Bio-refinery: Bringing commercial cellulosic ethanol production to the market with sunliquid®
CLARIANT AT A GLANCE
Clariant at a glance – a global leader in specialty chemicals serving a broad industry

CARE CHEMICALS
Personal Care
Industrial Applications
Home Care
Crop Solutions
Food Ingredients
Encapsulation Technologies

CATALYSIS
Catalysts
Biofuels & Derivatives

NATURAL RESOURCES
Additives
Oil Services
Mining Solutions
Refinery Services
Functional Minerals

4 399
Sales 2019 (CHF m) from continuing operations

15,7%
EBITDA margin\(^1\) 2019 after exceptional items from continuing operations

17 223
Employees 2019 of total Group including discontinued operations\(^2\)

118
Production sites worldwide of total Group including discontinued operations\(^2\)

\(^1\) excluding a CHF 231 million provision for an ongoing competition law investigation by the European Commission; \(^2\) As of 31 December 2019, discontinued operations comprised the pigments and masterbatches businesses.
“TOO MUCH CARBON IN THE AIR”

ADVANCED BIOFUELS – MARKET CONCERNS ADDRESSED & SOLVED
Lower emissions from transport urgent for reaching climate goals

In 2018, the transport sector was responsible for

24% of GHG emissions worldwide

and

27% in the EU¹

Lignocellulosic ethanol: the ideal candidate for immediate improvement

Made from agricultural residues such as straw, non-food lignocellulosic materials & waste

- Carbon negative: among the highest total life cycle reductions in GHG emissions¹
  Considering CO₂ capture or utilization

- Fully validated technology
  Commercially deployed product immediately lowers emissions

- Unrivalled in use
  Provides superior energy density in virtually all modes of transport

- Low carbon abatement costs
  Drop-in solution for existing engines and infrastructure

- Enhanced energy security
  Domestic production boosts energy independence & long-term security

- Local sources & green jobs
  Use of locally sourced feedstock & new revenue stream for farmers

¹ EtOH produced with sunliquid reaches > 120% GHG saving, % compared to gasoline, including CCU/S (Carbon Capture Utilization & sequestration)
EU market for advanced biofuel under RED II: the supportive path to decarbonize mobility

**RED II – ANNEX IX**

**PART A: »advanced« feedstocks and fuels**

- **Targets:** 2022: at least 0.2%, 2025: 1%, 2030: 3.5%
- **Defined feedstocks (excerpt):**
  - Straw
  - Bagasse
  - Nut shells
  - Cobs cleaned of kernels of corn
  - Other non-food cellulosic material
  - Other lignocellulosic material

**PART B: not considered as »advanced«**

- **Target:** capped to 1.7%
  - Used cooking oil (UCO)
  - Animal fats categories 1 and 2

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**PROJECTED DEVELOPMENT OF (THEORETICAL) SHARE OF RENEWABLE ENERGY SOURCES IN TRANSPORT**

- **up to 2030 based on RED II provisions**

- **ADVANCED BIOFUELS Annex IX A**
  - min. 3.5%

- **BIOFUELS Annex IX B**
  - max. 1.7%

- **CONVENTIONAL BIOFUELS**
  - max. 7.0%

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2. Assumption: 50kta sunliquid standard capacity; EU transport fuel demand in 2030 remains at similar levels as in 2016 - Total transport fuel demand (road & rail) in 2016: 306.567 ktoe; Source: Eurostat
3. Additional advanced fuels from Annex IXA, renewable electricity (used for transport), any other NON capped options (e.g. H2 if not produced neither with FOOD feedstock nor ANNEX IXB feedstock)
SUNLIQUID®: CLARIANT’S SOLUTION TO DECARBONISE MOBILITY
sunliquid®: fully integrated process

1. Straw
   Input: 4 to 5 t of cereal straw from an approx. 1-hectare wheat field

2. Enzymes & Microorganisms
   ENZYME PRODUCTION ORGANISM
   Integrated enzyme production aligned to the specific raw material reduces costs and dependence on external sources

