



HUNTSMAN

Enriching lives through innovation

**High-Performance Sustainable
Epoxy resins with
up to 100%
Carbon Footprint Reduction**

Huntsman Advanced Materials

MADE POSSIBLE

A sustainable future in construction

Clear actions and targets to improve our sustainability performance

Product safety

Alternatives to SoC

SVHC and CMR raw materials are **banned** from developments and **substituted** in legacy ranges



Environmental impact reduction (Manufacturing)

CO₂ emissions

- Optimizing energy mix
- Improving efficiency

Water consumption

Waste creation / reuse



Product life cycle

Life Cycle Analysis

End-of-Life:

- Design for recycling
- Chemicals recovery
- Debonding on demand
- Recyclable packaging



Portfolio Decarbonization

Use of Renewable materials

(scope 3 emissions)



CO₂ footprint is only one indicator among others ...

16
LIFE
CYCLE
ANALYSIS
INDICATORS

Impact category / Indicator	Unit	Description
Climate change – total, fossil, biogenic and land use	kg CO ₂ -eq	Indicator of potential global warming due to emissions of greenhouse gases to air. Divided into 3 subcategories based on the emission source: (1) fossil resources, (2) bio-based resources and (3) land use change.
Ozone depletion	kg CFC-11-eq	Indicator of emissions to air that cause the destruction of the stratospheric ozone layer
Acidification	kg mol H+	Indicator of the potential acidification of soils and water due to the release of gases such as nitrogen oxides and sulphur oxides
Eutrophication – freshwater	kg PO ₄ -eq	indicator of the enrichment of the fresh water ecosystem with nutritional elements, due to the emission of nitrogen or phosphor containing compounds
Eutrophication – marine	Kg N-eq	Indicator of the enrichment of the marine ecosystem with nutritional elements, due to the emission of nitrogen containing compounds.
Eutrophication – terrestrial	mol N-eq	Indicator of the enrichment of the terrestrial ecosystem with nutritional elements, due to the emission of nitrogen containing compounds.
Photochemical ozone formation	kg NMVOC-eq	Indicator of emissions of gases that affect the creation of photochemical ozone in the lower atmosphere (smog) catalysed by sunlight.
Depletion of abiotic resources – minerals and metals	kg Sb-eq	Indicator of the depletion of natural non-fossil resources.
Depletion of abiotic resources – fossil fuels	MJ, net calorific value	Indicator of the depletion of natural fossil fuel resources.
Human toxicity – cancer, non-cancer	CTUh	Impact on humans of toxic substances emitted to the environment. Divided into non-cancer and cancer related toxic substances.
Eco-toxicity (freshwater)	CTUe	Impact on freshwater organisms of toxic substances emitted to the environment.
Water use	m ³ world eq. deprived	Indicator of the relative amount of water used, based on regionalized water scarcity factors.
Land use	Dimensionless	Measure of the changes in soil quality (Biotic production, Erosion resistance, Mechanical filtration).
Ionising radiation, human health	kBq U-235	Damage to human health and ecosystems linked to the emissions of radionuclides.
Particulate matter emissions	Disease incidence	Indicator of the potential incidence of disease due to particulate matter emissions.

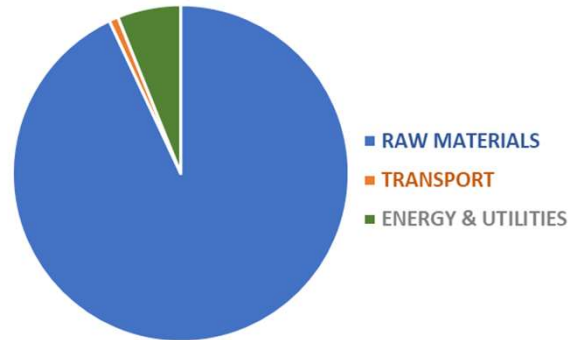
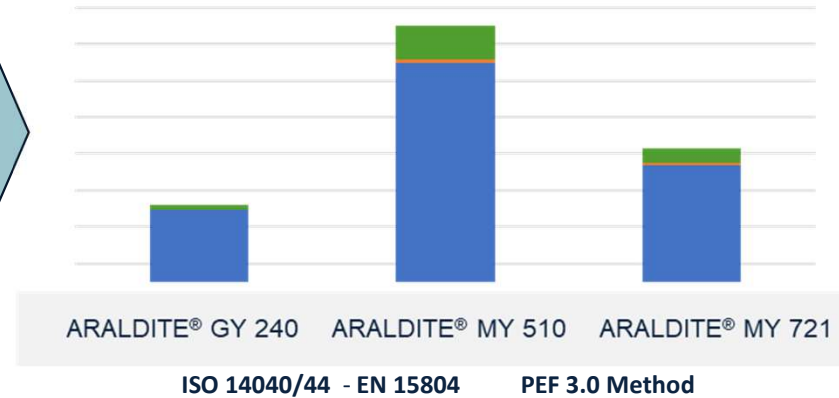
Climate change is also known as **GWP** (global warming potential), **PCF** (product carbon footprint)

Focus on raw materials to have major impact on CO₂ footprint

≈ **90%** of a resin's Carbon Footprint comes from the **Raw Materials**

PCF : Kg of CO₂eq. released for the production of 1 Kg of Product

PCF comparison of 3 epoxy resins



Typical relative contributions of Huntsman epoxy resins to PCF

CO₂eq. : CO₂ equivalent – Considers CO₂ and other greenhouse gases

Bio feedstock and recycled feedstock to reduce CO₂ emissions



MORE BIO IN or MORE RECYCLED IN , LESS CO₂ OUT



Before the industry can become fully bio-based, there are several problems to overcome.

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Introduction to Bio-Mass Balance Concept

