

Der sunliquid® Prozess:
Energieeffiziente und ressourcenschonende
Entwicklung und Herstellung biobasierter
Kraftstoffe – Gezielter Einsatz von
Enzymen und Mikroorganismen zur
Unterstützung der Biokraftstoffproduktion

Fuels of the Future 2016
13th International Conference on Biofuels

Confidential

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Biofuels & Derivatives
Group Biotechnology
19.01.2016

what is precious to you?

Clariant - A World Leader in Specialty Chemicals



Creating additional value through Sustainability – business benefits and Clariant's approach

SUSTAINABILITY AT CLARIANT

- Essential to achieve company targets
- Positioning in sustainability market
- Differentiate from competitors
- Support profitable growth
- Create added value for customers

External recognition of sustainability performance



Global voluntary initiatives and programs



Sustainability in the Supply Chain



Clariant's Group Biotechnology



Munich

- Since 2006
- 110 employees
- Main R&D center
- Lab and office space: 6,500 m²
- Pilot plant since 2009
- Over 15 different feedstock tested on pilot-scale



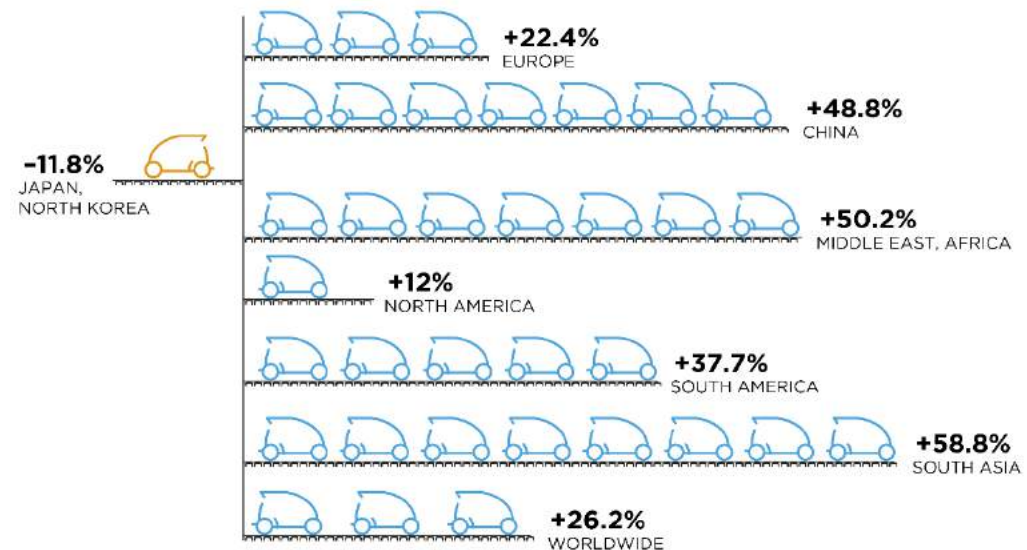
Straubing

- Since 2011
- 22 employees
- Pre-commercial sunliquid plant
- Area: 2,500 m²
- Wheat Straw, Corn Stover, and Sugarcane Bagasse converted to Ethanol

Mobility Worldwide: Situation & Challenges

- Transport covers 96% of its energy requirement with petroleum products
- Transport's share of the entire petroleum demand is 60%
- Mobility sector responsible for 23% of global CO₂ emissions (73% of that allotted to road transport)
- Prediction: in 2030 more than 2 billion automobiles worldwide
- CO₂ emissions expected to rise by 40% by 2030 due to global transport
- Finite resources of petroleum

