The Biomass Balance Approach: An innovative and complementary approach for using biomass in the chemical industry

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Four main drivers are influencing BASF’s renewable-based portfolio

1. **Competitiveness**: Product with a certain performance not accessible or at higher cost or market demand

2. **Sustainability**: Save fossil resources and protect climate
   - Vision 2050: a world in which nine billion people can live well, and within the planet’s resources

3. **Opportunities**: Customer / consumer demand and regulations

4. **Diversification** of raw material base
The Biomass Balance Approach

Biomass is added at the very beginning of our production chain.
Biomass Balance is the viable option for an immediate switch to renewable raw materials in the chemical industry.

<table>
<thead>
<tr>
<th>Traditional production</th>
<th>Biomass Balance approach</th>
<th>Dedicated production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil feedstock</td>
<td>Biomass-derived with 3rd party certification</td>
<td>Biobased analyzed by 14C method</td>
</tr>
<tr>
<td>Known performance</td>
<td>Same performance</td>
<td>Often different product performance</td>
</tr>
<tr>
<td>&gt; 20,000 products available in production scale</td>
<td>&gt; 20,000 products available in production scale</td>
<td>Not available for all products</td>
</tr>
<tr>
<td>Verbund production</td>
<td>Drop-in BASF Verbund production</td>
<td>Investment in R&amp;D and new plants</td>
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<td></td>
<td>Often additional cost for renewable feedstock</td>
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How does the Biomass Balance Approach work?

Feedstock

- Fossil
- Renewable

Use of renewable feedstock in very first steps of chemical production (e.g. steam cracker)

BASF Production Verbund

Utilization of existing Production Verbund for all production steps

Products

- Conventional
- Allocated

Allocation of renewable feedstock to selected products
Challenge: Renewable materials cannot be directed to one specific product

Therefore, a credible external certification system is needed.
Our solution: Certification and standardization

Feedstock
- Fossil
- Renewable

BASF Production Verbund

Products
- Conventional
- Allocated
Renewable raw materials need to be sourced sustainably

Use certified renewable raw materials
- Bionaphtha from vegetable and organic waste oils
- Biogas from organic waste (e.g. kitchen waste)
- Certification example: ISCC EU

Apply standardized sustainability criteria
- Greenhouse gas emissions savings
- Responsible biomass production
- Protection of areas with high biodiversity and large carbon stocks

We are exploring and qualifying feedstocks according to international sustainability standards and in dialog with NGOs (e.g. RED*)

*RED = Renewable Energy Directive of EU Commission
Biomass Balance approaches are addressed in existing standards

<table>
<thead>
<tr>
<th><strong>Sustainability standards for biomass</strong></th>
<th><strong>Political and market standards</strong></th>
<th><strong>Life Cycle Assessment</strong></th>
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<tbody>
<tr>
<td>RED* supports existing mass balance standards</td>
<td>Enhanced importance of green public procurement and product labelling</td>
<td>Existing standards and allocation rules already accommodate MB</td>
</tr>
<tr>
<td>RED* describes strict requirements for such biomass feedstocks</td>
<td>Market labels are already using biomass balance</td>
<td>Critical reviews proved conformity</td>
</tr>
<tr>
<td>TÜV SÜD CMS 71 is the 1st standard applicable for chemical industry</td>
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</table>

We are implementing the Biomass Balance approach to existing and upcoming standards

*RED = Renewable Energy Directive of EU Commission*
In LCA calculations the raw material use of fossil comparatives needs to be quantified

Model of production processes in BASF’s LCA software according to ISO 14040/14044

Quantification of material use of fossil comparatives by mass flows
A LCA calculation shall consider the chemical value of the renewables to allow a fair substitution of fossil comparatives

- Biomass has often less chemical value than its fossil comparatives
- Chemical value can be defined as lower heating value (LHV)
- Biomass balanced LCI can be calculated based on the LCI of the fossil comparative:

\[ \text{BMB-LCI} = \text{LCI}_{\text{fossil}} + a \cdot (c_v_{BN} \cdot \text{LCI}_{BN} - c_v_N \cdot \text{LCI}_N) + b \cdot (c_v_{BG} \cdot \text{LCI}_{BG} - c_v_{NG} \cdot \text{LCI}_{NG}) \]

- \( a \) (amount of naphtha)
- \( b \) (amount of natural gas)

**BMB:** Biomass balance
**LCI:** Life Cycle Inventory
**Cv:** chemical value factor
**Indices:** N = naphtha, NG = natural gas, BN = bionaphtha, BG = biogas
Summary

Biomass balance

- is the viable option for an **immediate switch to renewable raw materials** in the chemical industry and is complementary to biobased chemistry

- allows introduction of **certified renewable feedstocks** for a broad range of chemical pathways

- products are **drop-in solutions** without any compromise in performance

- can be easily implemented to **LCA** and shall consider the chemical value
BASF purchases a broad range of renewable raw materials

**Oils & Fats**
- Lauric oils & deriv.
- Natural oils
- Fatty acids & deriv.
- Glycerin

**Grains**
- (Modified) starches
- Dextrose
- Glucose syrups

**Sugar**
- Sucrose
- Ethanol
- Organic acids

**Wood**
- Ligninsulfonate
- Cellulose-derivatives
- Furfural
- Tall oil derivatives

5.4% of BASF’s total raw material purchase are renewables