Through the EPOXY production case

Introduction to Bio-Mass Balance concept

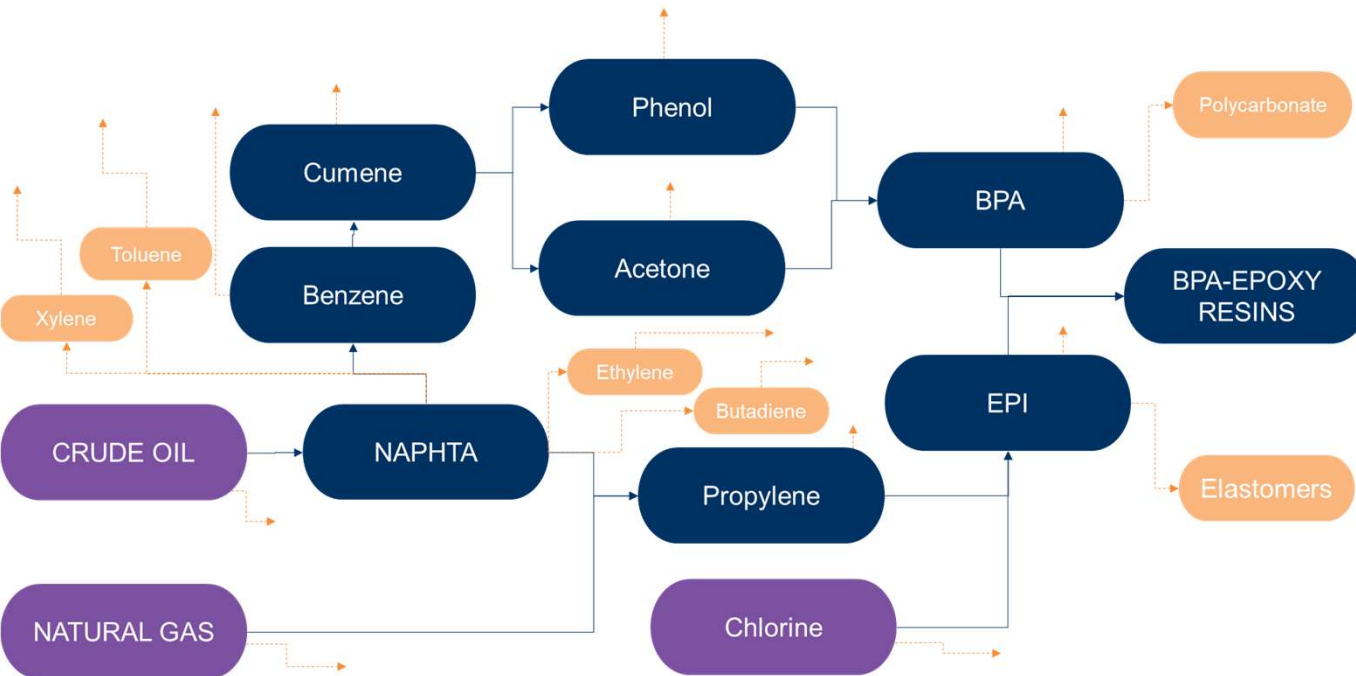
Epoxy resins Industrial path

An Entangled and Asset-intensive value chain

10 transformation operations

15 different raw-materials

In the middle of a multitude of industrial chemical paths



---> To Other Chemicals Production

The Industrial Reality

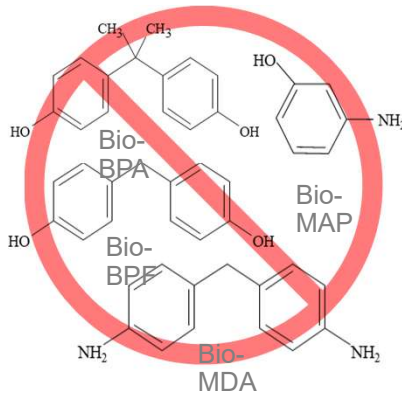
EPI (Epichlorohydrin)
exists as Bio-based material

Bio-Based precursors
do not exist at industrial scale



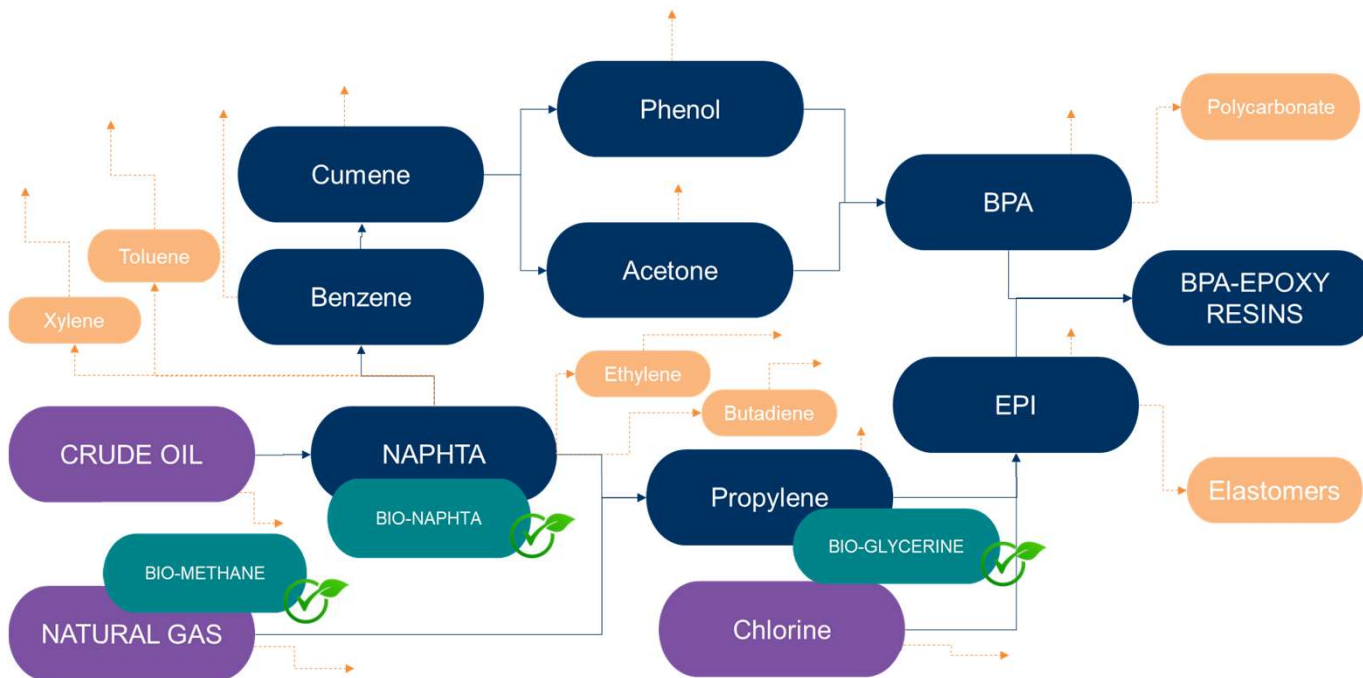
BPA based ARALDITE® GY 240	Max. ≈ 28%
MDA Based ARALDITE® MY 721	Max. ≈ 50%

(ASTM-D6866)



Bio-Content of existing BPA-Based epoxy resins is currently limited by the availability of Bio-Precursors

Bio-Mass to enhance Sustainability Character ?

