



Direvo
Engineering Biomass

BIO 10th World Congress on Industrial Biotechnology

June 17, 2013

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www.direvo.com

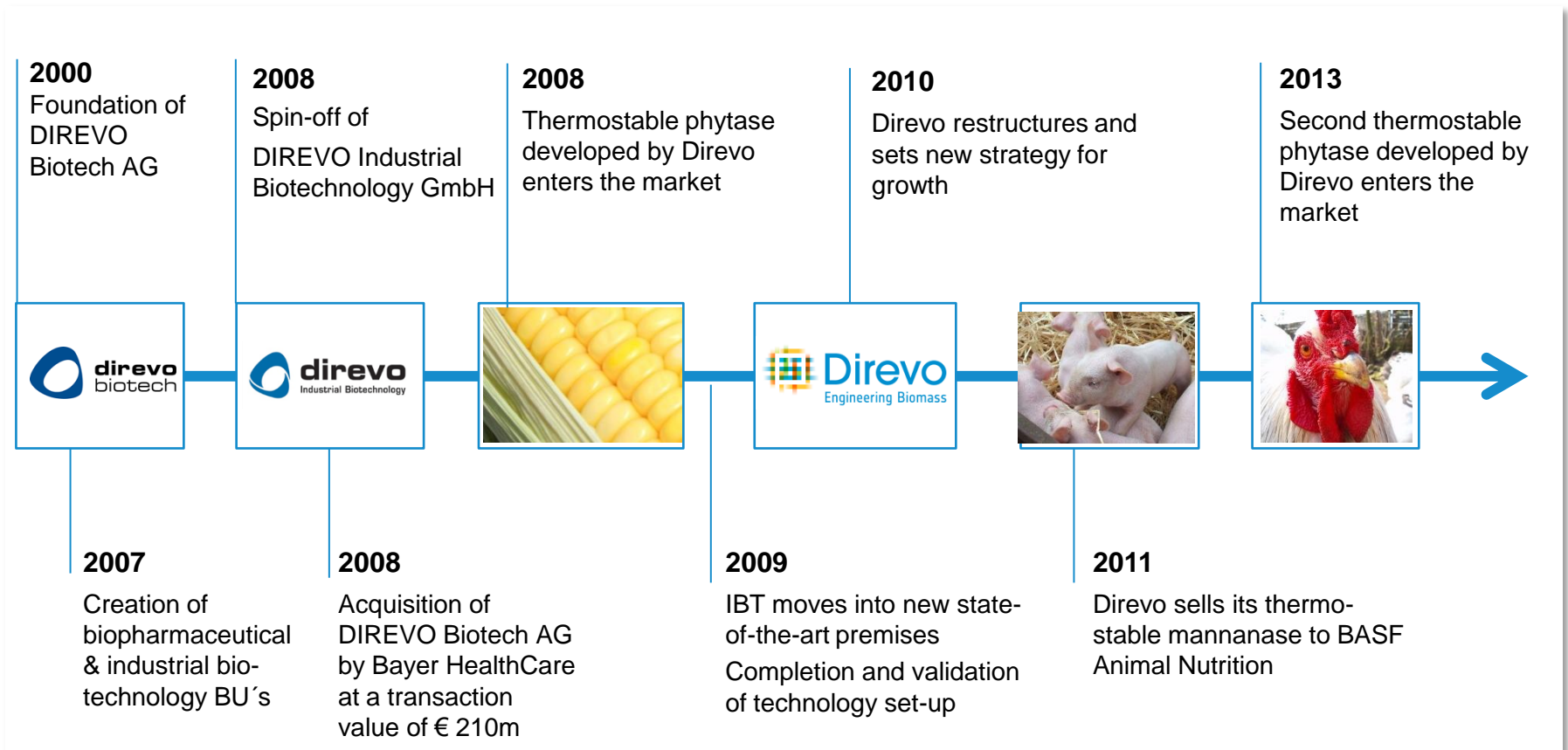
Our Mission

Direvo's profound know-how and expertise in the development of **bio-based technologies** positions us perfectly to

- deliver **proprietary solutions** allowing the best use of biomass while maximizing profitability
- create **new technologies** for the sustainable conversion of non-food **biomass to biofuels and chemicals** at lowest cost

Company

History



Direvo business overview

DIREVO is a leader in biocatalyst optimization for various industrial applications



- **BluServ™** covers the technology platform and services offered to the industry for enzyme engineering, strain development and fermentation processes.








- **BluZy®** is a line of enzyme based products targeting the US grain and animal feed industry



- **BluCon®** is a process platform developing new lignocellulose conversion processes.

Track record in enzyme engineering

Direvo has proven its ability to optimize enzymes to meet customer and market requirements

Product	Enzyme	Optimized parameters	Application	Customer	Market launch
BP-17 / 111	Phytase	Thermo stability pH resistance Protease stability Specificity		Genencor	since 2008
BP-17/111	Phytase	Thermo stability pH resistance Protease stability Specificity		Danisco	2013
PIN K224	Mannanase	Specific activity thermo stability pH/protease resistance		Sold to BASF in 2012	
CEL 1E	Cellulase	Specific activity		Proprietary	Patents granted
CEL 2D	Cellulase	Specific activity		Proprietary	Patents granted
	Protease	Specificity, activity	Biocatalysis	Confidential	Running project

