# Bioeconomy Value Chains

## *Commercial & Technical Options & Challenges*

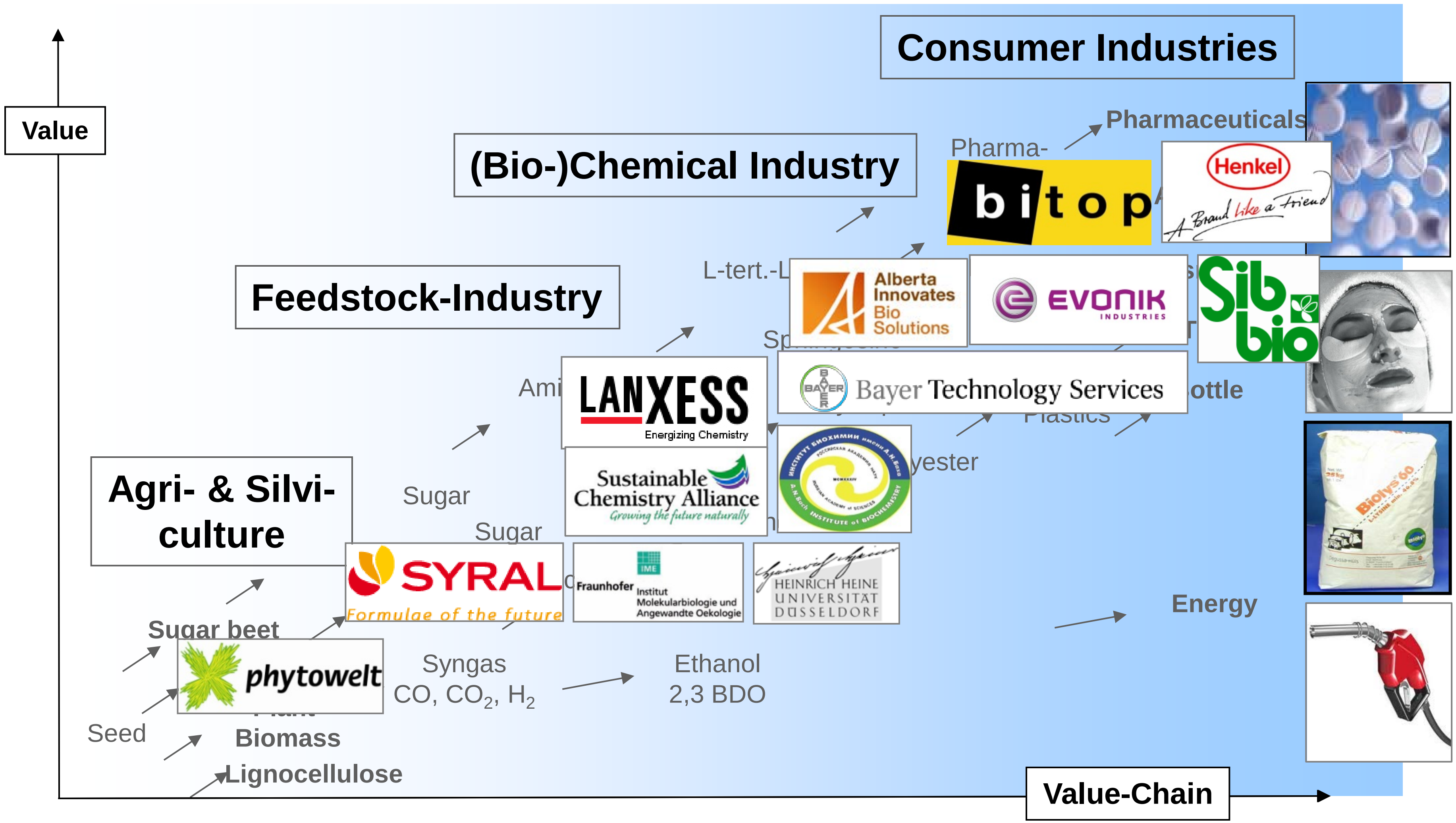
**Dr. Manfred Kircher**
Chairman Advisory Board CLIB2021