   SACCHARIFICATION
   Tailored enzymes ensure efficient hydrolysis and saccharification of the cellulose contained in the raw material

3. Fermentation organisms
   FERMENTATION
   Optimized microorganisms ferment C5/C6 sugars at the same time, delivering 50% more ethanol

4. Purification
   PURIFICATION
   Optimized, highly energy efficient purification method removes water from ethanol

5. Bioethanol
   BIOETHANOL
   Higher bioethanol yield due to utilization of all sugar types / according to biofuels specifications

Output:
- 1.5 t lignin
- 1 t vinasse
- 1 t bioethanol
- High sugar yield
- CO₂

LIGNIN
Thermal use of by-product for energy self-sufficiency

C5 & C6 SUGARS
Sugar stream

CO₂
High purity/1 t CO₂

VINASSE
Used as bio-fertilizer, biogas or energy feedstock

WATER
Water is fed back into process
BUT that is not all: sunliquid® - the ideal platform for highly sustainable bio-based products

sunliquid®
- Standalone, flexible sugar platform
- Development opportunities for biobased products
- Extensive know-how in biocatalysis, strain optimization and heterogenous catalysis
- Specifications can be adjusted to the need of the added downstream processing
SUNLIQUID® PRE-COMMERCIAL PLANT
Fully integrated process in operation at pre-commercial plant: reliable, stable & continued for >8 years acting as training facility

**PRE-COMMERICAL SUNLIQUID® PLANT IN STRAUBING, GERMANY**

- **Fully validated technology:** >8 years of testing (1,000 t/a EtOH; ~4,500 t/a feedstock) with scaled-down commercial design reproducing all process steps

- **Validated pre-treatment:** >8 years of operation with standard equipment from leading provider Valmet

- **Feedstock flexibility:** multiple feedstocks tested, identical process with feedstock-specific enzymes & yeast
  - Straw
  - Miscanthus
  - Rice straw/husks
  - Corn stover
  - Bagasse
  - Sugarcane tops & leaves

- **Your team on site:** testing of own feedstock with own team on site; training on plant operation, maintenance, start-up and shut-down
COMMERCIAL READINESS: SUNLIQUID® PLANT IN ROMANIA
Commercial-scale flagship plant in Romania

**COMMERCIAL SUNLIQUID® OPERATIONS IN PODARI, ROMANIA**

- **Investment:** Clariant invests in own greenfield 2G flagship plant in SW Romania (> 100 million euros)
- **Capacity:** 50,000 t/a EtOH; ~250,000 t/a feedstock (e.g. wheat & barley straw)
- **Job creation:** approx. 1,200 (~100 inside plant/ ~300 outside plant/ ~800 construction of plant)
- **Economic growth:** additional business opportunities for all actors along the value chain (e.g. provides farmers additional source of income)
- **Training facility:** plant serves as training facility for own & client staff
sunliquid® flagship plant en route to commercialization

- **CLARIANT PLANT ROMANIA**
  - Approval to invest in building a 50 kta plant in Romania
  - **2017**

- **GROUNDBREAKING PLANT ROMANIA**
  - 12 September 2018

- **2018**
  - HARVESTED 2.7K TONS OF STRAW

- **2019**
  - HARVESTED 20K TONS OF STRAW
  - WORKSHOP WITH FARMERS IN OLTENIA
  - MANAGEMENT TEAM FORMED
  - ISCC CERTIFICATION
  - «TECHNOLOGY PROVIDER OF THE YEAR» PRIZE BY DIPLOMAT ROMANIA

- **2020**
  - CONSTRUCTION ONGOING

- **2021**

*The project receives funding from the European Union’s Seventh Framework Programme for Research, Technological Development and Demonstration under Grant Agreement no. 322386 (FP7 SUNLIQUID) and from the Bio-Based Industries Joint Undertaking under the European Union’s Horizon 2020 research and innovation program under Grant Agreement no. 709606 (BBI LIGNOFLAG)*
How our dedicated feedstock team supports you