BluZy®: Improving economics along DDGS value chain

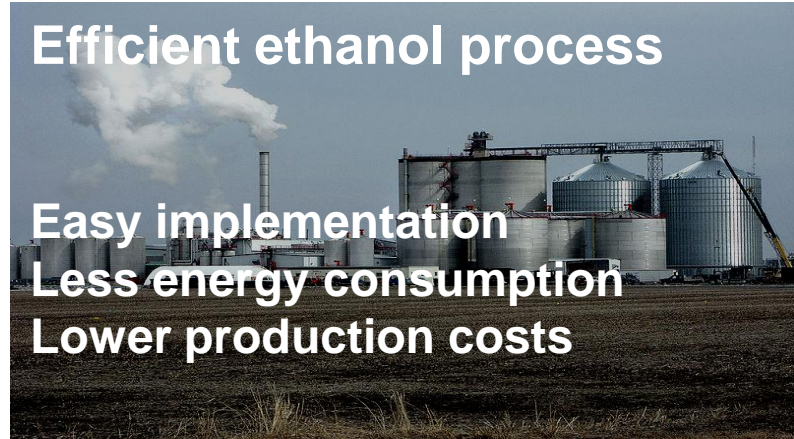
BluZy®-P

Efficient ethanol process

Easy implementation

Less energy consumption

Lower production costs



BluZy®-D

Premium Feed Product

High Value DDGS

High Inclusion Rates

Lower Feed Cost



BluCon®

by Direvo Industrial Biotechnology GmbH



Direvo BluCon®

Direvo's BluCon® high-temperature consolidated bioprocess, a substrate and product flexible approach to low-cost biofuels and biochemicals

BluCon®

A bio-based economy needs cheap sugar – and a lot of it !

Key-Drivers

Cash

Low feedstock price

CAPEX (Steel + Mortar)