**June 5, 2013**

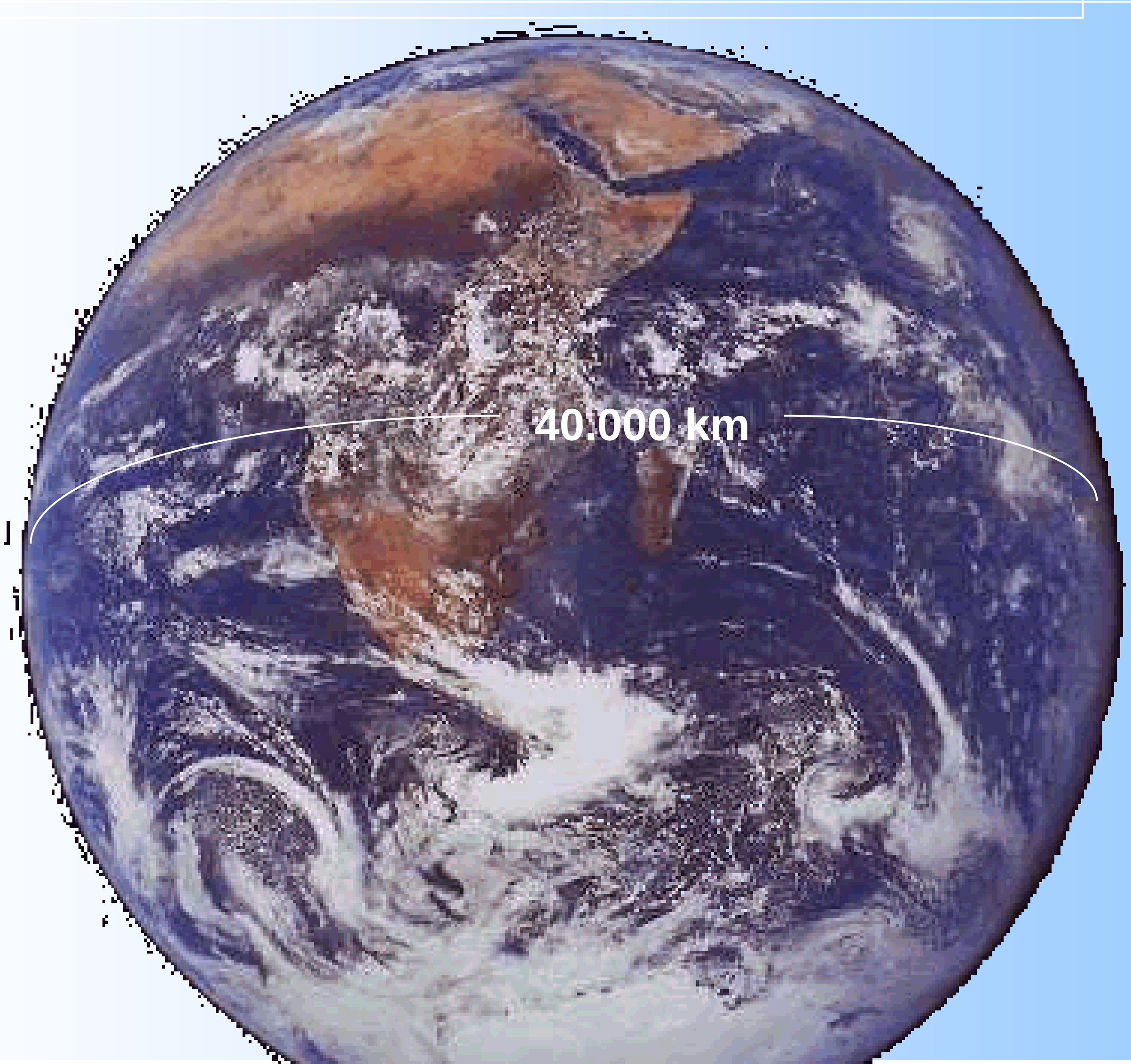
**University Guelph; Bioeconomy Seminar**