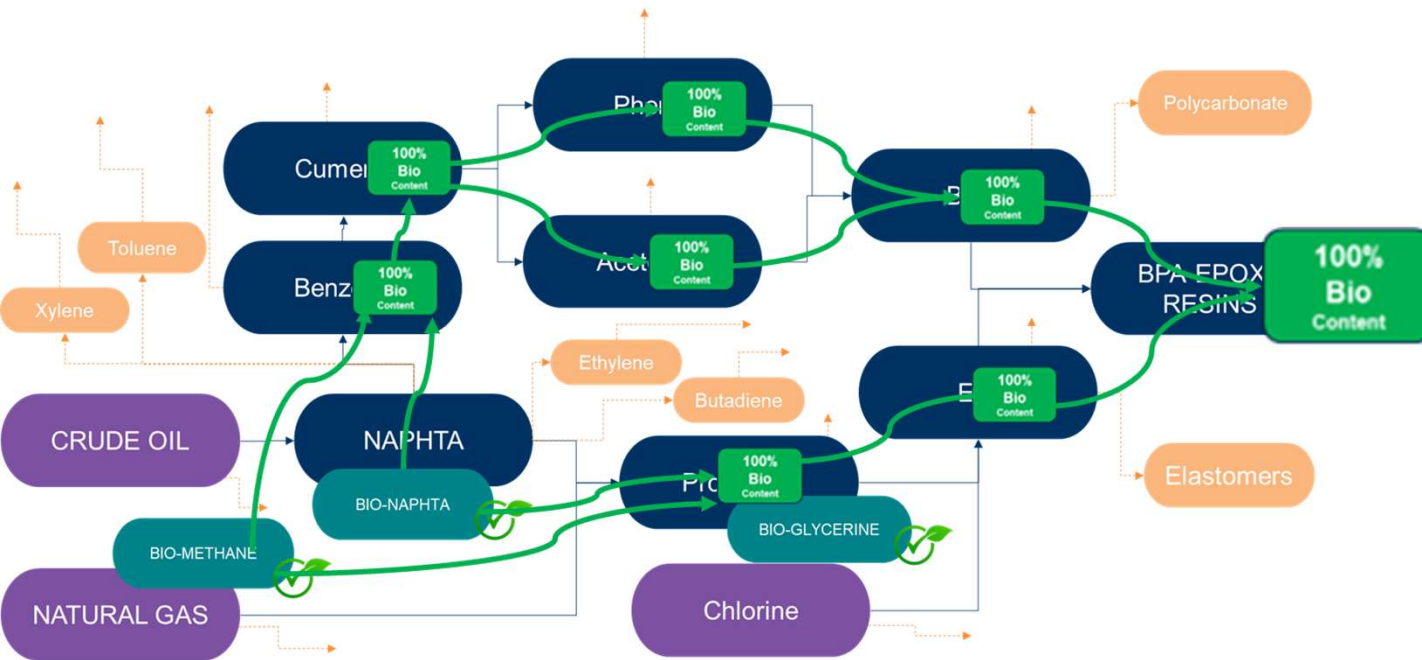


An
Entangled
and
Asset-intense
value chain

IN WHICH IT IS POSSIBLE
TO
INTRODUCE
BIOMASS
upstream

Introduction to Bio-Mass Balance concept

Transforming Bio-Mass in Bio-Based intermediates ...



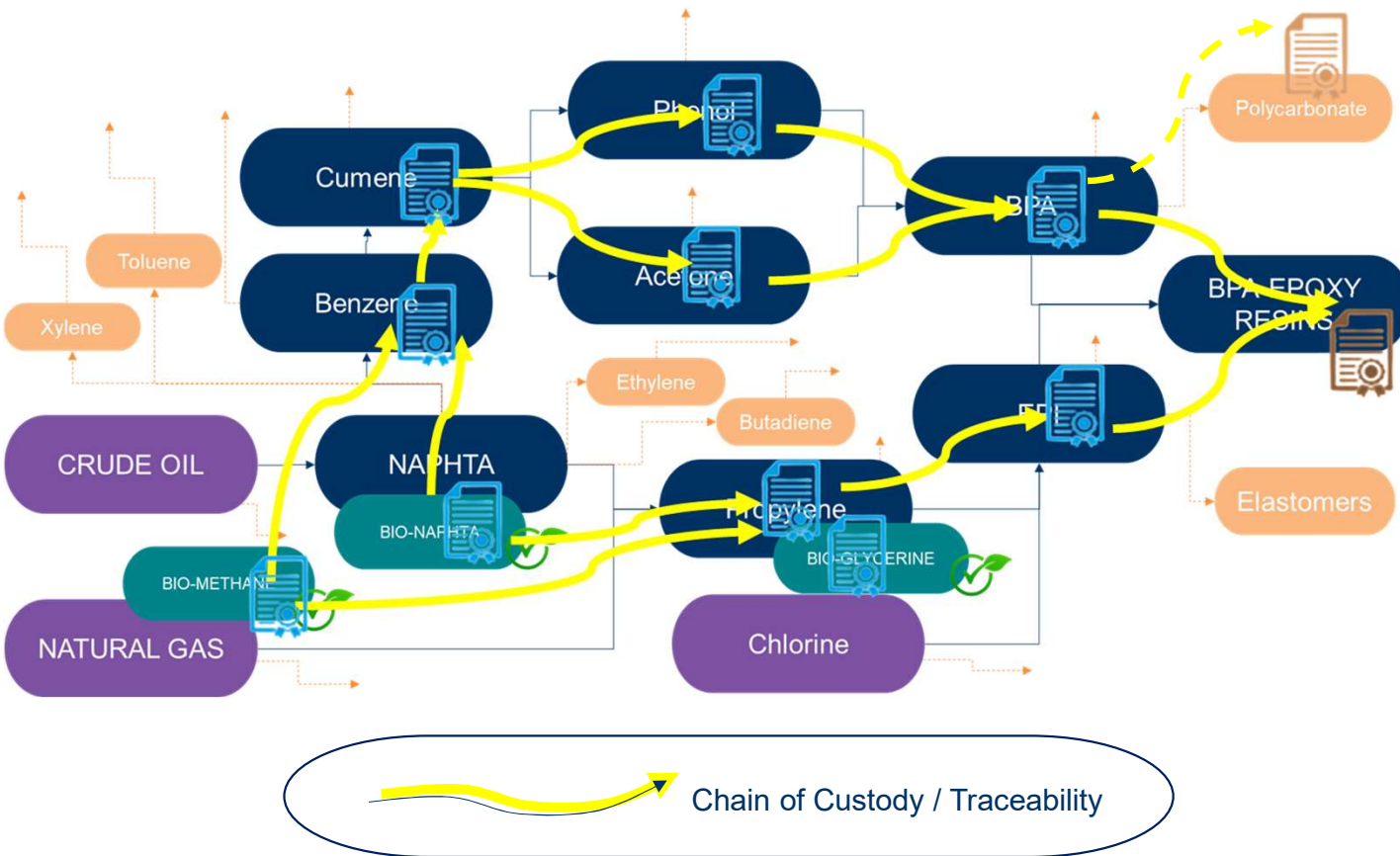
Targeting 100% BIO-CONTENT BPA-EPOXY RESINS

**PHYSICAL
SEGREGATION / DUPLICATIONS
of the different
TRANSFORMATION STEPS**

IMMENSE CAPEX

**NOT
ECONOMICALLY
VIABLE**

Tracking use of Bio-Mass and allocate ...