**GROWTH OF WORLDWIDE AUTOMOTIVE PRODUCTION
CHANGES BETWEEN 2013 AND THE FORECAST FOR 2020**

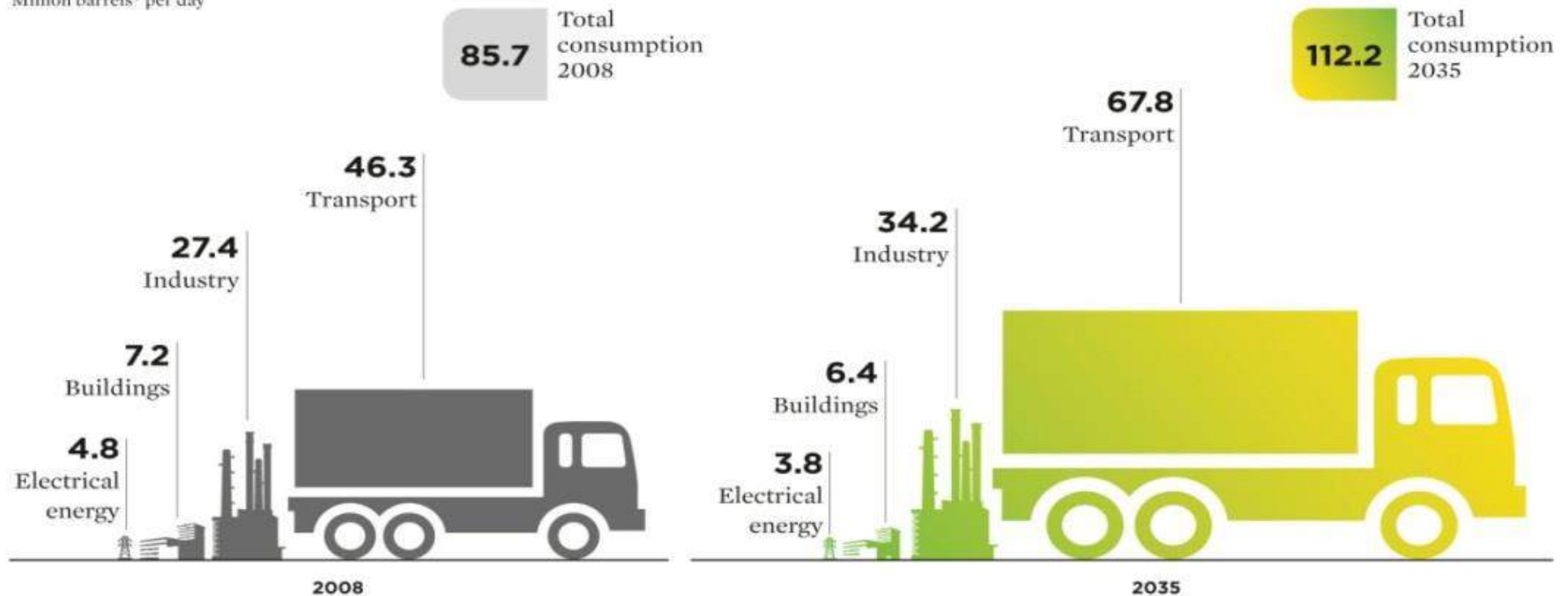


Source: Handelsblatt: Chefs nehmen die Politik in die Pflicht (29.10.2013), available online at <https://archiv.handelsblatt.com>