# CLIB$^{202}$: Cluster International Bioeconomy

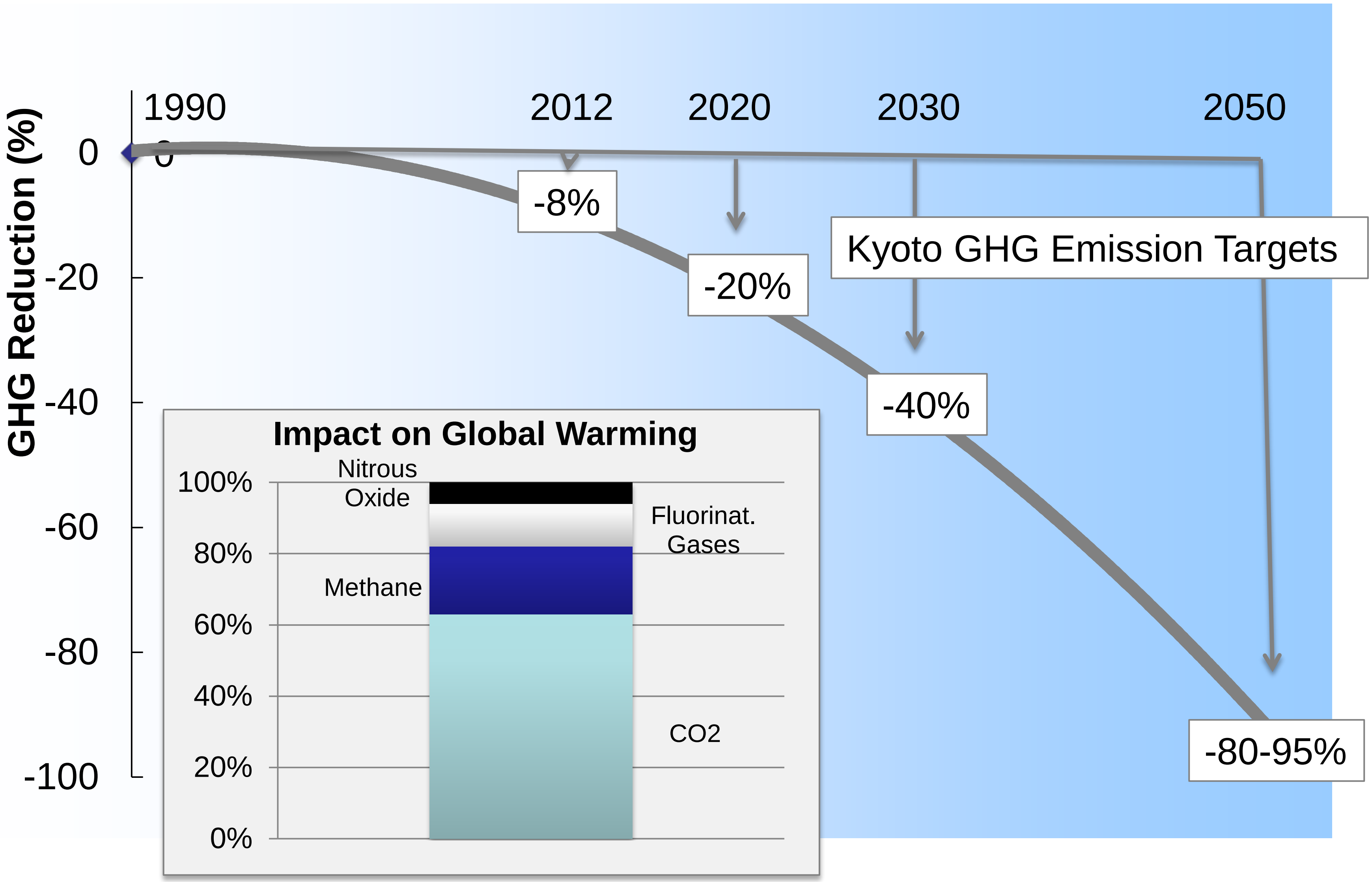
## 90 Members; Focus on Chemicals & Energy