Mathematical
& Verified
ALLOCATION of
“**BIO-QUANTITIES**”
through the value
chain

Up to 100%
BIO-ATTRIBUTED
BPA EPOXIES

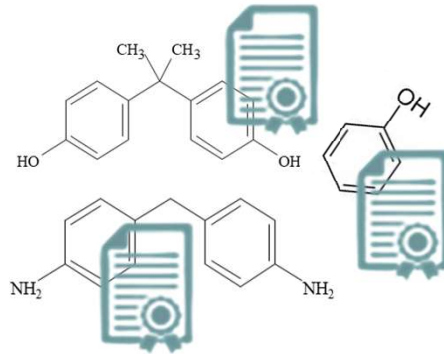
WHAT MATTERS IS FOSSIL
RESOURCES SAVING

The “Innovative Reality”

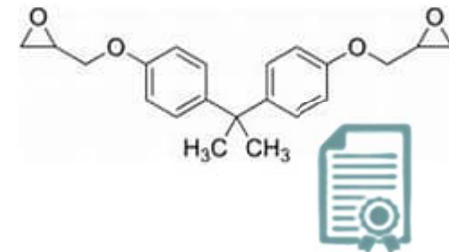
EPI (Epichlorohydrin) is available as **CERTIFIED** “Fossil-Saving” grade



Precursors are also available as **CERTIFIED** “Fossil-Saving” grade

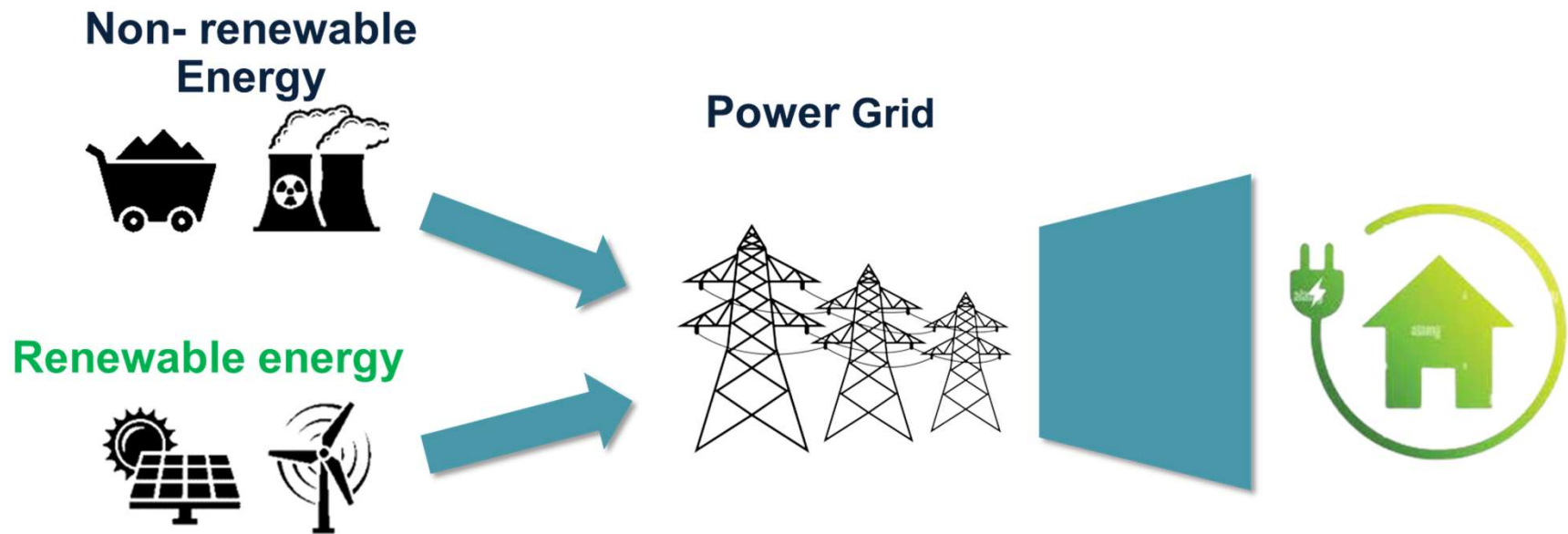


BPA-EPOXY resins can also be available as **CERTIFIED** “Fossil-Saving” products



This “Mathematical and Verified” allocation approach is what is called the **MASS BALANCE concept**

GREEN ELECTRICITY to give a feel about Biomass Balance concept



Consumer or Industrial plant choose to buy electricity from Renewable Energy Source...

but they DO NOT KNOW the nature/origin of electrons reaching their home/plant

Biomass Balance Concept

In the chemical industry a similar concept can be applied :



