

sunliquid® - Delivering a Proven Technology Solution for Commercial Cellulosic Ethanol Production

CLARIANT 



Group Biotechnology
Biofuels & Derivatives

what is precious to you?

Clariant at a glance

A GLOBALLY LEADING COMPANY IN SPECIALTY CHEMICALS



5847

Sales 2016 (CHF m)
from continuing operations

263

Net result 2016 (CHF m)
from continuing operations

4

Business Areas

887

EBITDA 2016 (CHF m)
before exceptionals

15.2%

EBITDA margin 2016
before exceptionals

140 in **53**

companies countries

17442

Employees 2016

Your committed partner for commercialization

CLARIANT GROUP BIOTECHNOLOGY



Munich R&D Center

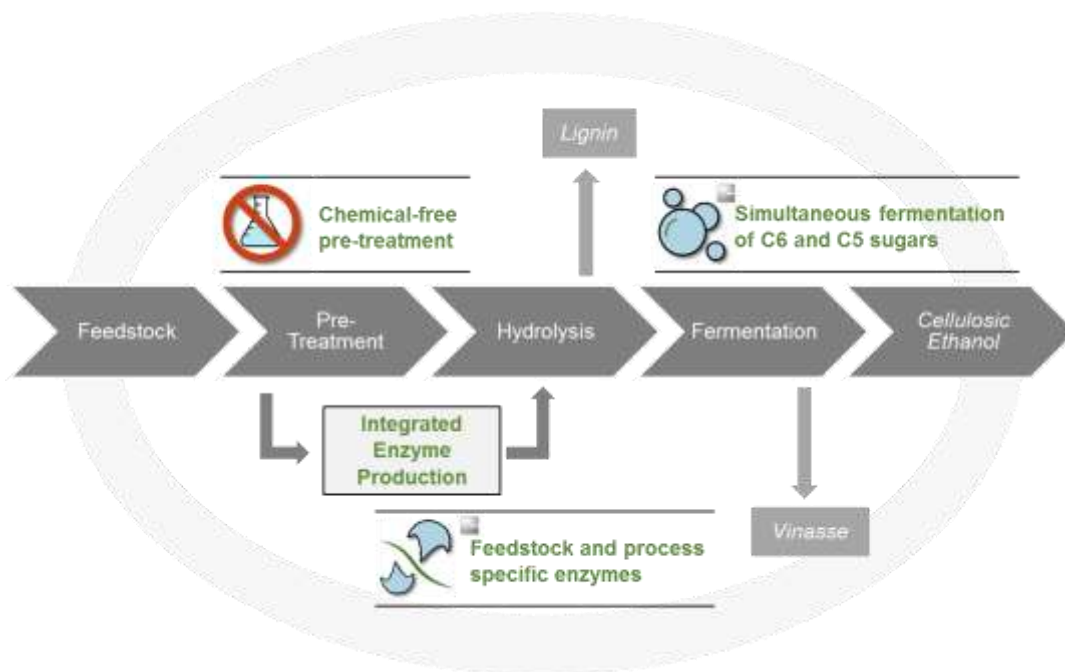
- Since 2006
- 118 employees
- Lab and office space: 6,500 m²
- Pilot plant since 2009
- Over 15 different feedstock tested on pilot-scale



Straubing pre-commercial plant

- Since 2011
- 22 employees
- Area: 2,500 m²
- Wheat straw, corn stover, and sugarcane bagasse and straw converted to Ethanol

Commercially Best in Class FULLY INTEGRATED SUNLIQUID® PROCESS



The **chemical-free** mechanical and thermal **pre-treatment** enables an optimal hydrolysis. Purification steps are unnecessary and makes for a safer and more environmentally friendly process.

Integrated Enzyme Production

Through the **process integrated enzyme production** costs can be reduced to a minimum. Enzymes are produced exactly when and where needed, there are no costs for logistics or formulation and no dependence on external suppliers.



Clariant can quickly adapt **enzymes** to new **feedstock and process conditions**. This achieves a most efficient hydrolysis with maximum yields and makes the process flexible for different boundary conditions.