# The Earth
# is Our only Resource



# Europe
# pushes the Bioeconomy



# Germany
# gives Bioeconomy Priority

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**CLIB main office**
**Düsseldorf, Germany**

**2.10.2012; Leuna**
Spitzencluster Bioeconomy
Lignocellulosic Biorefinery

# Chemical Industries realize the Bioeconomy

**CEFIC VIEWS ON THE EU BIOECONOMY**
June 2012

Cefic has a **high level of involvement in the bioeconomy**,

and considers the bioeconomy's implications for the chemical industry as composed of three clear dimensions:

- **access to renewable feedstock,**
- **innovation and**
- **market- driven demand generation.**

# Industrial Drivers towards the Bioeconomy

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***Drivers***

***Options***

***Challenges***

| Economical & Ecological | Product & Process | Renewable |
|---|---|---|
| **Sustainability** | **Innovation** | **Feedstock** |

# The Fossil Economy is based on Oil, Coal, Gas

**11 bn t/a Carbon** *consumed*



# Logistics of Fossil Feedstock is easy & cost-efficient



# Fossil Feedstock serve Large-Scale Industrial Centers

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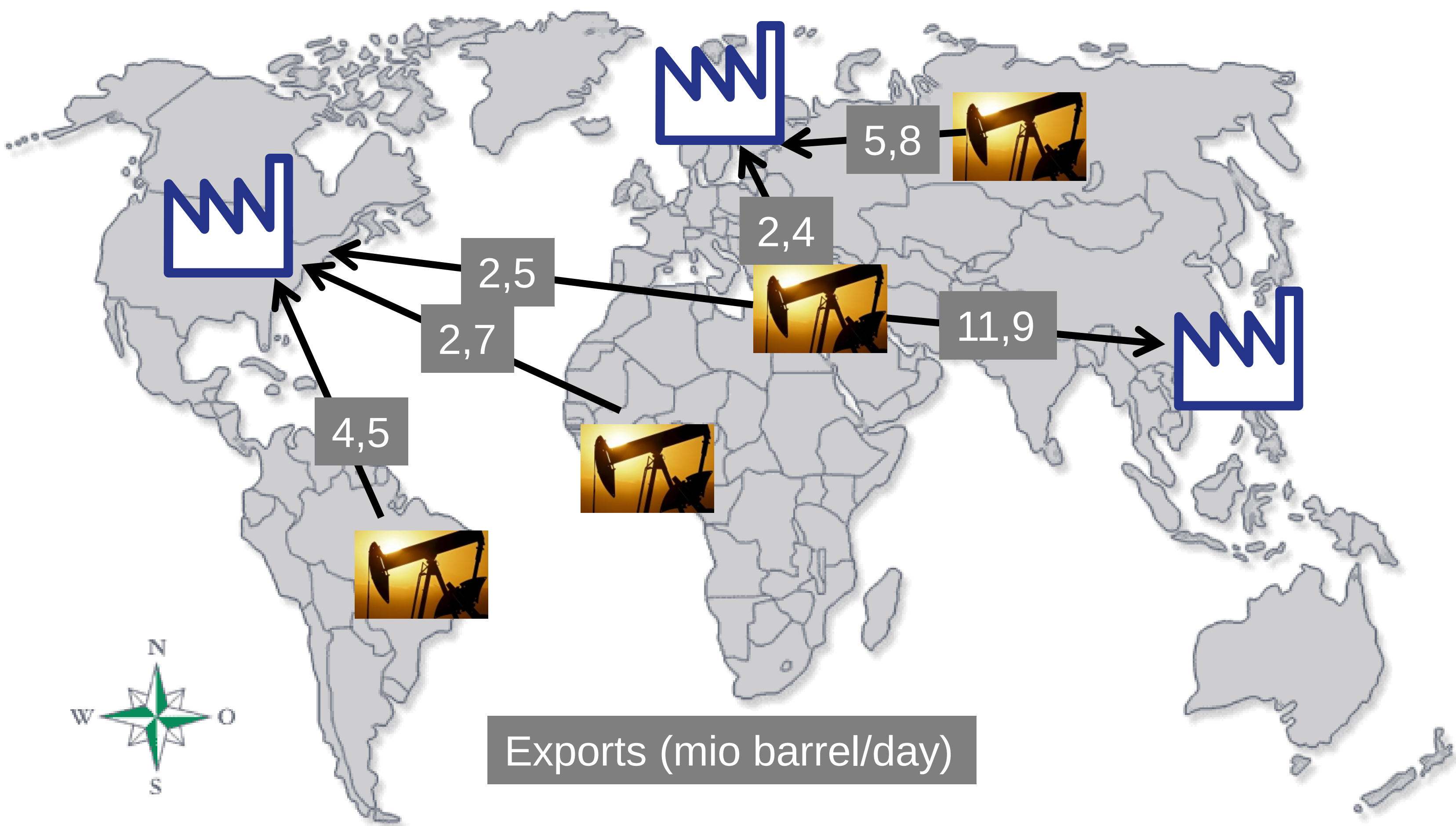
**Oil Refinery**
**Wesseling, Germany**