**A voluntary certification scheme
for the use of sustainable
materials in the chemical Industry**

Illustration : Courtesy of REDcert

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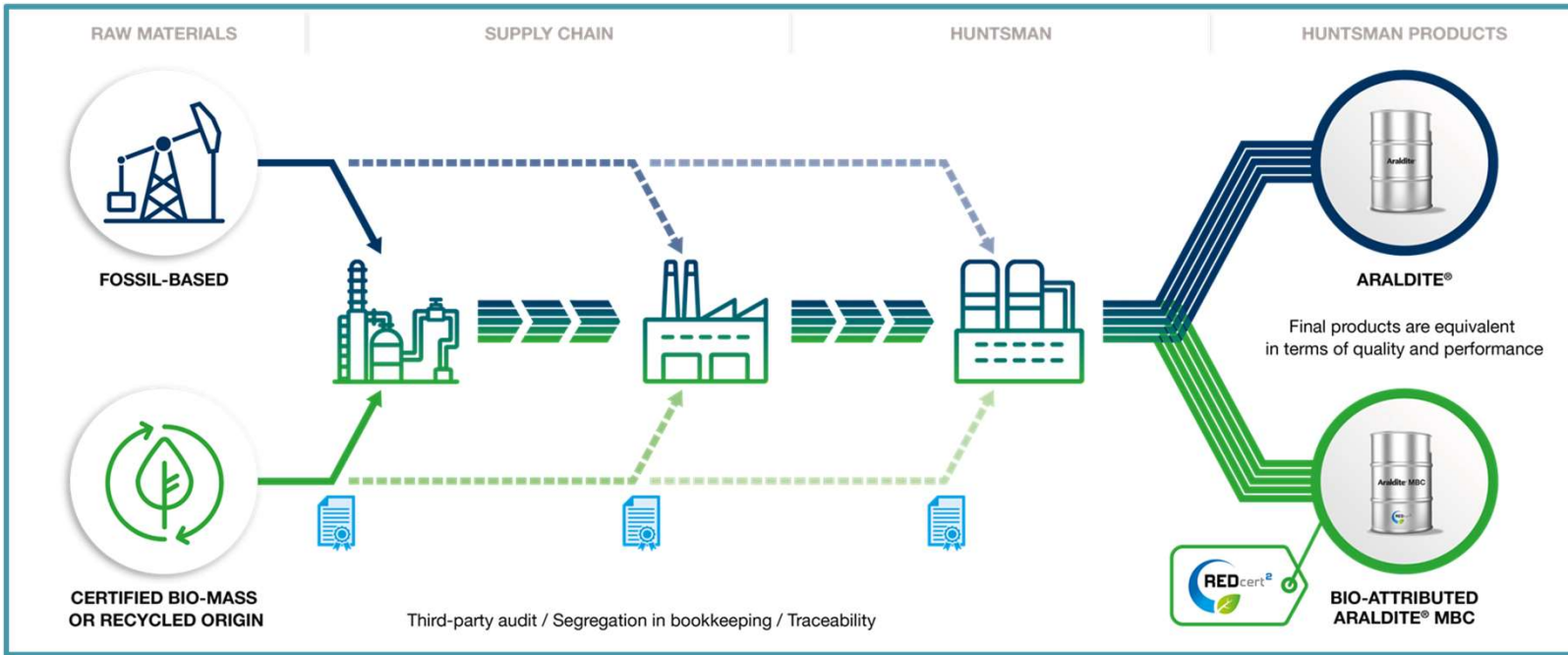
**Mixing of Sustainable &
Fossil materials**

**Co-Production in
Existing Infrastructure**

**No Physical Content
guaranteed**

Biomass Balance Concept

Verified substitution of fossil raw materials by sustainably certified biomass



Mixing
Tracking
Verifying

Mixing renewable and fossil raw materials,
Tracking the quantities in the books,
Verifying through an independent certification

Introducing Mass-Balance Units (MBUs)

Examples of LHV / MBUs
of two typical Huntsman's epoxy resins
and their main raw materials

Epichlorohydrin	20 MJ/Kg	0.40 MBU/Kg
Bisphenol A	33 MJ/Kg	0.66 MBU/Kg
Para-Aminophenol	26 MJ/Kg	0.52 MBU/Kg
ARALDITE® GY 250	32 MJ/Kg	0.64 MBU/Kg
ARALDITE® MY 0510	28 MJ/Kg	0.56 MBU/Kg

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Mass Balance concept
considers the **ENERGY**
contained in chemicals

LHV : Lower Heating Value
(or Net Calorific Value)

MJ/Kg - ASTM D240

Reference = METHANE

$LHV_{\text{METHANE}} = 50 \text{ MJ/Kg}$

1 MBU = 50 MJ

Biomass Balance Concept

Introducing Mass-Balance Units (MBUs)

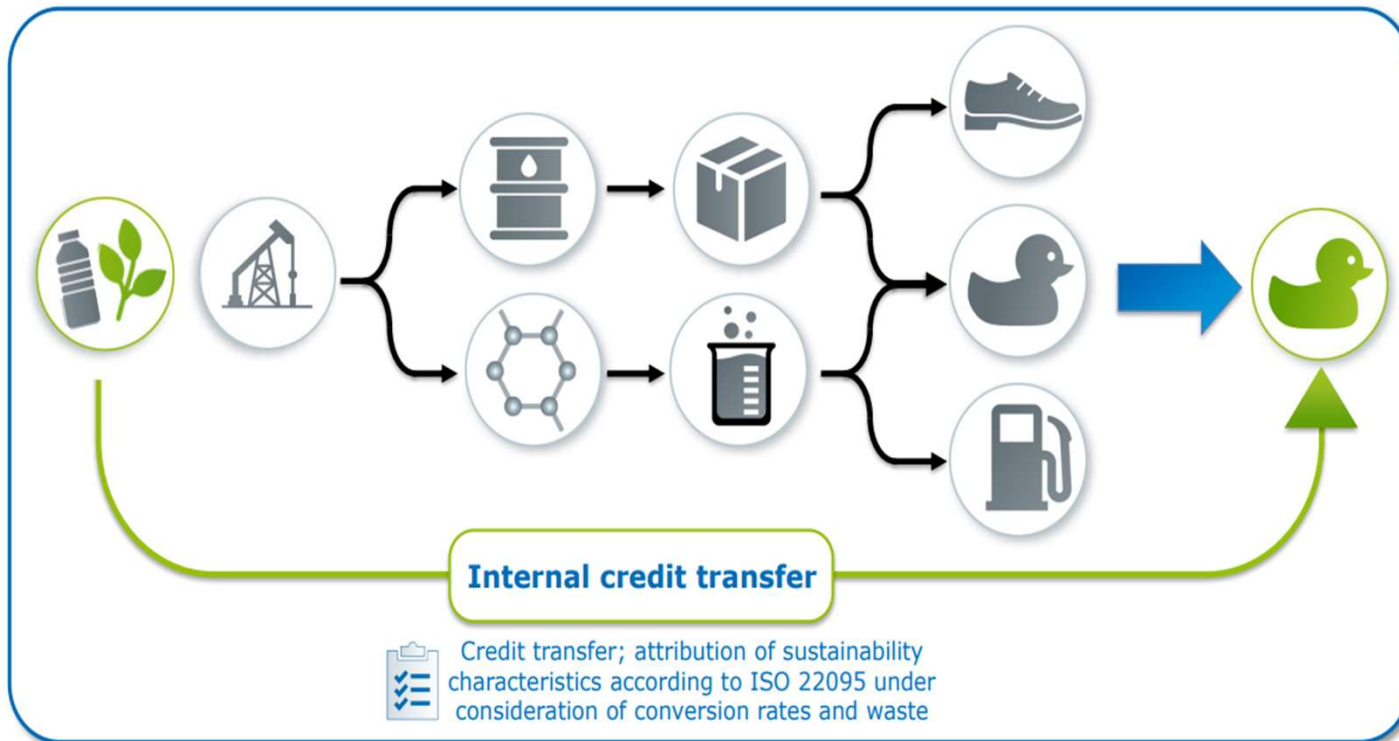


Illustration : Courtesy of REDcert

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Mass Balance Unit approach provides a statement on the substitution rate across several production stages at once.

Credit transfer system following **ISO 22095**

The overall demand of raw materials is calculated for each intermediate or product ...