**FEEDSTOCK SUPPLY & LOGISTICS SERVICES**

- Feedstock availability assessment
- Supply chain contract systems
- End-to-end supply chain assessment
  (from field to plant)
SUNLIQUID® REFERENCES & SUPPORT
Already 3 licenses sold in EU and own flagship in Romania

- **First EU license commercial plant**: Slovakia
  - **Enviral**: Slovakia’s biggest ethanol producer
  - Integrated into existing 1G plant
  - 50,000 tpa ethanol
  - Project based on excellent test results of Enviral’s feedstock at Clariant’s pre-commercial sunliquid® plant in Straubing (GER)

- **Second EU license commercial plant**: Poland
  - **ORLEN Południe**: leading player in the fuels and energy market
  - Integrated into the existing Jedlicze petroleum refinery
  - 25,000 tpa ethanol
  - Using locally sourced feedstock (wheat straw)

- **Clariant flagship commercial plant**: Romania
  - Clariant’s own investment in cellulosic ETOH flagship plant
  - Greenfield site in Podari, Romania
  - 50,000 tpa ethanol
  - 250,000 tons of straw annually
  - Investment value: over 100 million Euros
  - European Commission & BBI Joint Undertaking funding*

- **Third EU license commercial plant**: Bulgaria
  - **Eta Bio Ltd.**: a company of the Pavlovi family, a major player in the Bulgarian agricultural sector
  - Greenfield site in General Toshevo, Northeast Bulgaria
  - 50,000 tpa ethanol
  - Using locally sourced feedstock (wheat straw)

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Commercial sunliquid® plant in China

- Agreement signed for third sunliquid® cellulosic EtOH license/first license deal for sunliquid® in China
- Joint venture (JV) formed by Anhui Guozhen Group & Chemtex Chemical Engineering with the intention of realizing full-scale commercial plant
- 2G plant will be built at a greenfield site in Fuyang city, Anhui province in East China
- Planned annual plant capacity: 50,000 tons with an option to double capacity in a 2nd phase
- Using locally sourced feedstock such as wheat straw and corn stover
Tailored support for entire value chain from idea to operation

**ASSESSMENT**
- Project assessment
- Partner support
- Market support
- Conceptual engineering
- Feedstock, by-products & ethanol testing at pre-commercial plant
- Feedstock value chain workshop
- Site selection consultancy

**DEVELOPMENT**
- Basic engineering package
- License agreement
- Starter culture agreement
- Licensor support for detailed engineering
- Vendor support services
- Site support services
- Classroom training (lab, pre-commercial, commercial)
- Practical training at sunliquid® plant
- Commissioning & start-up support services

**PROJECT EXECUTION**
- Technology support services
- sunliquid® starter cultures
- Continuous improvement program
- Strong global presence and support
On our way to decarbonizing global mobility

Key conclusions:

- **Paris agreement** & global climate efforts will fail without **significant increase** of **sustainable energy solutions**
- **Variety of solutions** needed to **decarbonize transport sector** & achieve ambitious climate goals
- **Advanced biofuels** are a **key solution** & have **countless benefits** to make an **immediate impact**
- **Current market conditions** are favorable for **driving demand for advanced biofuels** even further

**Legislation:** global support mechanisms & mandates are current key drivers for strong growth

**Technology:** sunliquid® proven solution with >8 years of reliable, stable & continued pre-commercial operations, own commercial plant underway & 4 licenses sold

**Feedstock:** proven global abundance of agricultural residues → sunliquid® established clear, executable value chain from field to plant in Romania and can support you in replicating it

**Business opportunity:** low carbon abatement costs for advanced biofuels (no investments into infrastructure or engine adaption) → sunliquid®: sustainable high-margin investment with attractive OPEX & CAPEX
»We are looking forward to partner with you to drive lignocellulosic ethanol forward«

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