capacity: 16,3 mio t oil
(equ. **13,9 mio t C)**

# The Fossil Value Chain starts from limited Regions



# Fossil Feedstock deliver Energy Carriers & Chemical Precursors

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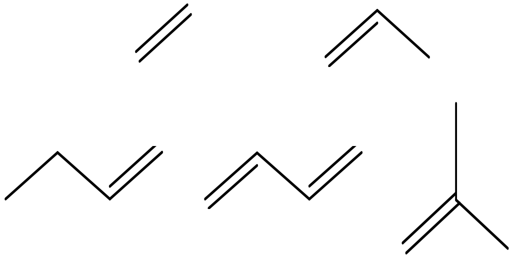
Gasoline

Diesel

Kerosine



**Organic Chemicals**

**Pharmaceuticals**

**Fine & Specialty Chemistry**

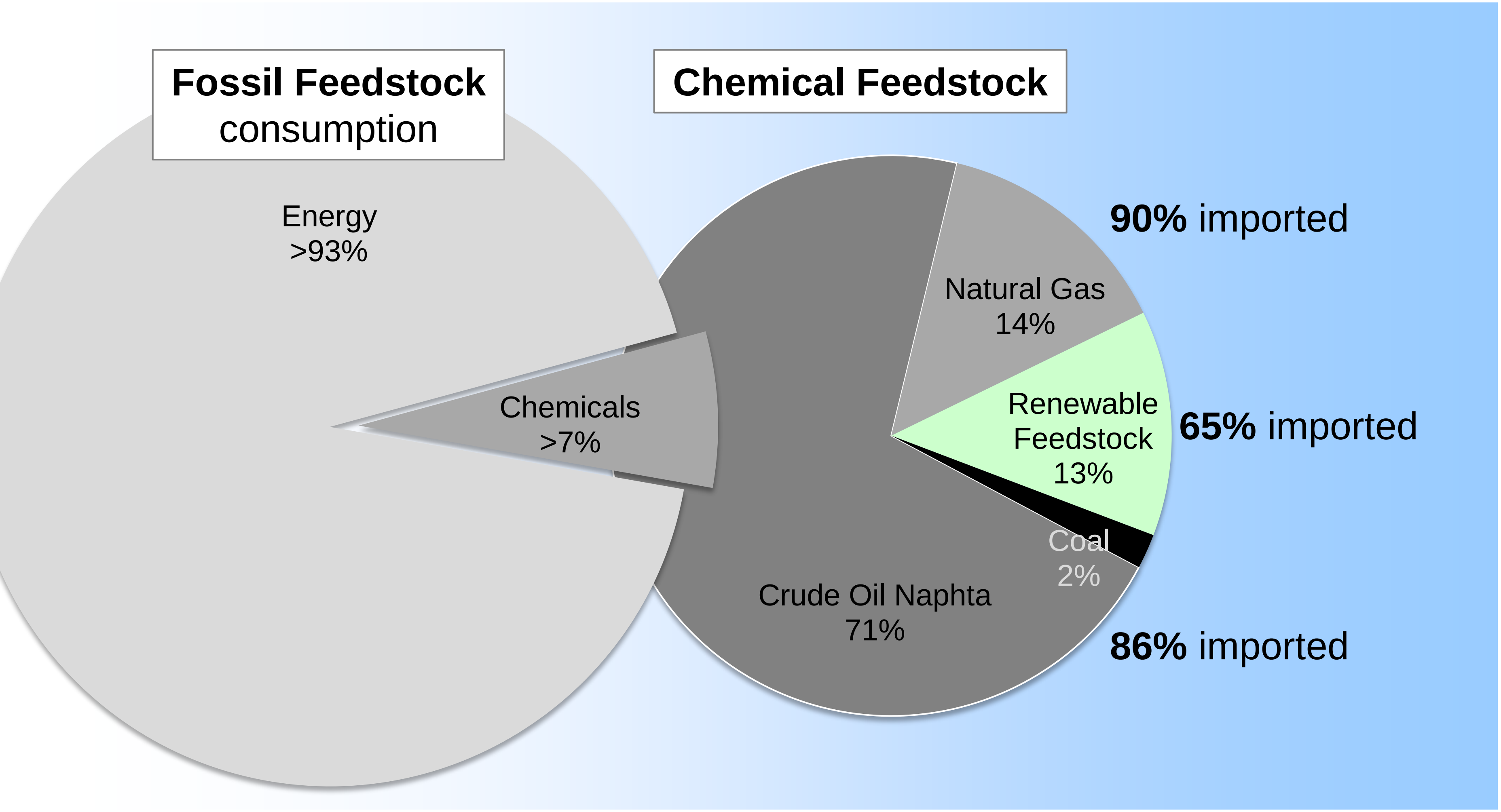
**Detergent & Hygiene Chemicals**

**Polymers**

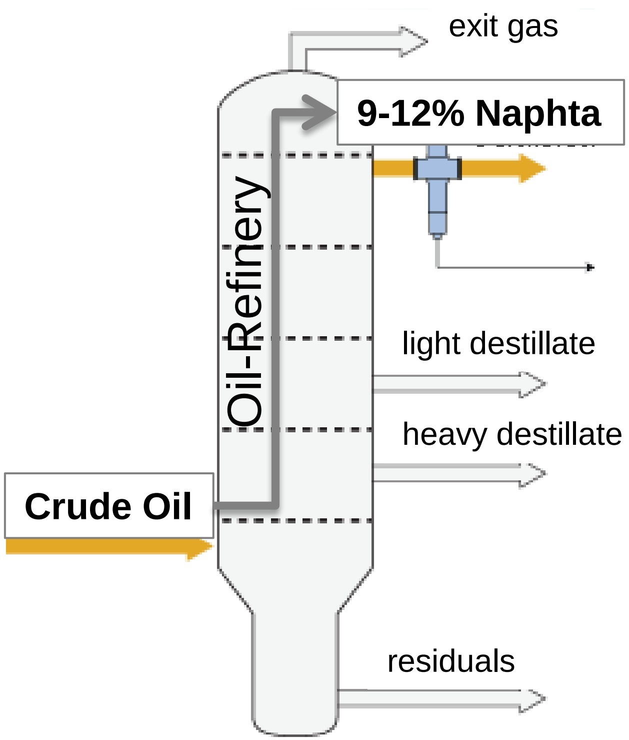
**Petrochemicals & Derivatives**

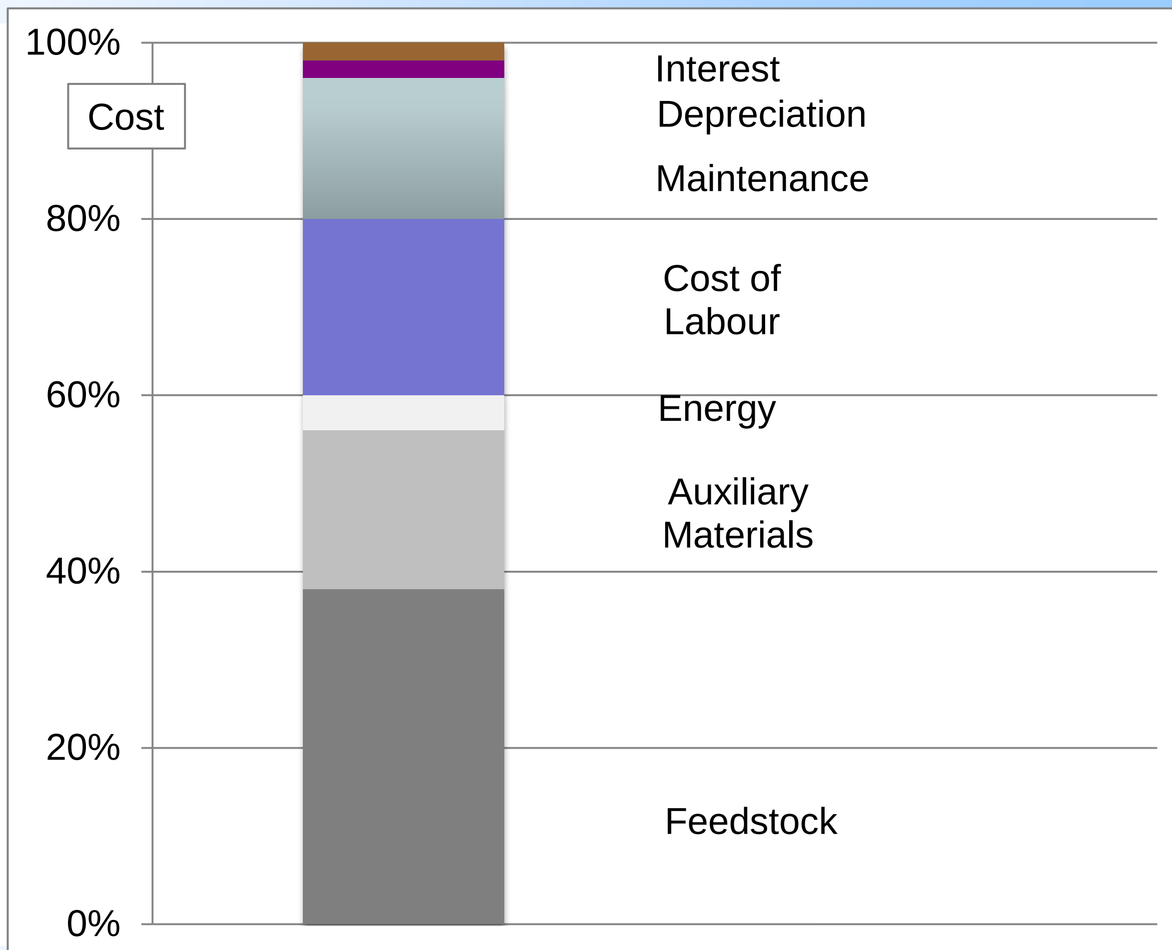