OPEX

Availability

Easy storage

Secured supply

Stable pricing

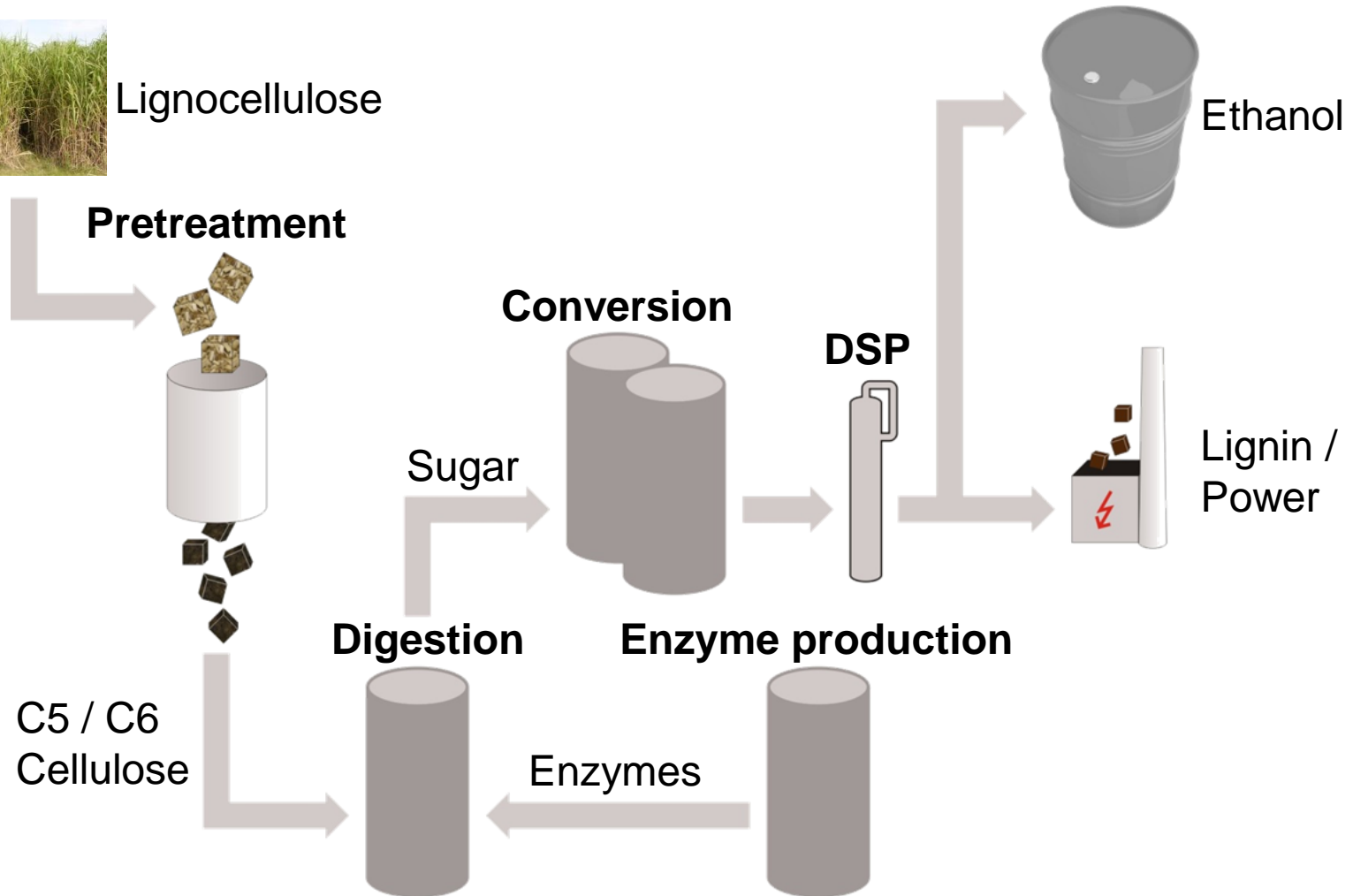
Reduction

of Green house
gas emission

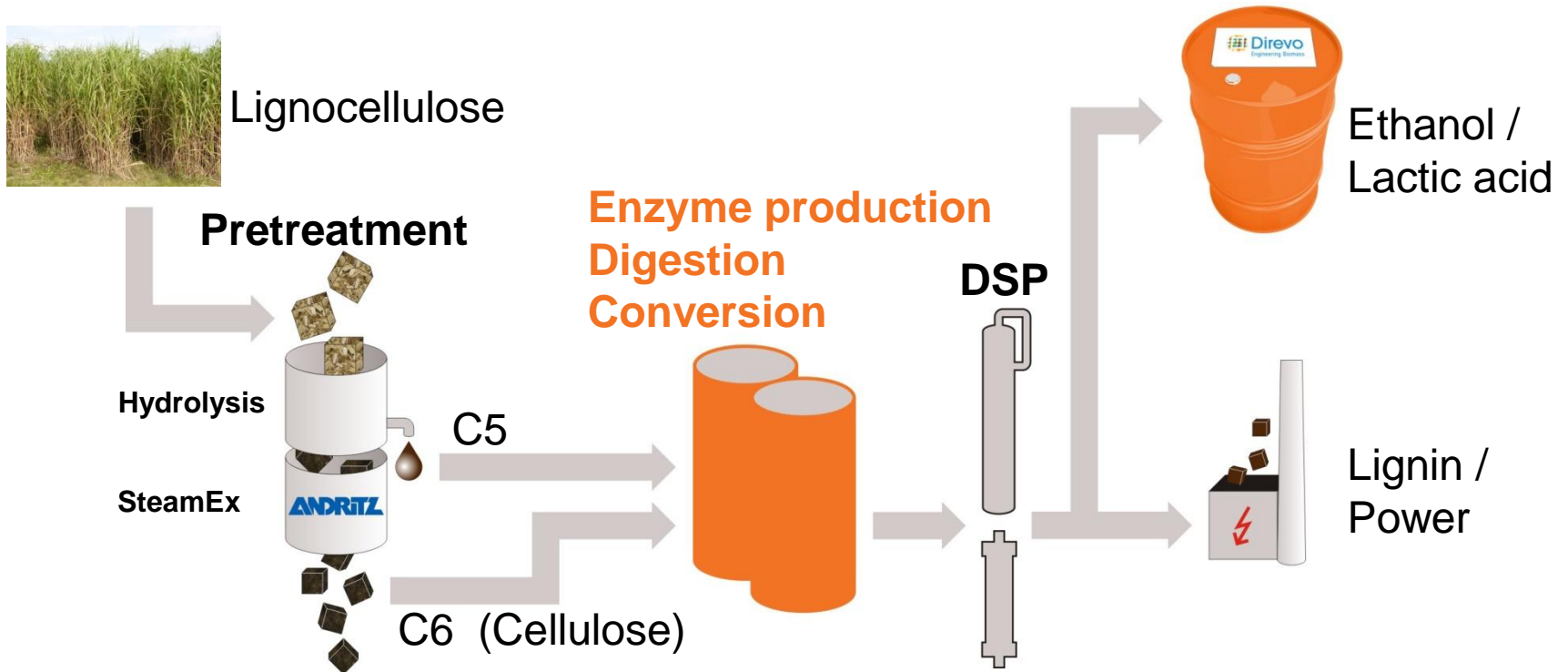
Established 2G process – SHF (no BluCon®)