The **organism** used for fermentation is **highly optimized** and able to **simultaneously ferment both C5 & C6 sugars in a one-pot reaction**. Thus the ethanol yield increases by 50% compared to only C6 fermentation.

The only validated integrated technology solution **THE SUNLIQUID® PRE-COMMERCIAL PLANT**



2012

Start of operation at pre-commercial plant

up to **1,000**

t/a output of ethanol

~ **4,500**

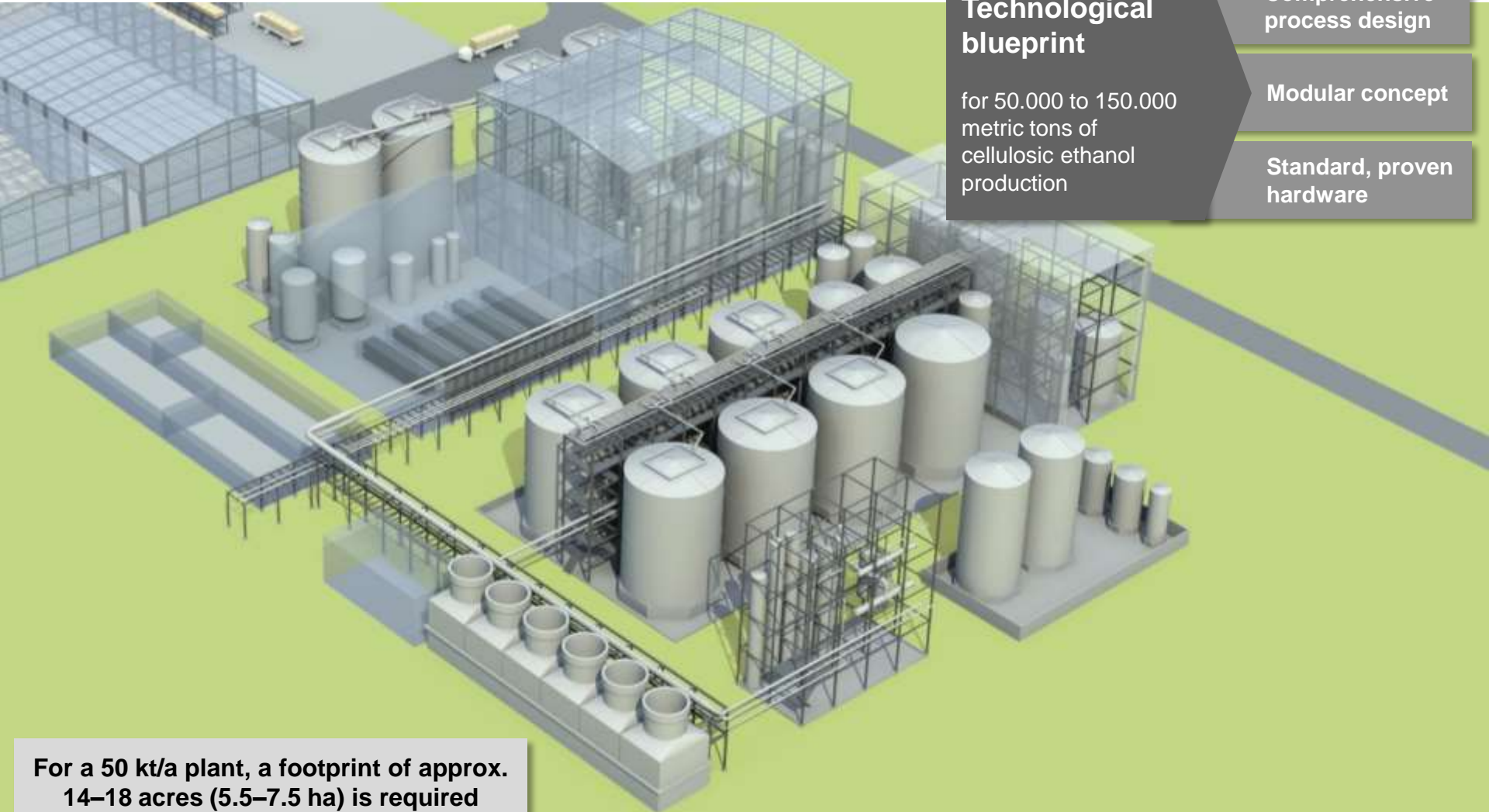
t/a feedstock *
* (cereal straw, corn stover, sugarcane bagasse & others)

