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
History

**2000**
Foundation of DIREVO Biotech AG

**2007**
Creation of biopharmaceutical & industrial biotechnology BU’s

**2008**
- Foundation of DIREVO Biotech AG
- Creation of biopharmaceutical & industrial biotechnology BU’s
- Spin-off of DIREVO Industrial Biotechnology GmbH
- Thermostable phytase developed by Direvo enters the market

**2009**
IBT moves into new state-of-the-art premises
Completion and validation of technology set-up

**2010**
Direvo restructures and sets new strategy for growth

**2011**
Direvo sells its thermostable mannanase to BASF Animal Nutrition

**2013**
Second thermostable phytase developed by Direvo enters the market
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.

<table>
<thead>
<tr>
<th>Product</th>
<th>Enzyme</th>
<th>Optimized parameters</th>
<th>Application</th>
<th>Customer</th>
<th>Market launch</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP-17 / 111</td>
<td>Phytase</td>
<td>Thermo stability, pH resistance, Protease stability, Specificity</td>
<td>Starch liquefaction</td>
<td>Genencor</td>
<td>since 2008</td>
</tr>
<tr>
<td>BP-17/111</td>
<td>Phytase</td>
<td>Thermo stability, pH resistance, Protease stability, Specificity</td>
<td>Animal nutrition</td>
<td>Danisco</td>
<td>2013</td>
</tr>
<tr>
<td>PIN K224</td>
<td>Mannanase</td>
<td>Specific activity, thermo stability, pH/protease resistance</td>
<td>Animal nutrition</td>
<td>Sold to BASF in 2012</td>
<td></td>
</tr>
<tr>
<td>CEL 1E</td>
<td>Cellulase</td>
<td>Specific activity</td>
<td>Proprietary</td>
<td>Patents granted</td>
<td></td>
</tr>
<tr>
<td>CEL 2D</td>
<td>Cellulase</td>
<td>Specific activity</td>
<td>Proprietary</td>
<td>Patents granted</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Protease</td>
<td>Specificity, activity</td>
<td>Biocatalysis</td>
<td>Confidential</td>
<td>Running project</td>
</tr>
</tbody>
</table>
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
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 → Pretreatment → Sugar → Conversion → DSP → Ethanol

- C5 / C6 Cellulose → Digestion → Enzyme production → Power

- Enzymes
BluCon® - Consolidated Bioprocessing

Lignocellulose

Pretreatment

Hydrolysis

SteamEx

C5

C6 (Cellulose)

Enzyme production

Digestion

Conversion

DSP

Ethanol / Lactic acid

Lignin / Power
BluCon®-E: Target production cost

- 65 $/t substrate
- 20% solids
- 96 h process
- 87 gal/t yield
- 1.98 $/gal Ethanol
- ~4 MWh/t Lignin
- 210 $/t sugar
- 65 $/t substrate
- 20% solids
- 96 h process
- 87 gal/t yield
- 1.98 $/gal Ethanol
- ~4 MWh/t Lignin
- 210 $/t sugar
BluCon®-L: Target production cost

- 65 $/t substrate
- 20 % solids
- 96 h process
- 460 kg/t yield
- 840 $/t Lactic acid
- 210 $/t sugar
- ~4 MWh/t Lignin

65 $/t substrate
20 % solids
96 h process
460 kg/t yield
840 $/t Lactic acid
210 $/t sugar
~4 MWh/t Lignin
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
- US 61/544,831
- US 61/556,448
- US 61/669,962
- US 61/ 669,981
- US 61/669,998
- PCT/EP2012/069808
- PCT/EP2012/069809
- PCT/EP2012/069810
- PCT/EP2012/068627
- PCT/EP2012/068628
- 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 –

Lactic acid purification:
Proof of concept!

Fermentation Scale-up

Separation Desalting Softening

Concentration Purification

Desalting Decoloring

Electrodialysis:
Concentration + free acid release
BluCon® – strain *Caldicellulosiruptor sp.*

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

### 2G biorefinery – process lineup

<table>
<thead>
<tr>
<th>SHF / SSF</th>
<th>CBP competition</th>
<th>BluCon®-CBP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enzymes required:</strong></td>
<td><strong>Reduced enzyme requirements</strong></td>
<td><strong>No added enzymes:</strong> major cost reduction</td>
</tr>
<tr>
<td>~150 $/t (sugar)</td>
<td></td>
<td>No contamination: ≥ 70 °C</td>
</tr>
<tr>
<td><strong>Contamination prone:</strong></td>
<td><strong>Contamination risk:</strong></td>
<td><strong>Flat process temperature profile</strong></td>
</tr>
<tr>
<td>30 – 40 °C:</td>
<td>30 – 60 °C</td>
<td></td>
</tr>
<tr>
<td><strong>Significant cooling and heating</strong></td>
<td></td>
<td></td>
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<tr>
<td>Today</td>
<td>Perspective</td>
<td></td>
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<td>---------------------</td>
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<td></td>
</tr>
<tr>
<td>Ethanol</td>
<td>Fuel Ethanol</td>
<td></td>
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<tr>
<td></td>
<td>Ethylene</td>
<td></td>
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<tr>
<td></td>
<td>Hydrocarbons</td>
<td></td>
</tr>
<tr>
<td>Lactic acid</td>
<td>Polylactide</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acrylic acid</td>
<td></td>
</tr>
<tr>
<td>Lignin</td>
<td>Steam / Power</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polymer blends</td>
<td></td>
</tr>
<tr>
<td>Acetic acid + Hydrogen</td>
<td>Biogas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ethanol</td>
<td></td>
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<tr>
<td></td>
<td>Malate</td>
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<tr>
<td></td>
<td>Fumarate</td>
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<tr>
<td></td>
<td>Succinate</td>
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<tr>
<td></td>
<td>Propanediol</td>
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<tr>
<td></td>
<td>Butanediol</td>
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</tr>
<tr>
<td></td>
<td>Ethyleneglycol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acetoine</td>
<td></td>
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<tr>
<td></td>
<td>Hydroxyacetone</td>
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<td></td>
<td>…</td>
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</tr>
</tbody>
</table>
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

Genome exploration

Thermostable enzymes:
- Animal Feed
- Green chemistry

*currently not in focus
BluCon® – development

- Process Optimization
- Metabolic Engineering
- Directed Evolution
- Pretreatment

Production cost
BluCon® – development

EtOH production cost

Lactic acid production cost

01/11
BluCon®

Summary

<table>
<thead>
<tr>
<th>Upstream</th>
<th>Process</th>
<th>Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad substrate basis</td>
<td>Contamination proof</td>
<td>Product flexible:</td>
</tr>
<tr>
<td>Geographical flexibility</td>
<td>Less cooling</td>
<td>Biofuels, Biochemicals</td>
</tr>
<tr>
<td>Powerful pretreatment</td>
<td>No enzyme cost:</td>
<td>Established unit operations</td>
</tr>
<tr>
<td>Abundant and stable non-food feedstocks</td>
<td>Robust and proprietary process</td>
<td>Large markets for products</td>
</tr>
</tbody>
</table>

>150 $/t savings
Thank you for your attention.
Danke für Ihre Aufmerksamkeit.

June 17, 2013
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