Raw materials are compared based on their

Lower Heating Value (LHV) converted in MBUs

Three essential rules

Rule n°1 The concept requires an excess of MBUs in stock vs. MBUs leaving the plant (sold)

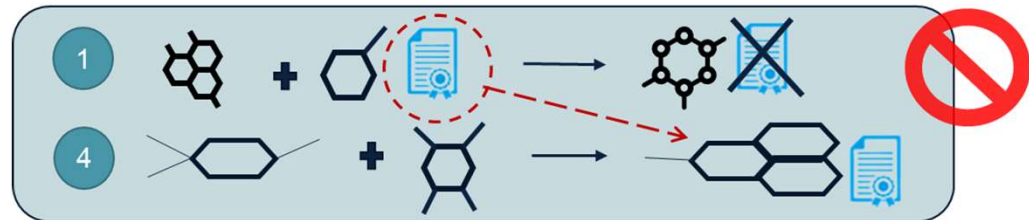
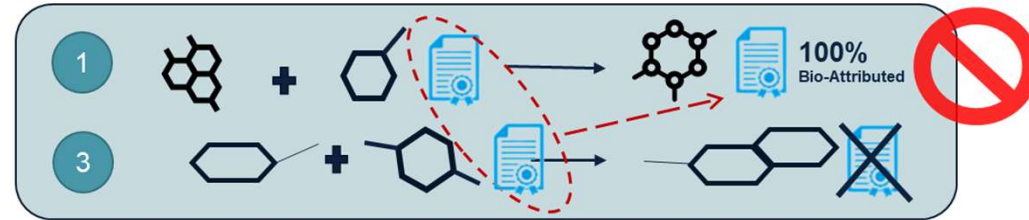
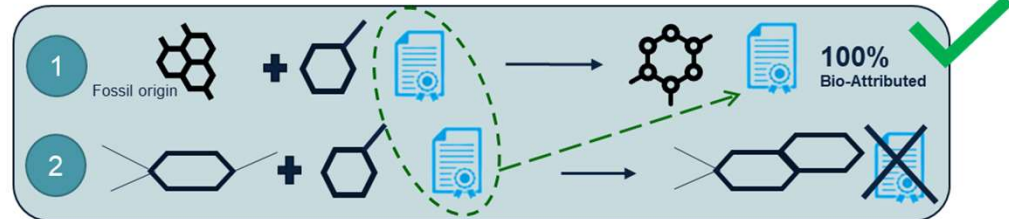
MBUs "IN" →  → MBUs "OUT" ✓

$$\sum \text{MBUs "IN"} \geq \sum \text{MBUs "OUT"}$$

Rule n°2 Certified products are made from at least one certified raw material

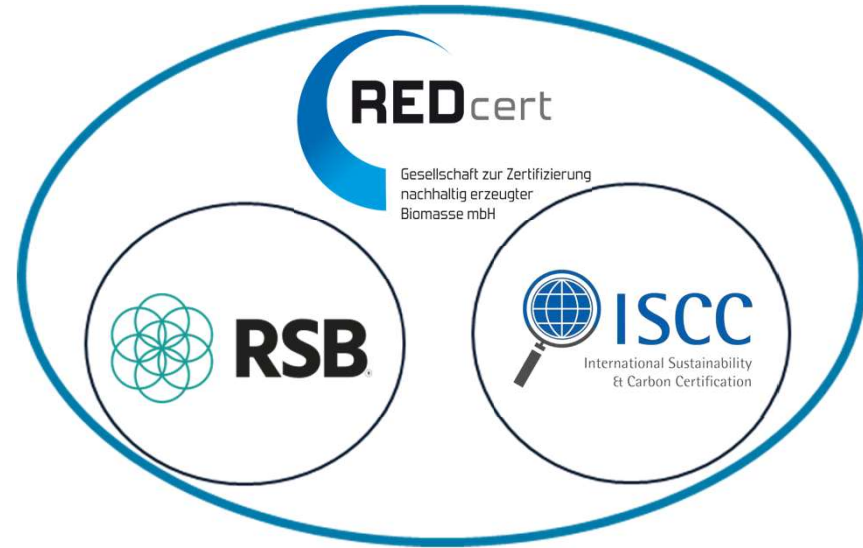


Rule n°3 Cross-allocation of MBUs is possible if "donor" is a reactant **and** if rule n°2 is followed



REDcert is the certification scheme chosen by Huntsman Advanced Materials

REDcert is a
“Universal” certification scheme
allowing combinations of *RSB*,
ISCC-Plus or *REDcert²* certified
raw materials



- Organisation created in 2010 (Bio-Fuels)
- **Accredited by the European Commission in 2012**
- **REDcert² : extension to the chemical industry in 2018**



Sources of Sustainably certified raw materials have been identified for most of Huntsman's high-performance epoxy resins

Certified sustainable raw materials

Certified Huntsman Resins

Certified EPI



Certified MDA



TGMDA series

Certified PHENOL



EPN series
BPF series

Certified BPA



BPA series



The REDcert² logo is registered as a figurative and word mark in the trademark register of the Office of the European Union for Intellectual Property (EUIPO) and is protected by trademark law.

Advanced Materials

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The Huntsman's “MBC” offer

and its benefits

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Huntsman's "MBC" offer

Scope of REDcert² certification



REDcert² Mass Balance certification is about BOTH :

- 1) Company, organization & Plants
- 2) Individual Products



COMPANY
CERTIFICATE



PLANT
CERTIFICATE



INDIVIDUAL
PRODUCT
CERTIFICATE

Huntsman's "MBC" offer

Monthey, Switzerland : Huntsman's first REDcert² certified plant

Mass-balance certified epoxy resins
are now commercialized under the name

ARALDITE[®] MBC

- ✦ up to 100% bio-attribution
- ✦ up to 100% CO₂ savings (*)
- ✦ made from Bio-Circular Feedstocks (**)

(*) vs. fossil-based epoxy resins

(**) feedstocks derived from waste and residues

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DIN CERTCO
Gesellschaft für Konformitätsbewertung mbH



CERTIFICATE

REDcert²-943-66600048

DIN CERTCO Gesellschaft für Konformitätsbewertung mbH
Alboinstraße 56, 12103 Berlin, GERMANY
confirms that

Huntsman Advanced Materials Switzerland GmbH
Klybeckstr. 200, 4057 Basel, Switzerland
complies with the requirements of the certification system

REDcert²

The inspection reports (2023-02-15 / 66600048) documents that the requirements of the REDcert² certification system for the purpose of mass balanced products is fulfilled.

The certified system user is a
(501) Supplier (before the last interface)

This certificate is valid from 2023-03-28 to 2024-03-27.