Energy needs and developments

WORLD LIQUID FUEL CONSUMPTION 2008 AND 2035

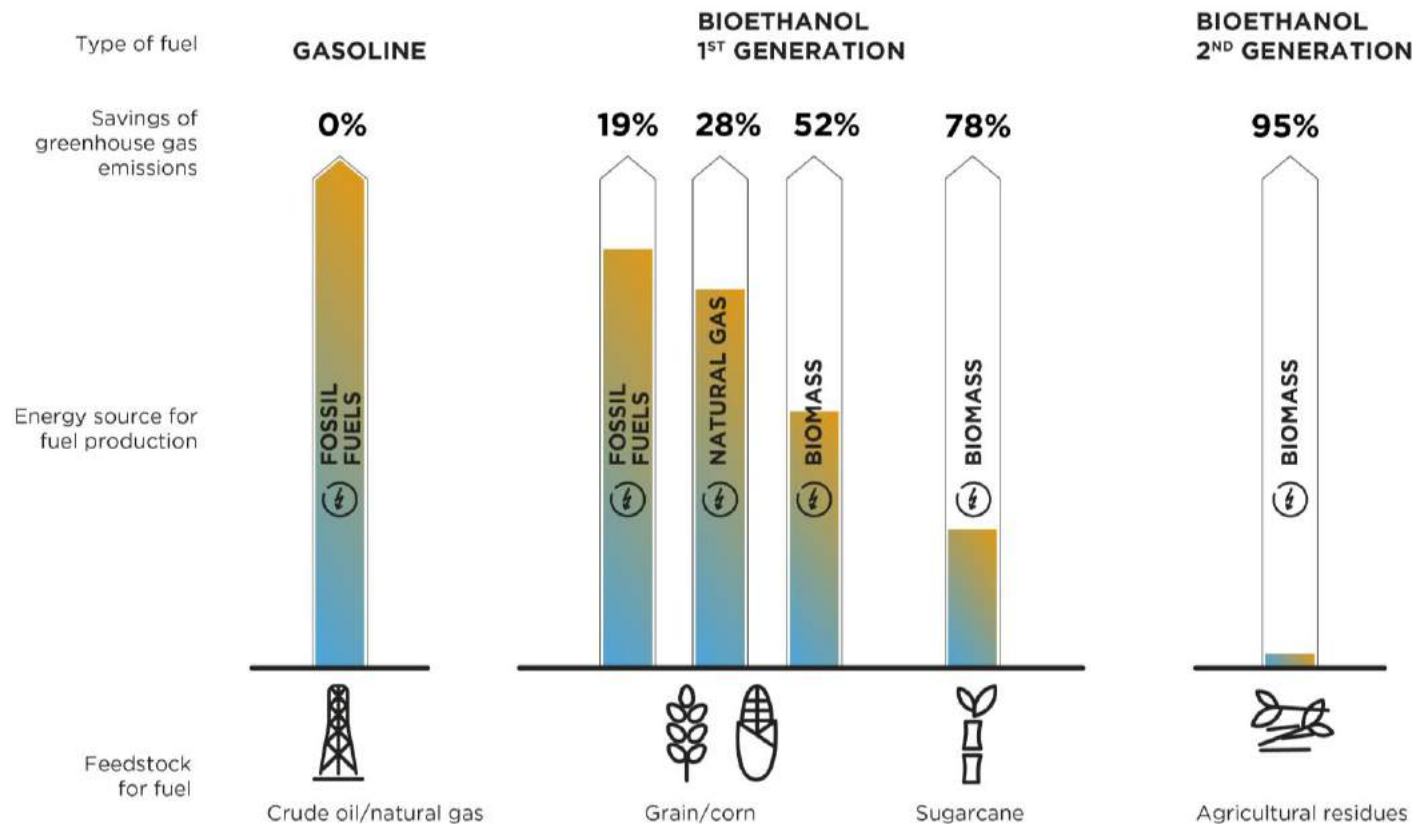
Million barrels* per day



Source: http://www.eia.gov/forecasts/ieo/liquid_fuels.cfm

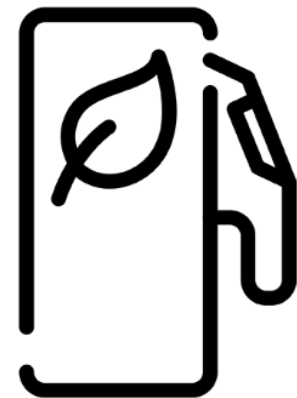
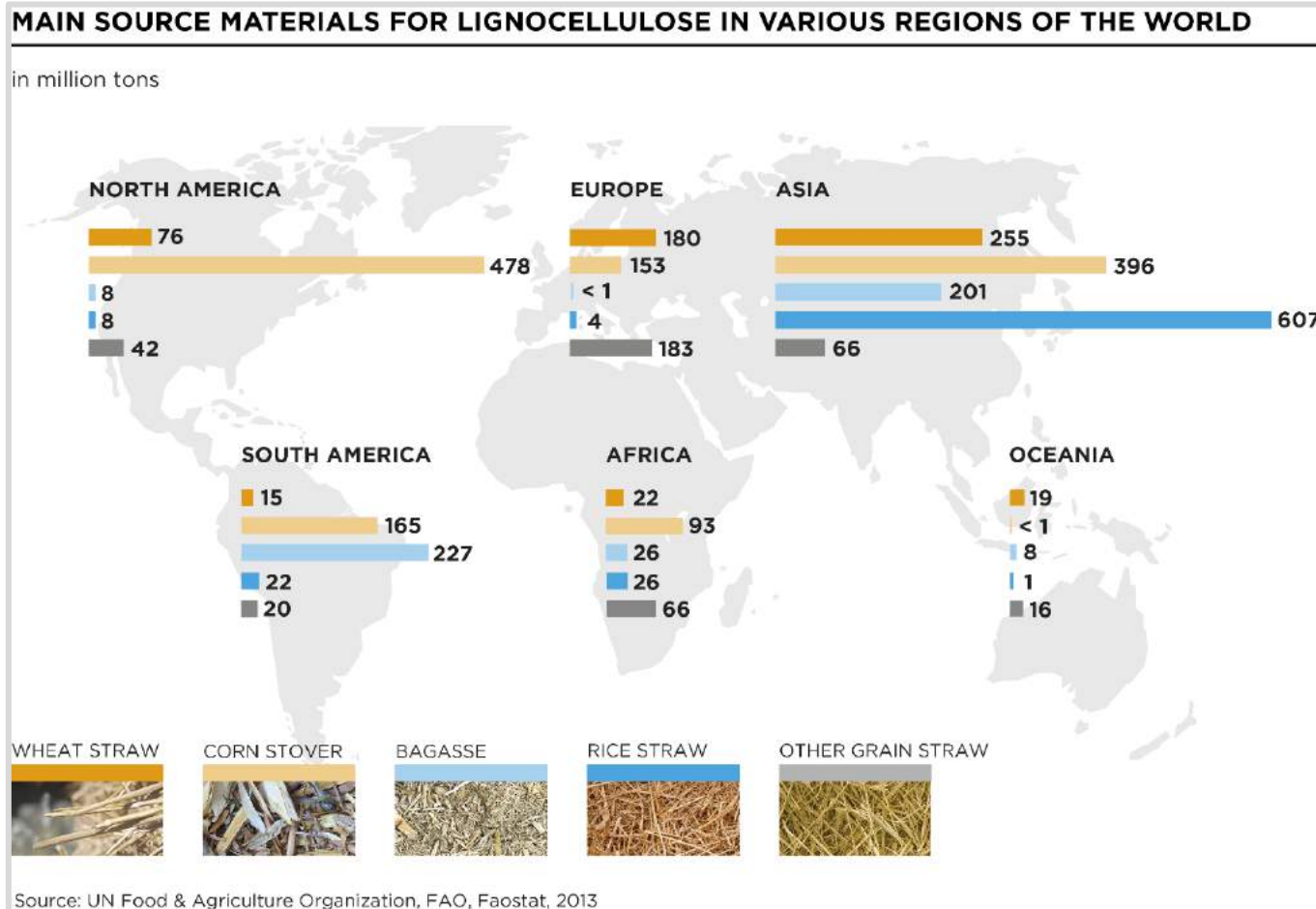
Savings of Greenhouse Gas Emissions in the Production of Different Biofuels

compared with gasoline



Source: Michael Wang, May Wu, Hong Huo (Center of Transportation Research – Argonne National Laboratory): Life-cycle energy and greenhouse gas emission impacts of different corn ethanol plant types (22.05.2007), in Environmental Research Letters, Volume 2, Nr. 024001, p. 12, available online at <http://iopscience.iop.org> and Markus Rarbach (Clariant): Zellulose-Ethanol aus Agrarreststoffen – Biokraftstoff der 2. Generation für eine nachhaltige Mobilität (02.12.2011), p. 28

