hours with Brazil yeast loading of 2.5 x 10^7/g.
- The efficiency of glucose convert to ethanol is around 88-91%.

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Yeast Fermentation

Inhibitor levels:

T0								
Furolic acid	5-HMF	Furfural	4HBA	Syringic acid	Vanillin	Syringaldehyde	Coumaric acid	Ferulic acid
27.7	108.9	746.2	44.9	25.4	59.7	98.3	15.8	37.4

	T4 Inhibitors								
	Furolic acid	5-HMF	Furfural	4HBA	Syringic acid	Vanillin	Syringaldehyde	Coumaric acid	Ferulic acid
2x 10^8/g	42.9	63.8	2.3	19.2	21.9	37.6	73.7	8.6	32.6
1x 10^8/g	41.7	55.7	4.2	18.8	19.8	39.5	91.6	7.7	39.4
5 x 10^7/g	45.2	53.3	6.8	19	19.9	38.6	93.3	7.2	40.4
2.5 x 10^7/g	47.7	56.3	8.1	20.9	19.5	37.8	100.2	7.4	40.2

Observation:

- After 4 hours fermentation, furfural and 5-HMF concentration dropped to very low levels (furfural from >700ppm to < 10ppm).

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CSP Scope – Process Scale-up

Visalia Pilot designed to inform/ optimize Brazil operations

Visalia Pilot Plant

- 1 dry ton/day
- Test Continuous Pretreatment Processes
- Integrated with CCM Pretreatment and Solid / Liquid Separation systems
- Gather metrics for scale-up to a commercial-sized facility
- Operated Sacc Augers and Sugar Recovery since Q1 2013
- Test Recycle and Recovery Processes
- Multi-day to Multi-week runs

Brazil Demonstration Plant

- 10 dry ton/day (1/30 Commercial)
- Located on Usina Vale's sugar cane ethanol mill
- Bagasse supply onsite
- Return lignin rich solids
- Product sugars feed supplied to existing fermentation
- Bolt-on to mill's utilities and operations
- Demonstrate feasibility and metrics of near commercial operation
- In construction

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Continuous Sugars Pilot (CSP)

PROCESS FLOW DIAGRAM