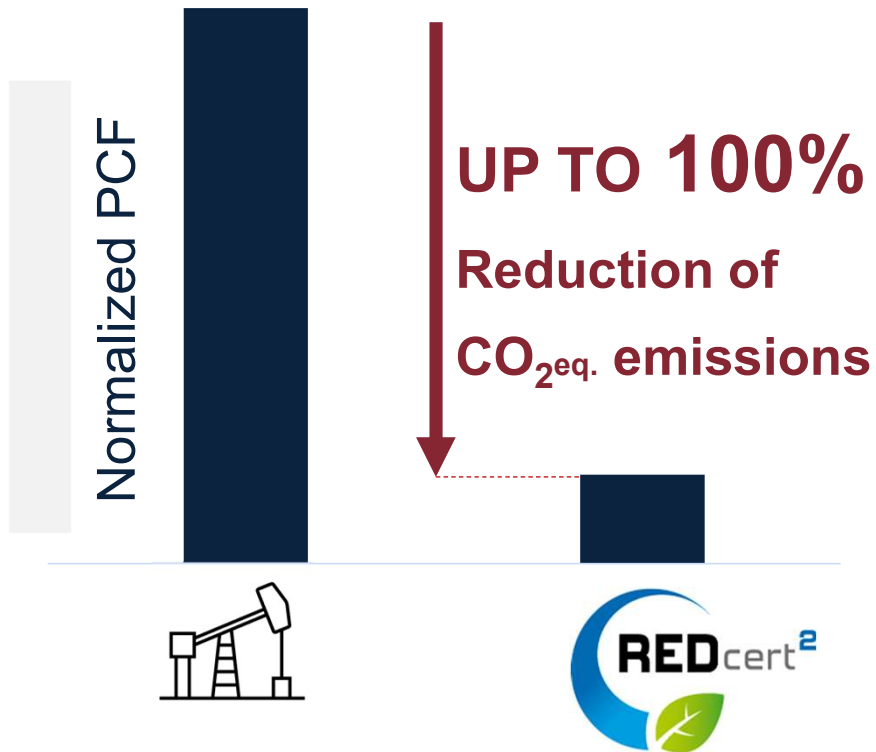
C. Seiser
Dipl.-Phys. Carlo Seiser
- Head of Certification Body -

Signature of the certificate.



Biomass Balance certified resins show significant CO_{2eq.} footprint reduction

Huntsman's Epoxy Resins (*)



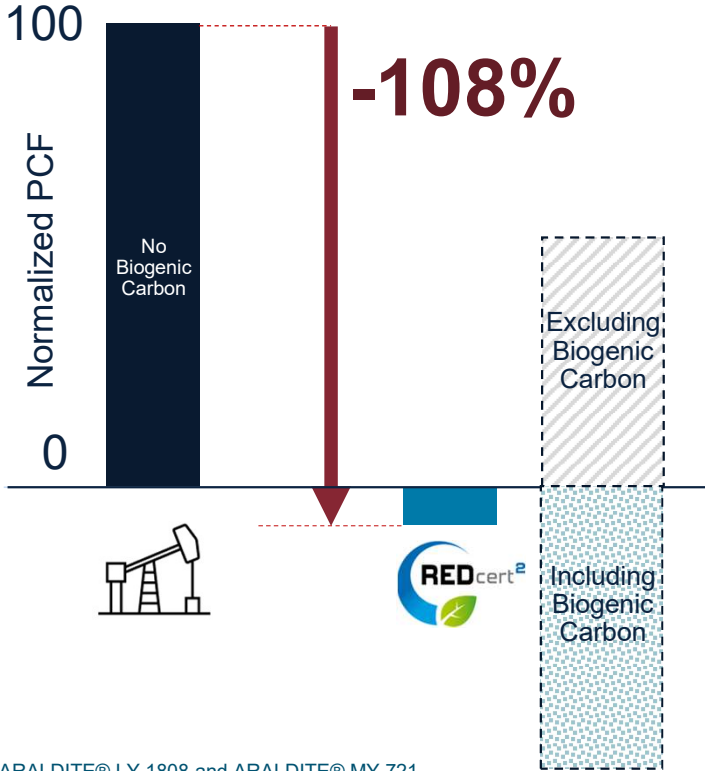
No deterioration of other LCA indicators

- Water usage
- Land Usage
- Eco-toxicity
- Human Toxicity

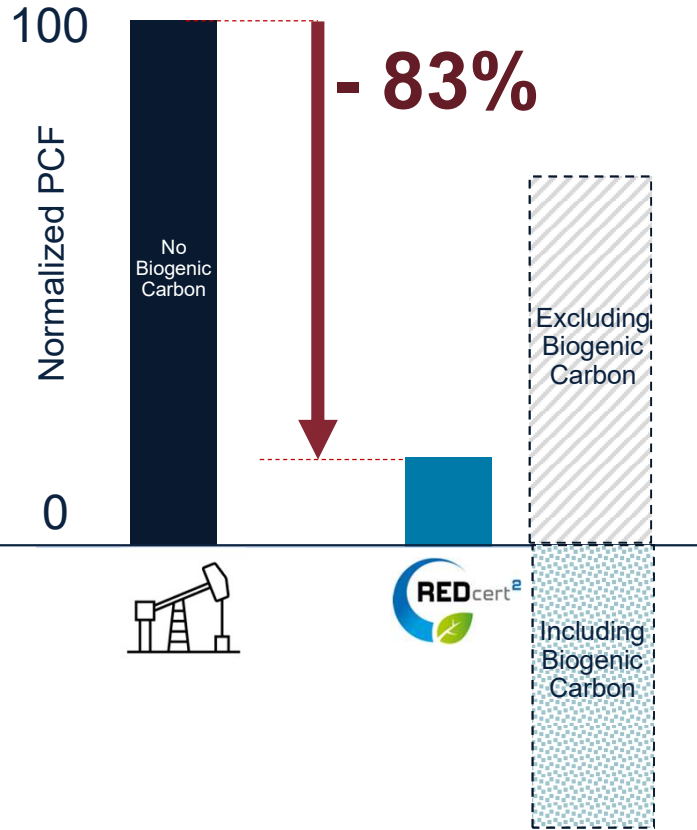
(*) Manufacturing Plant dependent

Biomass Balance certified resins show significant CO_{2eq.} footprint reduction

ARALDITE® LY 1808(*)



ARALDITE® MY 721 (*)



25 (*) ARALDITE® LY 1808 and ARALDITE® MY 721 are two examples from the Huntsman's epoxy resins range illustrating the benefit of Mass Balance concept implementation.