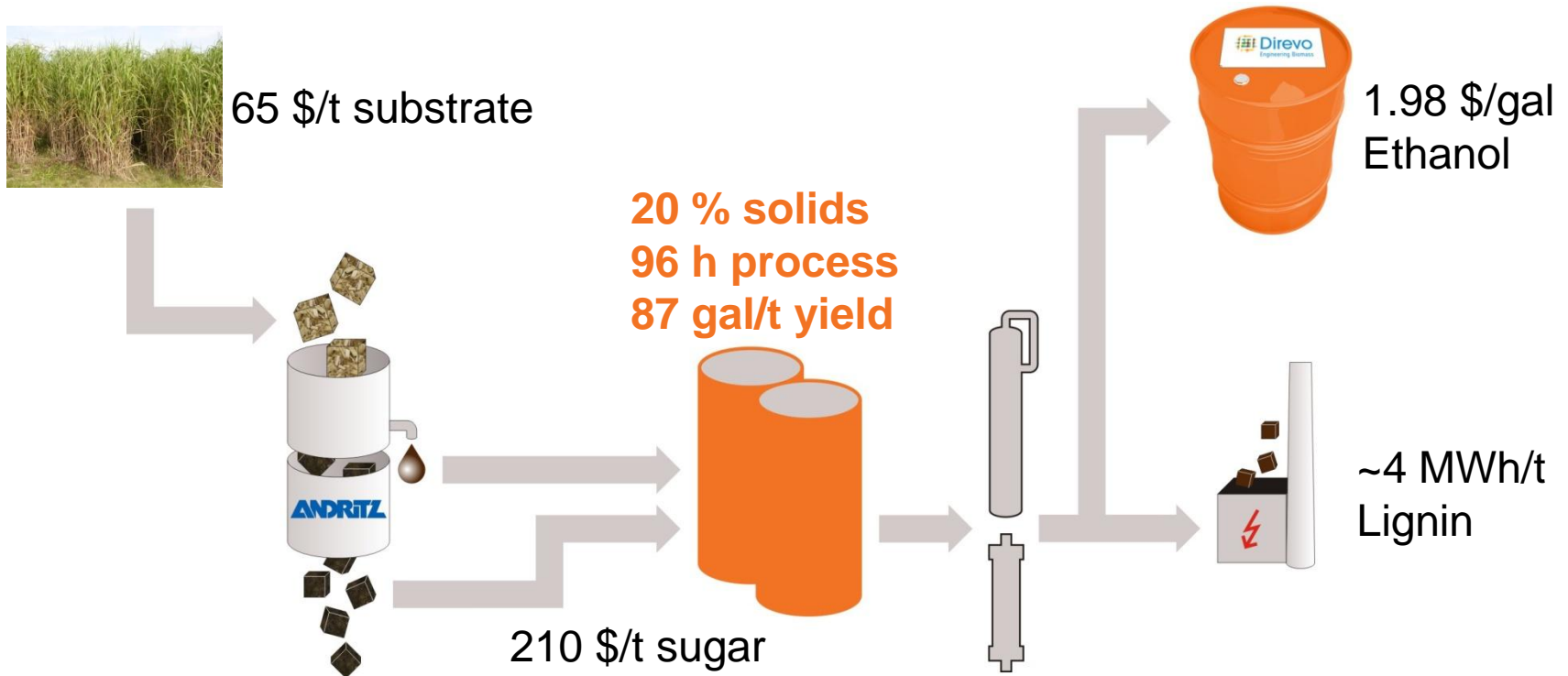
Lignocellulose



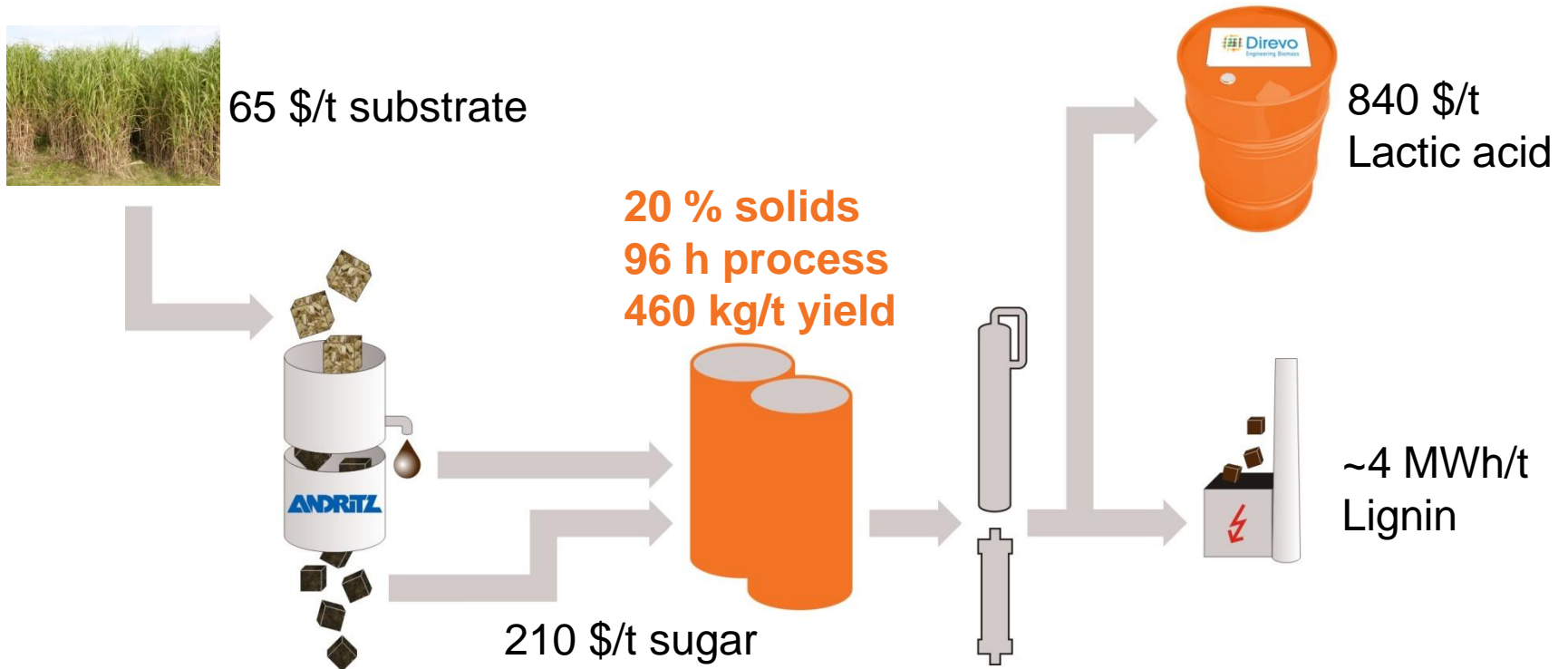
BluCon® - Consolidated Bioprocessing



BluCon®-E: Target production cost



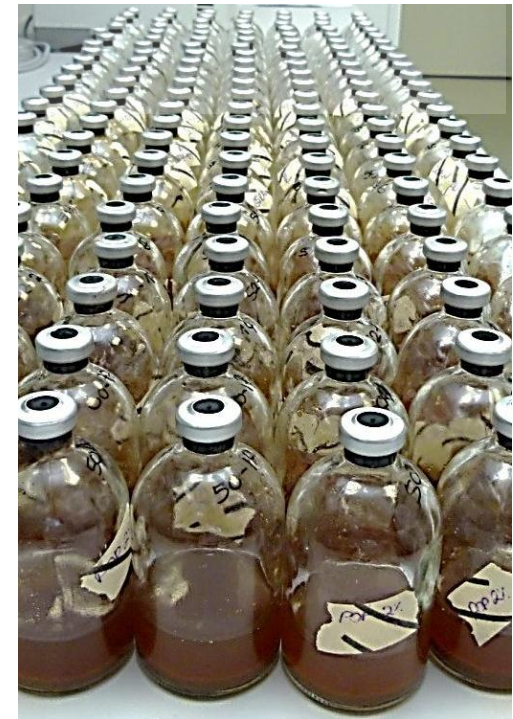
BluCon®-L: Target production cost



BluCon – IP portfolio strains

- 12 patent files on strains, processes, products and applications
- 7 proprietary *Caldicellulosiruptor* isolates
- 8 complementary *Thermoanaerobacter* isolates