~ **5**

Years confirmation of commercial-scale design

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PROCESS DESIGN PACKAGE



Technological blueprint

for 50.000 to 150.000 metric tons of cellulosic ethanol production

- Comprehensive process design
- Modular concept
- Standard, proven hardware

For a 50 kt/a plant, a footprint of approx. 14–18 acres (5.5–7.5 ha) is required

sunliquid® is certified as sustainable under high German standard



ISCC certification

- Clariant certified the Straubing demonstration plant according to the ISCC-EU scheme (International Sustainability and Carbon Certification)
- Demonstrating the sustainability of the production and management system so that the produced cellulosic ethanol can be credited towards the target of the RED (EU Renewable Energy Directive 2009/28/EC)
- High GHG savings of sunliquid® confirmed making it the most sustainable biofuel on the market

Sunliquid cellulosic ethanol is non-waste technology and with GHG savings over 95%

Non-waste technology and energy self-sufficient

- Chemical free pretreatment
- Water recycling >90%
- No waste solid, water and gas
- All by-products with high value and usage without complicated downstream process
- Energy self-sufficient

GHG savings of 95%

Production of Ethanol from Wheat-straw (steam from straw CHP) (no allocation of agricultural cultivation) Version 3 - Public

Overview Results

All results in g CO _{2,eq} / MJ Ethanol	Non- allocated results	Allocation factor	Allocated results	Total
Cultivation e_{ec}				0.0
Cultivation of wheat-straw	0.00	100.0%	0.00	
Processing e_p				1.3
Ethanol plant	1.34	100.0%	1.34	
Transport e_{td}				2.5
Handling & storage of wheat straw	0.16	100.0%	0.16	
Transport of wheat straw	0.82	100.0%	0.82	
Transport of ethanol	1.10	100%	1.10	
Filling station	0.44	100%	0.44	
Land use change e_l	0.0	100.0%	0.0	0.0
e _{sca} + e _{ccr} + e _{ccs}	0.0	100%	0.0	0.0
Totals	3.9			3.9

GHG savings 95%

Allocation factors
Ethanol plant
100.0% to ethanol
0.0% to lignin

Emission reduction
Fossil fuel reference (petrol)
83.8 g CO _{2,eq} /MJ
GHG emission reduction
95.4%

Calculations in this Excel sheet.....

- strictly follow the methodology as given in Directives 2009/28/EC and 2009/30/EC
- follow JEC calculations by using GWP values 25 for CH4 and 298 for N2O

As explained in "About" under "Inconsistent use of GWP's"

sunliquid® - En route to commercialization

PRE-COMMERCIAL PLANT OPERATIONAL

Capacity 1,000 t/a
Ethanol

Validation on wheat
straw



E20 FUEL TESTING

With Mercedes Benz &
Haltermann

PROCESS DESIGN PACKAGE

For commercial-size plants



COOPERATION WITH WERNER & MERTZ

sunliquid® ethanol in
cleaning supplies

GERMAN INNOVATION PRICE

for Climate &
Environment
(IKU)



1ST LICENSE DEAL

Enviral to build
commercial cellulosic
ethanol plant with
sunliquid® technology



2012

2013

2014

2015

2016

2017

FEEDSTOCK VALIDATION

Corn stover &
sugarcane bagasse



ISCC SUSTAINABILITY CERTIFICATION OF PLANT

PERFORMANCE RUNS

With sugarcane
residues (bagasse, tops
& leaves)