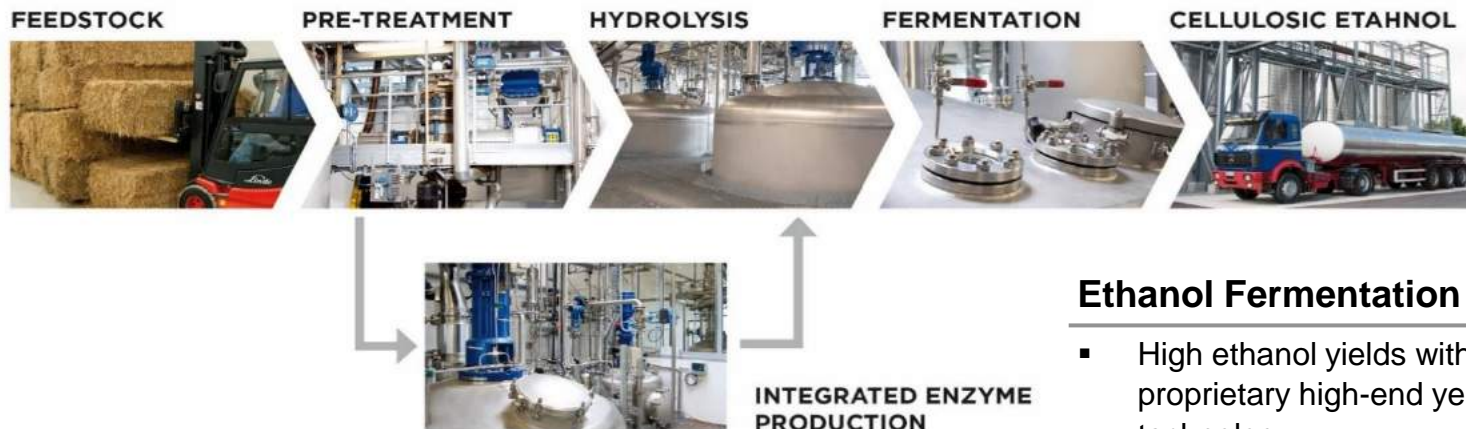
Market Potential for Cellulosic Ethanol



**OVER
700 MIO
TONS***

* with technologies like sunliquid

With its Focus on Integration, sunliquid® is Designed to Achieve Optimal Efficiency

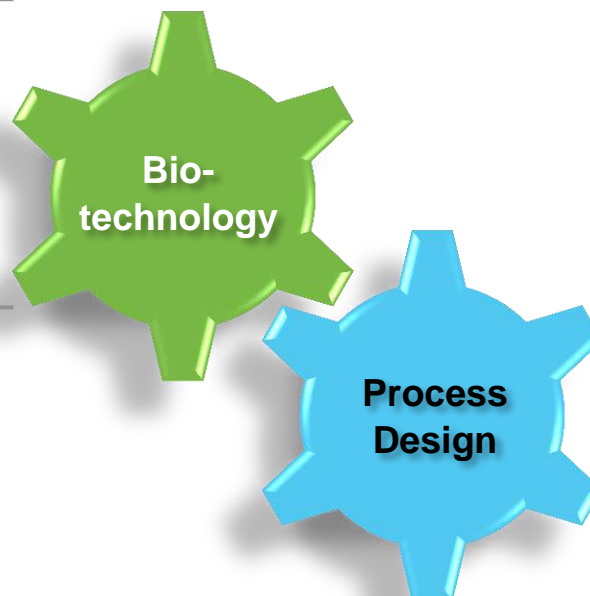


Biomass pre-treatment

- Chemical-free & low-cost pre-treatment
- Conditions optimized jointly with enzyme production