- | | |
|------------------|---------------------|
| ■ US 61/537,892 | ■ PCT/EP2012/069808 |
| ■ US 61/544,831 | ■ PCT/EP2012/069809 |
| ■ US 61/556,448 | ■ PCT/EP2012/069810 |
| ■ US 61/669,962 | ■ PCT/EP2012/068627 |
| ■ US 61/ 669,981 | ■ PCT/EP2012/068628 |
| ■ US 61/669,998 | ■ PCT/EP2012/068629 |



BluCon® – substrate base + pretreatment



- ~ 20 substrates tested:
up to 100 % yield
 - Hard-, softwood
 - Bagasse
 - Perennial grasses
 - Oil palm residues
- Pretreatment scaled up

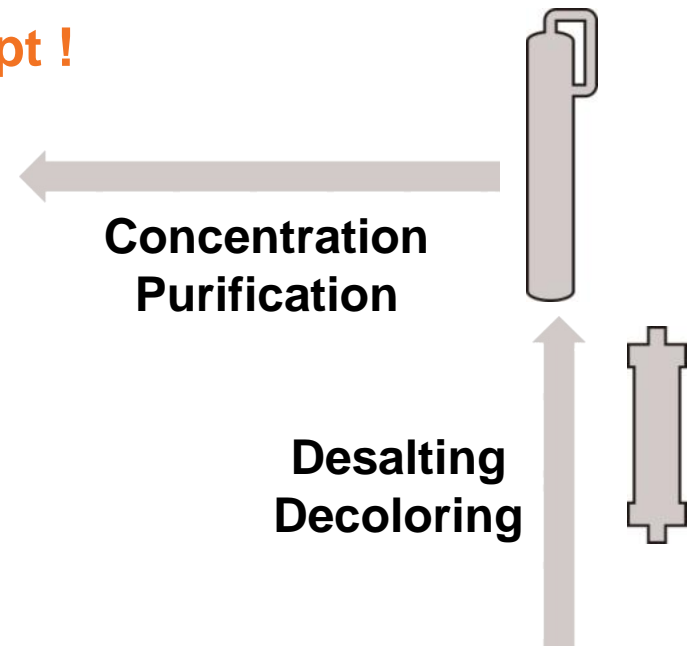


BluCon® – development – downstream processing –



**Fermentation
Scale-up**

**Lactic acid purification:
Proof of concept !**



**Separation
Desalting
Softening**

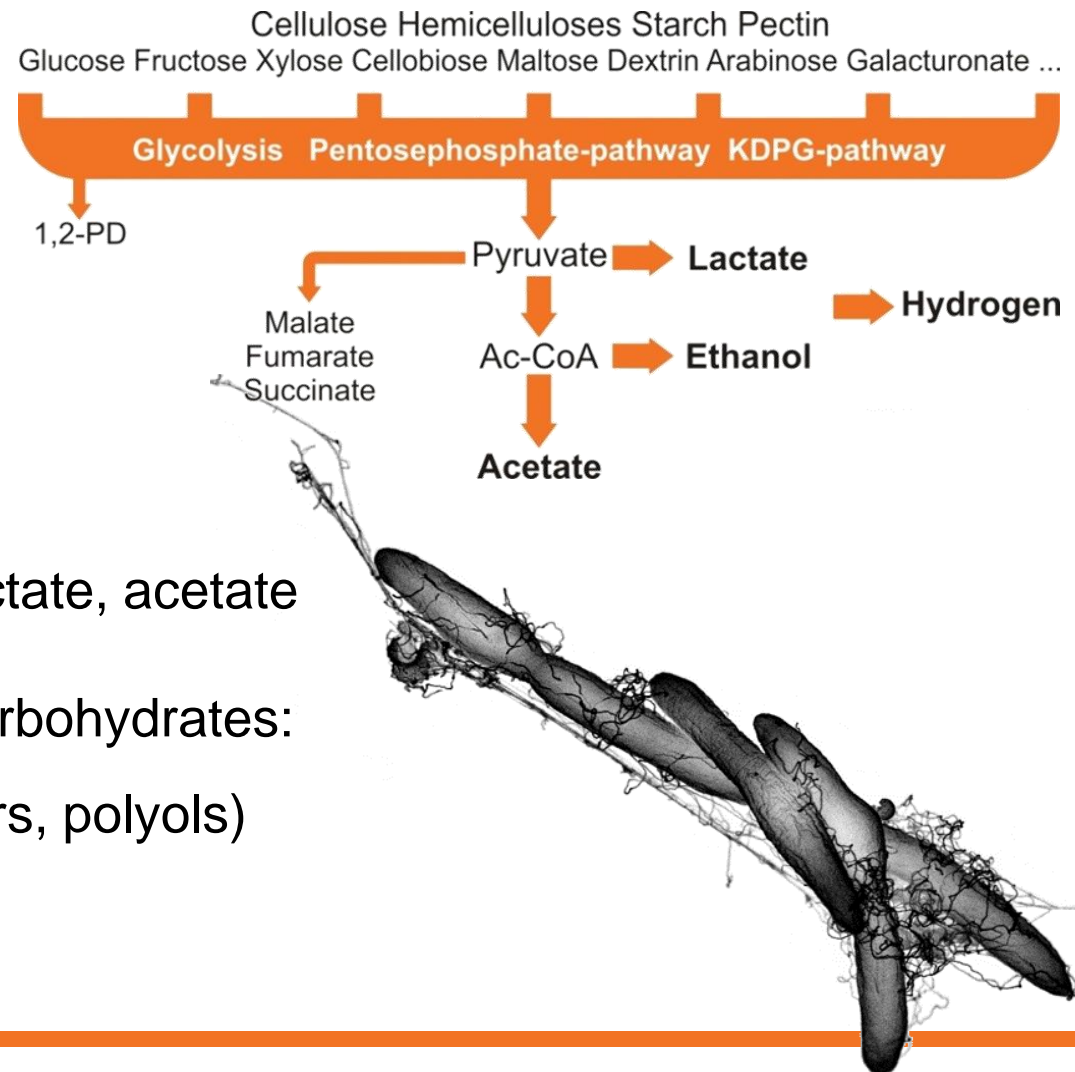


**Electrodialysis:
Concentration +
free acid release**



BluCon® – strain *Caldicellulosiruptor sp.*

- Cellulolytic
- Hemicellulolytic