With wheat & barley
straw

PARTNERSHIP WITH SCANIA

Ecotrucks use sunliquid
2G EtOH from bagasse in
Brasil



Enviral licenses the Clariant sunliquid[®] technology for a commercial cellulosic ethanol project



&



announce commercial cellulosic ethanol project

- Largest ethanol producer in Slovakia
- Current annual production capacity is 145,000 m³.
- 1G Production plant located in Leopoldov, Slovakia.
- Slovakian government has set targets for advanced biofuels market share



- World-leader in specialty chemicals
- sunliquid technology offers best-in-class performance
- Only validated technology solution
- Committed partner for project realization

Enviral licenses the Clariant sunliquid[®] technology for a commercial cellulosic ethanol project



Enviral acquires first sunliquid[®] cellulosic ethanol licence to realize a full scale commercial cellulosic ethanol plant



The 2G plant is planned to be **integrated into the existing 1G facilities at Enviral's Leopoldov site** in Slovakia



Annual production **capacity is 50,000 tons.**



Project is based on **excellent test results of Enviral's feedstock** at Clariant's precommercial sunliquid[®] plant in Straubing (Germany) – **a service we offer to all our customers!**



Next steps are detailed engineering studies before the **official ground breaking** which is **expected at the end of 2017.**

Clariant to build flagship sunliquid® plant

- Clariant approved investment in commercial scale plant for the production of 50,000 ton/yr ethanol in Romania
- Further step in the commercialization of cellulosic ethanol, technology licensing and enzymes
- Mid double digit millions peak sales potential
- Ground breaking and construction planned for 2018

www.clariant.com/corporate/news



Comunicado de imprensa

Clariant construirá uma fábrica-modelo comercial de etanol celulósico sunliquid® na Romênia

- A Clariant aprova o investimento em uma nova fábrica para produção comercial de etanol celulósico em larga escala com base em sua própria tecnologia sunliquid®
- O próximo passo para a comercialização de bioetanol, licenças e enzimas
- O potencial de vendas de etanol celulósico sunliquid® se encontra na faixa de dois dígitos de milhões de francos suíços

Muttenz, 31 de outubro de 2017 – A Clariant, líder mundial em especialidades químicas, anunciou hoje a aprovação de sua Diretoria para investir em uma nova fábrica comercial para a produção de etanol celulósico em larga escala a partir de resíduos agrícolas com base em sua tecnologia sunliquid®. A nova fábrica, com capacidade de produção anual de 50.000 toneladas, será construída no sudoeste da Romênia. As instalações serão um local-modelo, confirmando a competitividade e a sustentabilidade da tecnologia sunliquid® em escala comercial, respaldando assim a estratégia de negócios da Clariant para o licenciamento do sunliquid®.

"A Clariant investe continuamente no desenvolvimento de produtos sustentáveis e soluções inovadoras, como o sunliquid®. Este processo pioneiro demonstra a produção de biocombustíveis avançados, eficientes e sustentáveis e tem grande potencial como plataformas de tecnologia para uma variedade de materiais bioquímicos. Esta é mais uma ilustração do sucesso da estratégia de inovação da Clariant, uma vez que esta tecnologia acrescenta potencial de crescimento a um portfólio já bastante sólido", afirma Christian Kohlpointner, membro do Executive Committee da Clariant.