Enzymatic hydrolysis

- High sugar yields through feedstock and process-specific cellulase enzymes
- Integrated on-site enzyme production with biomass as nutrient source



Ethanol Fermentation

- High ethanol yields with proprietary high-end yeast technology
- Simultaneous one-pot C5&C6 fermentation

Energy integration

- Side products (e.g. Lignin) as energy sources
- Integration with site-specific energy infrastructure

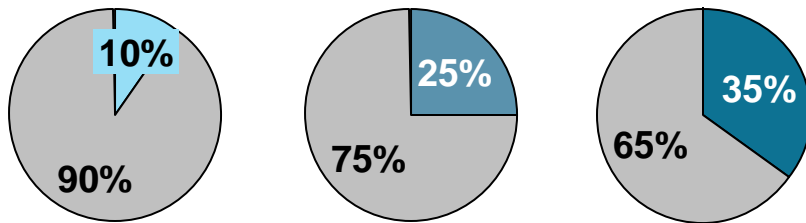
Standard equipment

- Low scale-up risk due to established equipment
- Standard protocols for plant and equipment operations

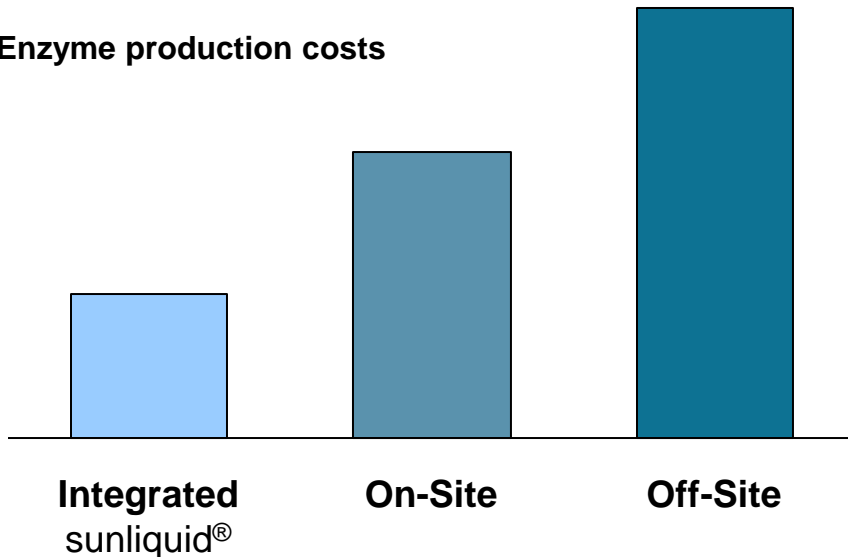
Integrated enzyme production makes cellulosic ethanol economically viable and competitive

Enzyme cost comparison

Enzyme costs of total production costs



Enzyme production costs



Integrated enzyme production

- Pre-treated biomass as source
- No enzyme formulation & stabilization
- No transportation

- Enzyme costs only **10%** of total production cost
- Enzyme production costs **50% less** than On-Site; **75% less** than Off-Site
- Ensures availability and cost efficiency

sunliquid® Benefits in a Nutshell - High Performance Technology Package



REDUCED CO₂-EMISSIONS

Reduction by 95%



INCREASED BIOETHANOL YIELD

Conversion of all types of sugar is possible



ENERGY SELF-SUFFICIENT

All energy comes from the combustion of waste flows such as lignin



PROCESS-INTEGRATED ENZYME PRODUCTION

Reduces costs



USE OF LOCAL RESOURCES

Location-specific factors can be taken into consideration



GREEN JOBS

Strengthening of local agricultural business

sunliquid® - En Route to Commercialization



- **2009**
 - **Pilot plant** operational
 - Capacity 1 t/a Ethanol

- **2013**
 - Validation with **corn stover** and sugarcane **bagasse** in demo plant
 - ISCC certification



