Contribution to sustainable technology solutions to decarbonize mobility
Are we doing enough to meet the Climate Goals?

Climate Goal: <2 °C with further efforts to limit to 1.5 °C

Transport sector consumes 1/3 of total energy while its share of global CO2 emissions is nearly ¼

Liquid fuels will have a substantial role for the foreseeable future

Multiple study projections concur on ICE prevailing over EVs in next 30 years

MIO light duty vehicles

- Today
- UBS base case
- IEA 2DS
- Bloomer NEF
- WM base case
- UBS upside
- IEA B2DS
- BP
- WM carbon constrained
- UBC downside
- IEA RTS
- IEA RTS
- OPEC
Advanced Ethanol: solutions in reducing GHG emissions

1. **Sustainable**: among the highest total life cycle GHG emissions (95% GHG EU - 15 gCO2/MJ California) → a carbon neutral mobility solution

2. **Cost-efficient**: one of the most cost-efficient ways to cut emissions in both light and heavy-duty transport

3. **Compatible**: no need for large investments in fuel distribution infrastructure or engine adaptation

4. **Unrivalled for use**: superior energy density also for long haul heavy duty road transport, aviation & marine

5. **Integrated**: full transformation of available biomass feedstock into fuel, power, heat, fertilizer and bio-chemicals

6. **Ready**: technology already deployed at commercial level

7. **Replicable**: abundancy of worldwide sustainable feedstock

8. **Extensive new job creation**: along the whole value chain
Resource potential for cellulosic ethanol

**MAIN SOURCE FOR LIGNOCELLULOSE IN VARIOUS REGIONS OF THE WORLD**

in million tons, 2016

- **NORTH AMERICA**: 41, 19, 8, 516, 75
- **EUROPE**: 182, 14, <1, 153, 200
- **ASIA**: 60, 601, 195, 421, 261
- **SOUTH AMERICA**: 17, 21, 234, 102, 24
- **CENTRAL AMERICA**: 9, 1, 32, 42, 3
- **AFRICA**: 66, 29, 25, 92, 18
- **OCEANIA**: 17, <1, 10, <1, 18

Data source: Food and Agriculture Organization of the United Nations (FAO), FAOSTAT, available online at www.fao.org, accessed on 11.07.2019

* the production potential of theoretically usable lignocellulosic biomass (not including forestry residues) with conversion technologies with similar conversion rate to the sunliquid® process

over 700 MIO TONS* of cellulosic ethanol
Advanced biofuels resource potential in the EU by 2030 –
cellulosic feedstock availability¹

225m tons/year²
of residues and wastes

36.7Mtoe
of advanced biofuels

Up to 16%
of projected road fuel consumption
in the EU in 2030

¹ Source: Wasted – Europe’s Untapped Resource, ICCT
² Wastes and residues incl. agricultural and forestry residues, municipal solid wastes, used cooking oils that are sustainably available
(sustainable land management practices that maintain carbon balances, safeguard biodiversity, water resources and soil functionality)
Legislation is Driving Market Demand in the EU – Mandated demand for advanced biofuels¹ in accordance with REDII

3.5% of the EU’s transport fuel demand² by 2030

~ 10m tons of cellulosic ethanol³

Assumptions:
¹ REDII mandated demand is fulfilled solely with cellulosic ethanol (no other REDII Annex IX Part A derived fuels were considered)
² demand in 2030 remains at similar levels as in 2016 (total transport fuel demand in 2016: 367mtoe ~ 564m tons cellulosic ethanol); source: eurostat; internal team analysis
³ double counted

Legislation focus on 2G in other countries

E10 mandate by 2020 (~ 13m tons/year) with strong support from the gov. on non-food based biofuel & 2G EtOH demo/commercial plant

National Biofuel Policy approved/mandated implementation of E10 by 2022; 12 2G EtOH plants mandated by the Ministry of Petroleum & Natural Gas by 2022 to be built by Indian Oil companies
Generic cellulosic ethanol production needs multiple supplies

- Chemicals
- Enzymes/yeasts
- Biomass
- Liquid by-products
- Lignin
- Cellulosic sugars/ethanol
- Fertilizer
Clariant sunliquid® Integrated Solution

- **Cellulosic sugars**
- **Enzymes/yeasts**
- **Integrated enzyme & yeast production**

**Surplus biomass**
- Vinasse as organic fertilizer or biogas feedstock

**High quality Lignin**
- Energy

**Cellulosic sugars/ethanol**

**Public, sunliquid**

Paolo Corvo, Head of Sales & Marketing, Business Line Biofuels & Derivatives, 11.04.2019
sunliquid® Technology Platform Providing Access to 2nd Generation Sugars and Biofuels Made from Agricultural Residues

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

SUNLIQUID® biotechnology

CELLULOSIC SUGARS

SUNLIQUID® biotechnology

CELLULOSIC ETHANOL

catalytic conversion

Bio-based chemicals

biocatalysis

catalytic conversion
The sunliquid® technology – competitive path from feedstock to cellulosic ethanol

**KEY ADVANTAGES and DIFFERENTIATORS**
- Chemical free pre-treatment
- Process integrated enzyme production
- Simultaneous C₅/C₆ fermentation
- Fully integrated process
The sunliquid® pre-commercial plant

A FULLY INTEGRATED AND PROVEN PROCESS

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 and others incl. customer’s feedstock)

~ 6 years confirmation of commercial-scale design
Performance guarantee based on >6y testing of different feedstock in precommercial plant