- $T \geq 70\text{ }^{\circ}\text{C}$
- Main products: ethanol, lactate, acetate
- Conversion of all tested carbohydrates:
(C6 + C5, sugars, oligomers, polyols)



BluCon® - Differentiations

2G biorefinery – process lineup

SHF / SSF

Enzymes required:
~150 \$/t (sugar)

Contamination prone:
30 – 40 °C:

Significant cooling and
heating

CBP competition

Reduced enzyme
requirements

Contamination risk:
30 – 60 °C

BluCon®-CBP

No added enzymes:
major cost reduction

No contamination:
≥ 70 °C

Flat process
temperature profile

BluCon® – product opportunities

Today

Ethanol

Fuel Ethanol
Ethylene
Hydrocarbons

Lactic acid

Poly lactide
Acrylic acid

Lignin

Steam / Power
Polymer blends

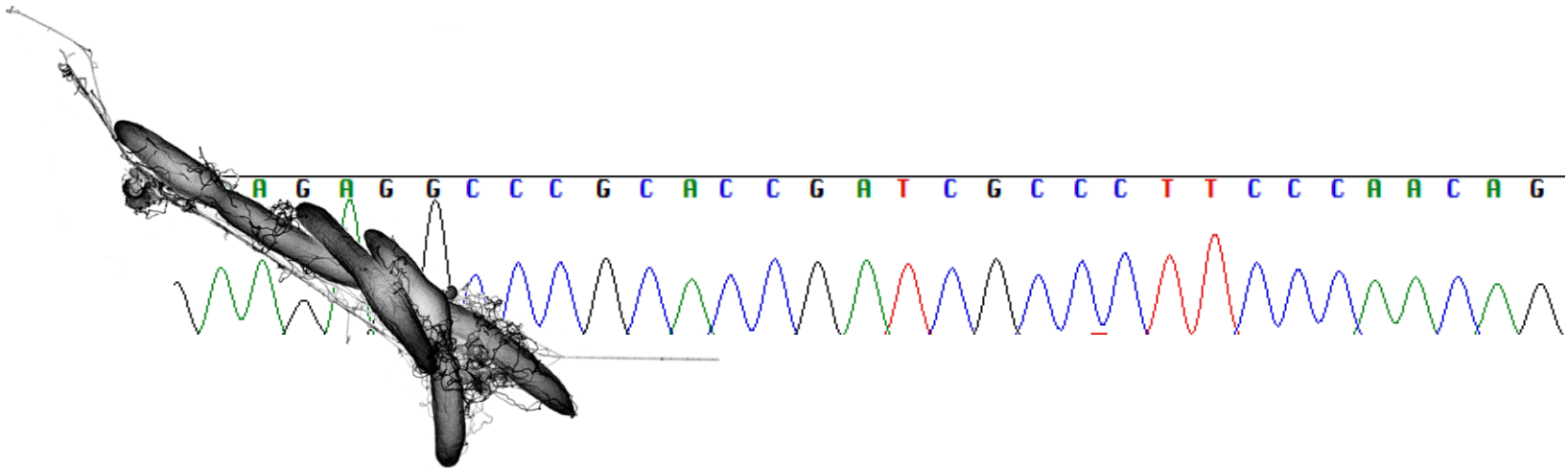
Acetic acid
+ Hydrogen

Biogas
Ethanol

Perspective

Malate
Fumarate
Succinate
Propanediol
Butanediol
Ethylenglycol
Acetoin
Hydroxyacetone
...