- **2014**
 - **Process Design Package** for commercial-scale plant

- **2015**
 - Top-3 **GreenTec** award

- **2006**
 - Start of the development (as Süd-Chemie)
 - Setup of **Biotech R&D** Center in Munich

- **2012**
 - **Pre-commercial plant** operational
 - Capacity 1,000 t/a Ethanol
 - Validation on **wheat straw**



- **2014**
 - **E20 fuel testing** with Mercedes Benz & Haltermann



- **2014**
 - Awarded of **EU FP7** grant



- **2015**
 - Nominated for **German Innovation Award for Climate and Environment (IKU)**



Commercialization

Application of sunliquid® - Successfully Tested in Fleet

- **sunliquid®20**: Gasoline-Ethanol blend containing **20% cellulosic ethanol** from **Clariant's pre-commercial plant**
- In 2014 **sunliquid®20** was tested in **Mercedes' fleet**:
 - Particle emissions reduced by 50%
 - Today's vehicles can already use E20 blends
 - High-quality fuel for best efficiency and specification

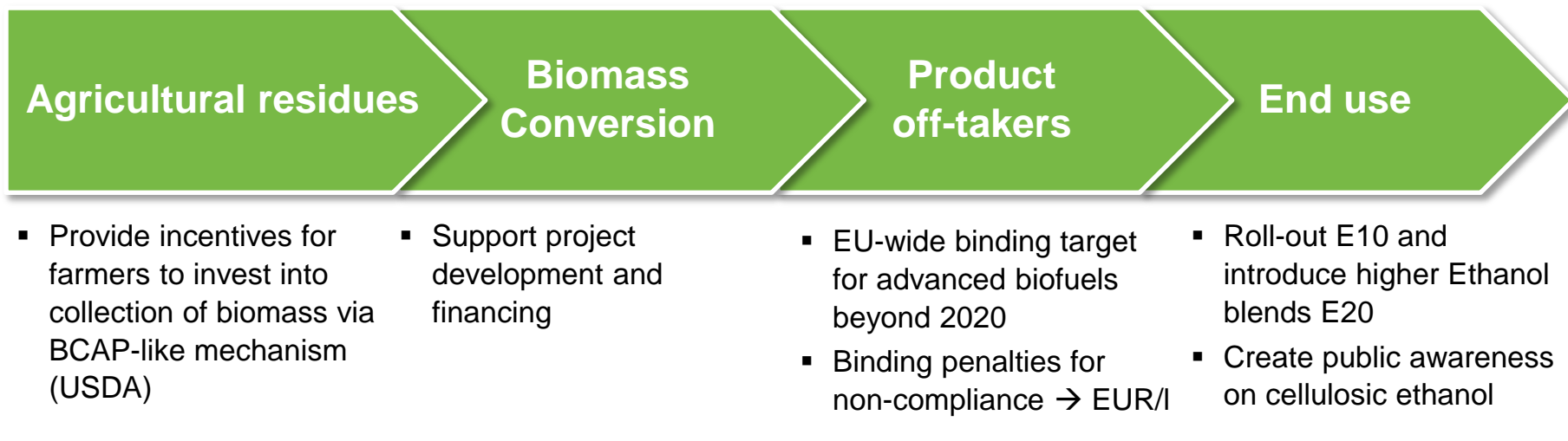
CLARIANT



Mercedes-Benz



Testing not Enough: Advanced Biofuels Need Stable & Long-Term Policy Framework along the Value Chain



What Germany can do now

- With switch from Biofuels Quota to GHG-Emission-Saving-Quota de facto no support for advanced biofuels (tax exemption and double-counting for advanced biofuels has expired)
- Germany should transpose the new ILUC directive quickly and thereby establish:
 - A binding target of 0.5% for advanced biofuels in 2020 and beyond
 - Punish non-compliance with penalties

Thank You!



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