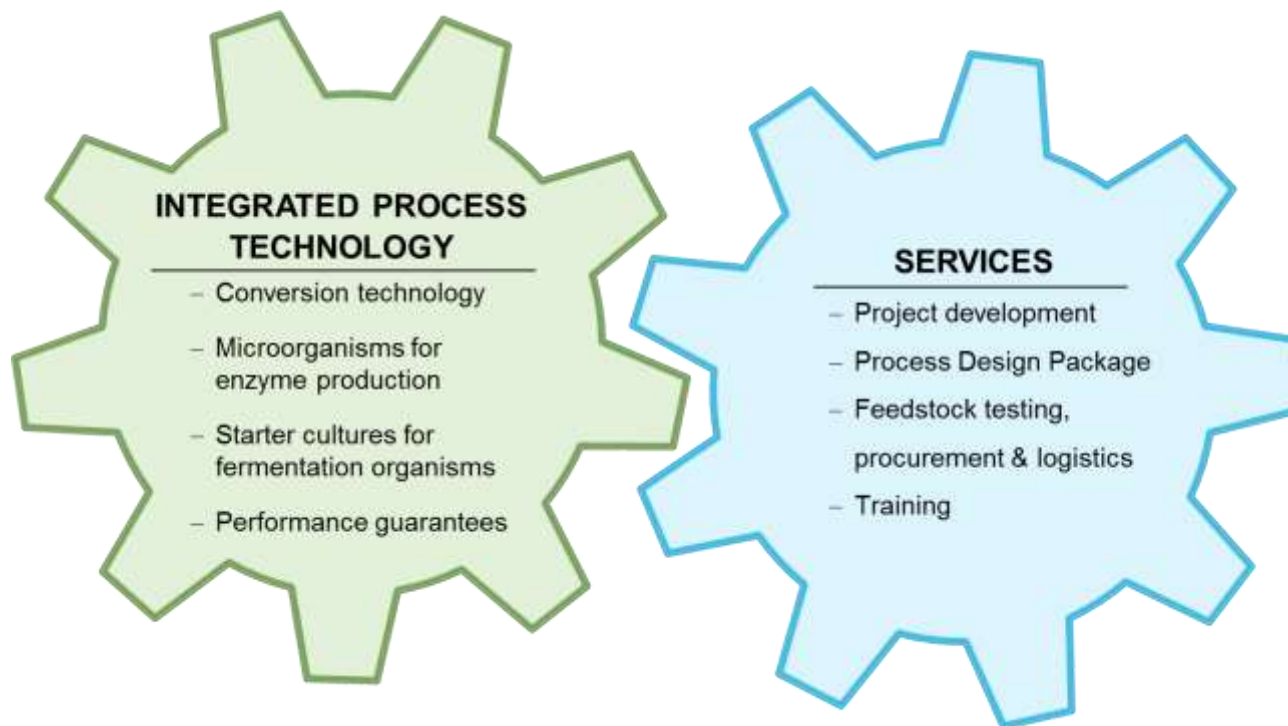
Para se concentrar ainda mais na comercialização de bioetanol, licenças e enzimas, a Clariant criou uma nova Business Line Biofuels & Derivatives, como parte da área de negócios Catalysis. A partir de janeiro de 2018, todas as atividades e custos relacionados à plataforma de tecnologia sunliquid® serão transferidos do setor Corporate Costs para a Business Line Biofuels & Derivatives.

Em setembro deste ano, a Clariant anunciou um passo importante que visa aumentar a atratividade comercial da tecnologia sunliquid® ao assinar o primeiro contrato de licença tecnológica com a Enviral, um membro do Enviro Group.

"Após cinco anos de operação da nossa fábrica de sunliquid® pré-comercial, em Straubing, na Alemanha, e com a demonstração do processo, estamos prontos para atingir um novo patamar", explica Marius Barbach, Head do novo setor Biofuels & Derivatives da Clariant. "É o próximo grande passo para ingressar em um mercado atraente e em avanço

Your committed partner for commercialization

OFFERING A COMPREHENSIVE PACKAGE



Integrated Technology Package:

- Integrated process technology package including all steps along the ethanol production chain
- Starter cultures for proprietary process-integrated enzyme production
- Starter cultures for the proprietary fermentation organism which converts C5 and C6 to ethanol
- Energy efficient design to ensure overall cost efficiency

Service Package:

- Develop project customized to specific needs of client
- Process Design Package to provide technical specifications and input for engineering
- Testing of customer-specific feedstock in our pre-commercial plant and pilot plant
- Support for feedstock logistics and sourcing, off-taking and regulatory affairs
- Training of customer employees in pre-commercial plant