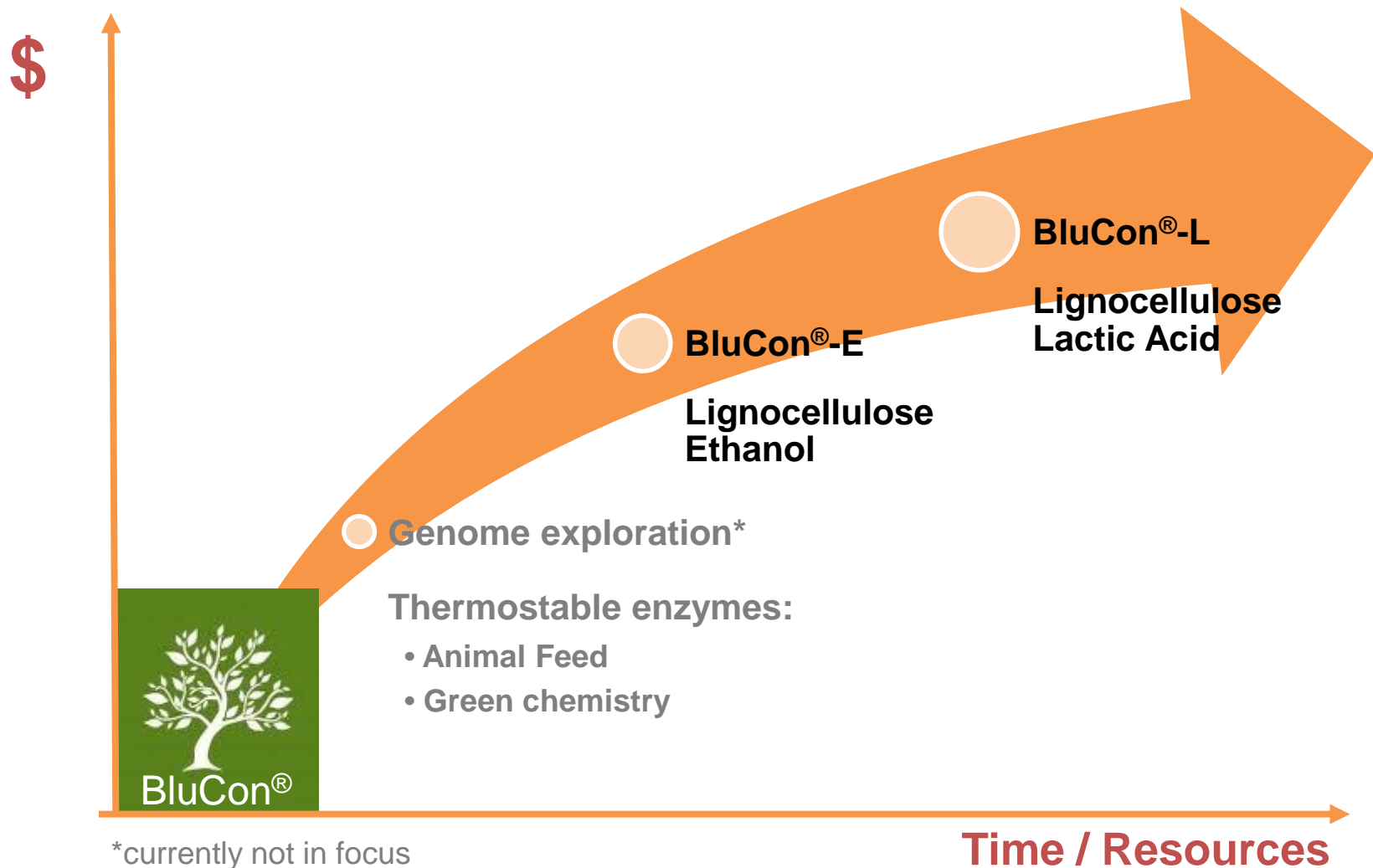
BluCon® - Genome exploration



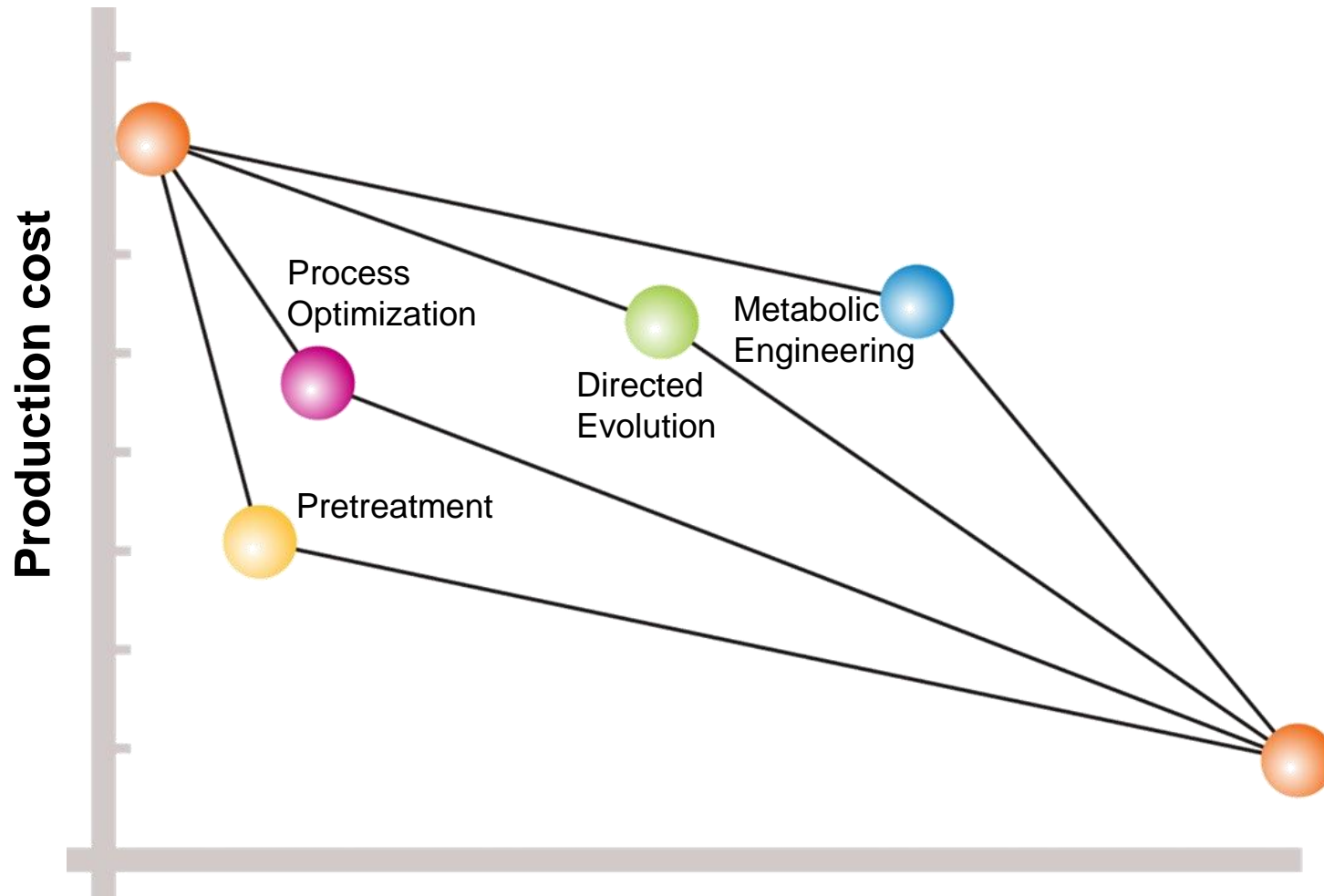
Thermostable enzymes for feed and green chemistry:

- Cellulases
- Hemicellulases
- Alcohol-Dehydrogenases
- Esterases / Lipases
- Proteases / Peptidases
- Transaldolases / -ketolases

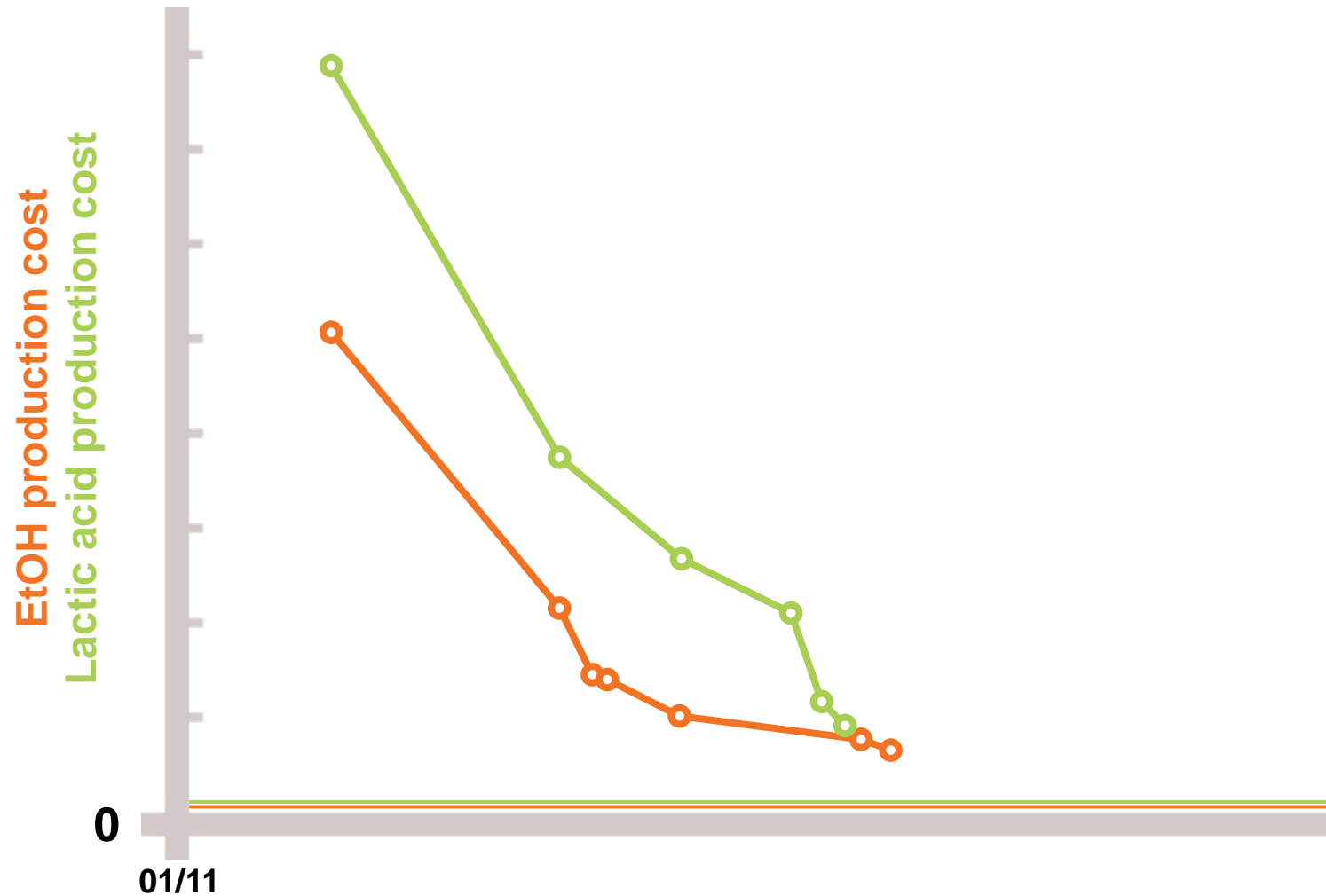
BluCon® microbes build the foundation for a series of businesses



BluCon® – development



BluCon® – development



Summary

Upstream

Broad substrate basis
Geographical flexibility
Powerful pretreatment

Abundant and stable
non-food feedstocks

Process

Contamination proof
Less cooling
No enzyme cost:
>150 \$/t savings

Robust and
proprietary process

Downstream

Product flexible:
Biofuels, Biochemicals

Established unit
operations

Large markets
for products

Thank you for your attention.
Danke für Ihre Aufmerksamkeit.

June 17, 2013

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