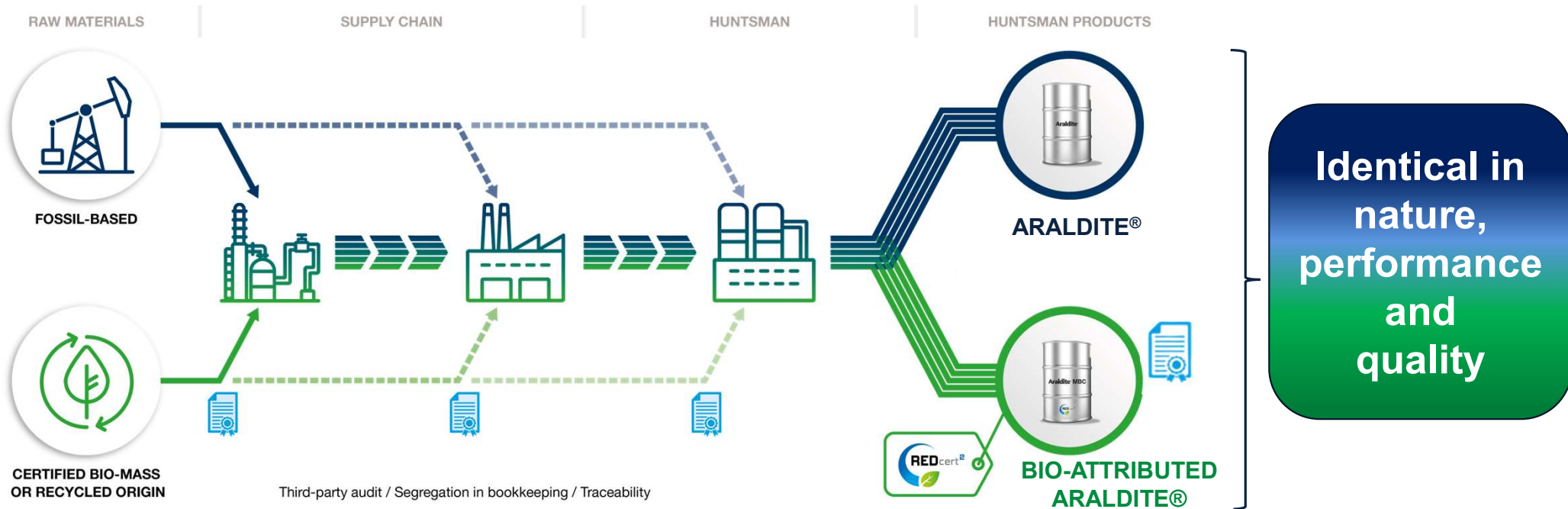
Huntsman's "MBC" offer



NO CHANGE = DROP-IN SOLUTIONS – No need for requalification

Mass Balanced Raw Materials : Same supplier, Same Processes, Same Specifications

Certified ARALDITE® Resins : Same plant/lines, Same processes, Same Specifications



Advanced Materials



Conclusion and Outlook

MADE POSSIBLE

Biomass Balance Concept

Benefits of Mass Balance Concept

- Immediate reduction of CO₂ emissions
- No deterioration of other LCA indicators
- No need for requalification of final products

**FAST and EFFICIENT
SUSTAINABLE TRANSFORMATION
of the CHEMICAL INDUSTRY**

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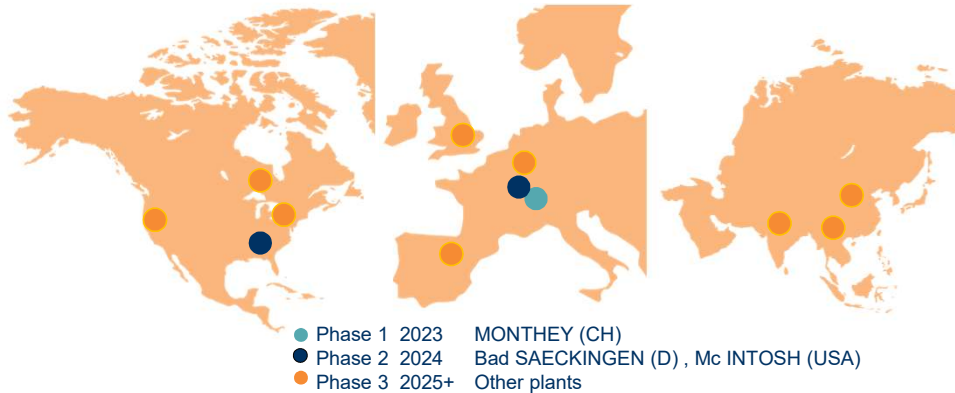


**What Matters is
Saving the Use
of Fossil
Resources**

Sustainable future

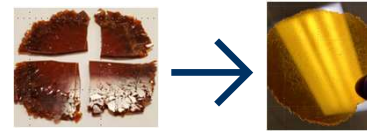
Outlook for our Sustainability Journey

“MBC” Extension : New plants, New Product ranges

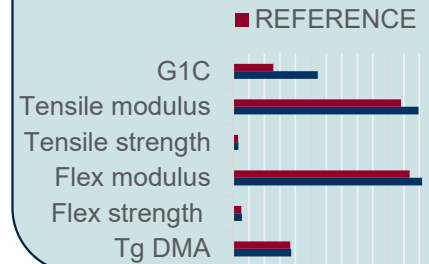


Designing for Circularity

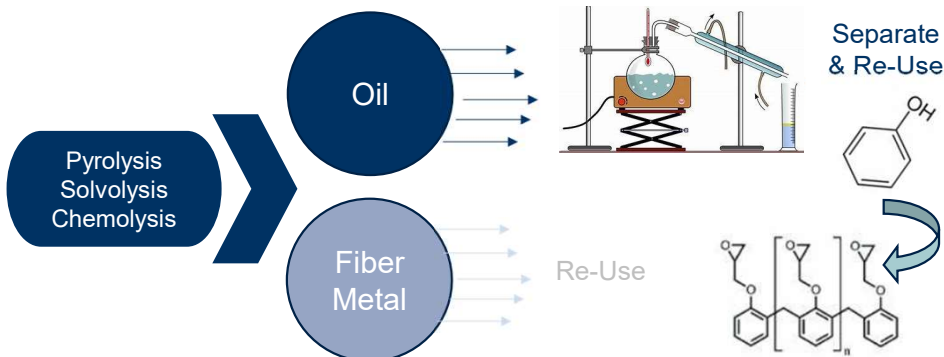
Development of VITRIMERS



Example : Epoxy system for H2 PV



Chemicals Recovery



HUNTSMAN INTERNATIONAL LLC PROPRIETARY AND CONFIDENTIAL INFORMATION

Debonding On Demand

RECYCLING =

- 1) Separation
- 2) Preparation
- 3) Re-use



ARALDITE® Structural adhesives =

- 1) Performance
- 2) Resistance

ARALDITE®
Debonding Primer