**Challenge:** fragmented agricultural sector with numerous feedstock producers and multiple crops, volume & price fluctuation

**Solution:** multifeedstock process with specific enzymes

- Economic production on cellulosic material as carbon source
- Feedstock flexibility: hardware (equipment) always identical, software (starter cultures for enzyme production and yeast) change with feedstock campaigns
- >6 years testing experience in Pre-Commercial plant in Germany to provide process guarantees
sunliquid® – from idea to commercialization
Successful path to scaling up

**PRE-COMMERCIAL PLANT OPERATIONAL**
Capacity 1,000 t/a ethanol
Validation on wheat straw

**E20 FUEL TESTING**
With Mercedes Benz and Haltermann
PROCESS DESIGN PACKAGE
For commercial-size plants

**COOPERATION WITH WERNER & MERTZ**
sunliquid® ethanol in cleaning supplies
GERMAN INNOVATION PRICE
for Climate & Environment

**PARTNERSHIP WITH ESCANGIA**
Ecotrucks use sunliquid® 2G ETOH from bagasse in Brazil

**FEEDSTOCK VALIDATION**
Corn stover and sugarcane bagasse

**ISCC SUSTAINABILITY CERTIFICATION OF PLANT**

**PERFORMANCE RUNS**
With sugarcane residues (bagasse, tops and leaves)
With wheat and barley straw

**GROUNDBREAKING PLANT ROMANIA**
12. September 2018

**1ST LICENSE DEAL**
Enviral to build commercial cellulose ethanol plant with sunliquid® technology

**CLARIANT PLANT ROMANIA**
Clariant to build 50 kta plant in Southwest Romania

**PARTNERSHIP INTO BIODIESEL RESEARCH**
Use of Clariant’s sugars platform & combining technologies into single, integrated biodiesel production process
sunliquid® commercial plants footprint in EU

- First sunliquid® cellulosic ethanol license plant
- Acquired by Slovakia’s biggest ethanol producer, Enviral
- 2G plant to be integrated into the existing 1G facilities at Enviral’s Leopoldov site in Slovakia
- Plant capacity 50,000 tpa
- Project based on excellent test results of Enviral’s feedstock at Clariant’s pre-commercial sunliquid® plant in Straubing (GER)

- Clariant’s own investment in cellulosic ethanol flagship plant
- Greenfield site in Podari, Romania (near Craiova)
- Plant capacity 50,000 tpa
- Processing 250,000 tons of straw annually
- Investment value: over 100 million Euros
- Operational in 2020
- Receives funding from the European Commission and the Bio-Based Industries Joint Undertaking*

* The project receives funding from the European Union’s Seventh Framework Program 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)
sunliquid delivers 95% GHG & 6x lower carbon intensity than fossil gasoline

- Clariant sunliquid EtOH reaches up to 95% GHG with respect to EU RED sustainability calculations (without considering CO2 capture, storage or use)
- Clariant sunliquid technology delivers CI score of 15 gCO2/MJ for 2G ethanol using agricultural residue feedstock
- Substantiates integrated process technology with chemical free pre-treatment and process integrated enzymes
Clariant testing INA’s miscanthus in Straubing - Germany

• INA (Croatian multinational oil company) & Novamont (Italian world leader in the development and production of bioplastics & biochemical) chose sunliquid technology to test INA’s miscanthus within EU’s GRACE* project

• Circa 30 tonnes of miscanthus biomass was harvested & baled at INA demo site in Croatia in FEB’19, and shipped to Clariant’s pre-commercial plant for processing.

• Preliminary results show that sunliquid® process can successfully process miscanthus biomass on pre-commercial scale.

• Clariant’s sugars are used/tested by Novamont into BDO & ethanol used/tested by INA.


*This project receives funding from the Bio-Based Industries Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under Grant Agreement no. 745012
Clariant partners with ExxonMobil and Genomatica

**Partnership to advance research into cellulosic biodiesel**

Clariant’s sunliquid® technology to facilitate creation of compatible cellulosic sugars

Objective is to combine technologies into a single, integrated biodiesel production process

OPTISOCHEM* cellulosic sugars for isobutene production: 1\textsuperscript{st} production of isobutene from WSH at demo scale successfully achieved

\[\text{Global Sustainability analysis of entire Value Chain}\]

\[\text{Feedstock sourcing and hydrolysis} \]
\[\text{Bio-IBN production} \]
\[\text{Bio-IBN conversion to end products} \]

\[\text{Wheat straw sourcing} \]
\[\text{Wheat straw hydrolysis} \]
\[\text{IBN fermentation & purification} \]
\[\text{Bio-IBN} \]
\[\text{IBN Oligomerisation} \]
\[\text{IBN Polymerization} \]
\[\text{Market applications} \]
\[\text{Feedstock sourcing} \]
\[\text{Intermediate Product} \]
\[\text{Conversion unit} \]

*This project receives funding from the Bio-Based Industries Joint Undertaking under the European Union’s Horizon 2020 research and innovation programme under Grant Agreement no. 744330
Clariant offers an optimized sunliquid® package to suit your needs

- **sunliquid® package**: integrated technology package for 2G sugars & EtOH commercial plant from feedstock to end product including starter culture package → 1 supplier
- Continuous **improvement program** on technology & enzymes development
- **Training of local staff in German pre-commercial plant** and, once started up, in commercial plant in Romania
- Possibility to **test locally sourced feedstock** in German pre-commercial plant at multiple tons scale
- **Strong presence & support**, global footprint with local team staff