Commercial site location characteristics for potential licensors

Feedstock

Yearly feedstock dry tons

~250,000

Feedstock 1
(corn, wheat, sugarcane, rice)

Straw

Feedstock 2

Bagasse

Products

Main product

~50,000 t
Ethanol

Side product

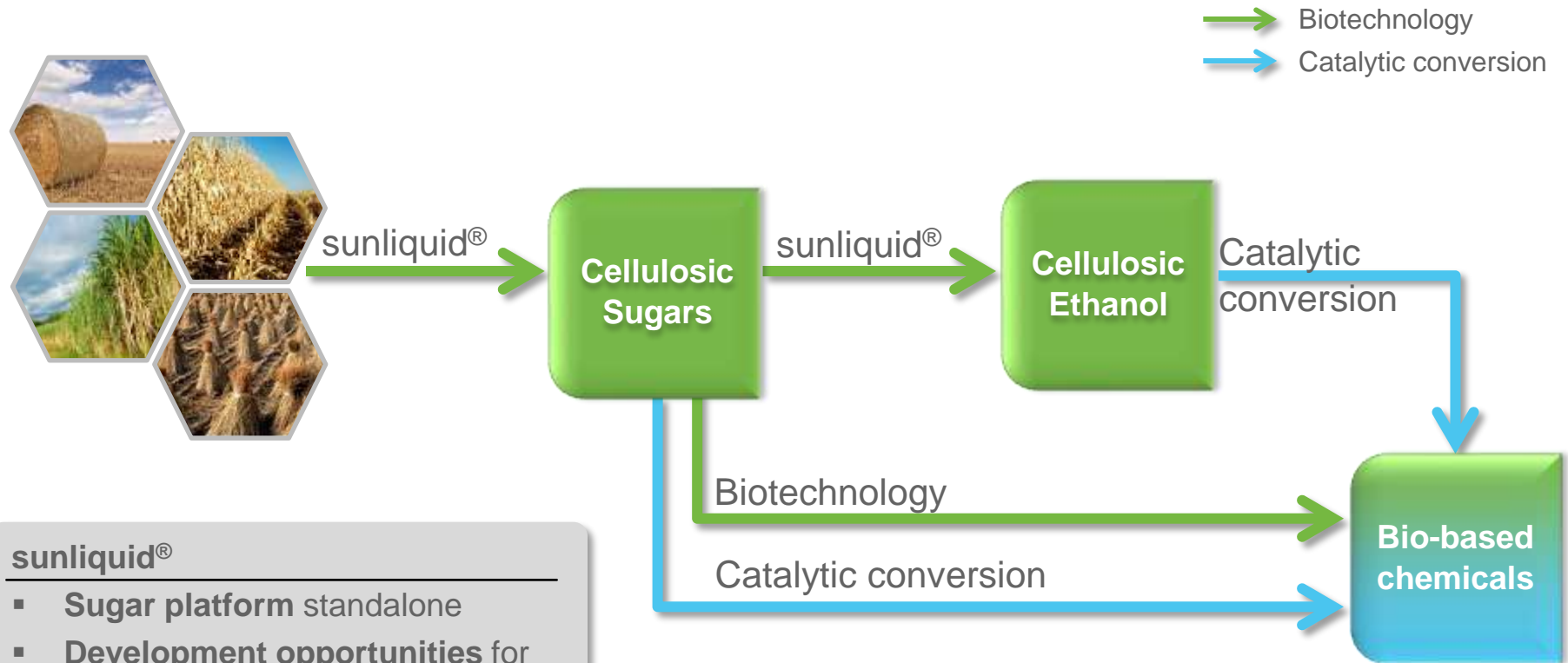
~100,000 t
Lignin (dry)

Side product

~50,000 t
Vinasse (dry)



sunliquid[®] is the ideal technology platform for highly sustainable bio-based products



sunliquid[®]

- **Sugar platform** standalone
- **Development opportunities** for biobased products
- **Extensive know-how** in biocatalysis, strain optimization and heterogenous catalysis

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For more information on sunliquid® technology visit www.sunliquid.com