**Agrochemicals**

# German Chemical Industries depend on Fossil Feedstock

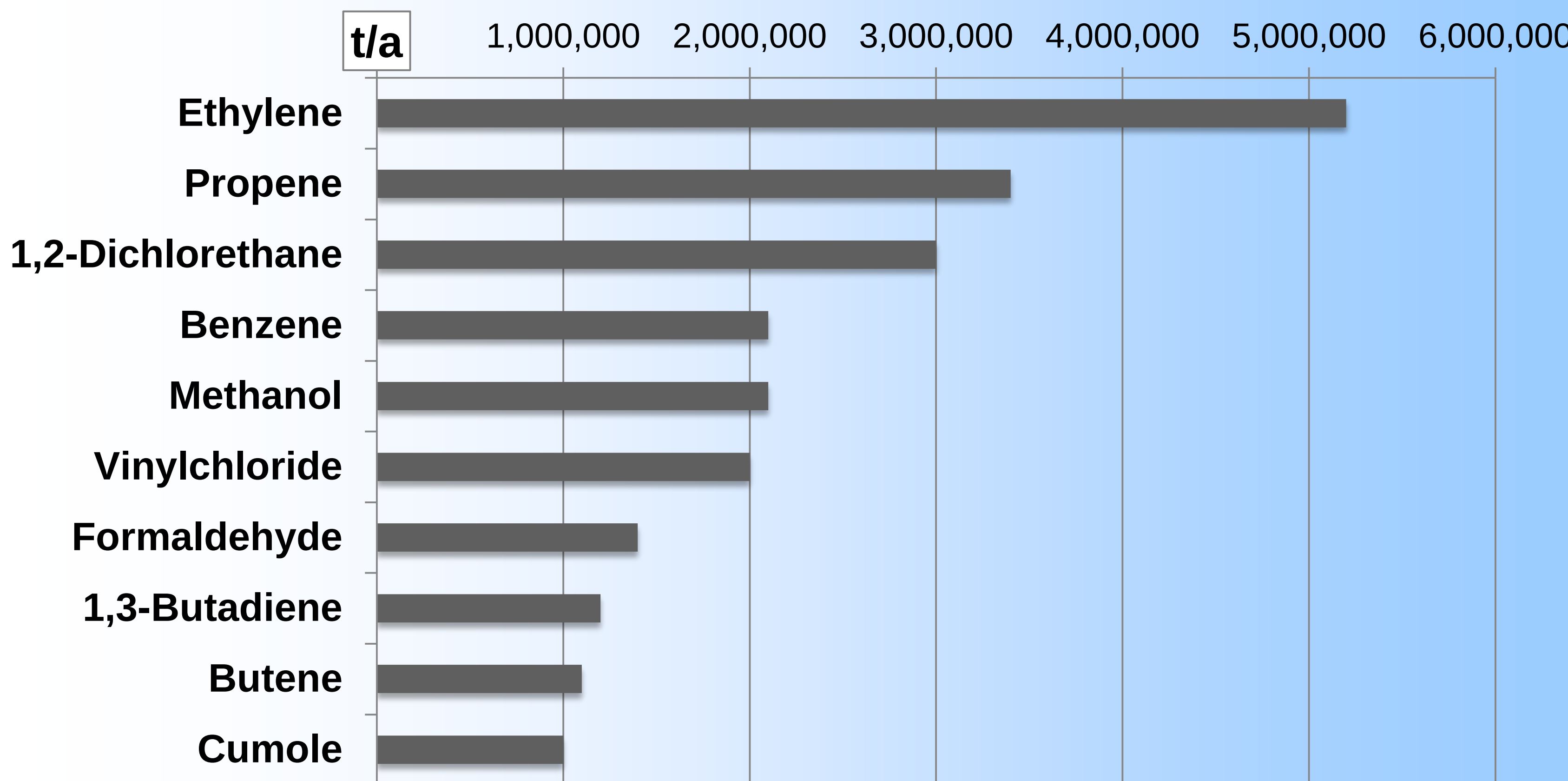


# Naphta
## makes 40 % of Chemical Cost



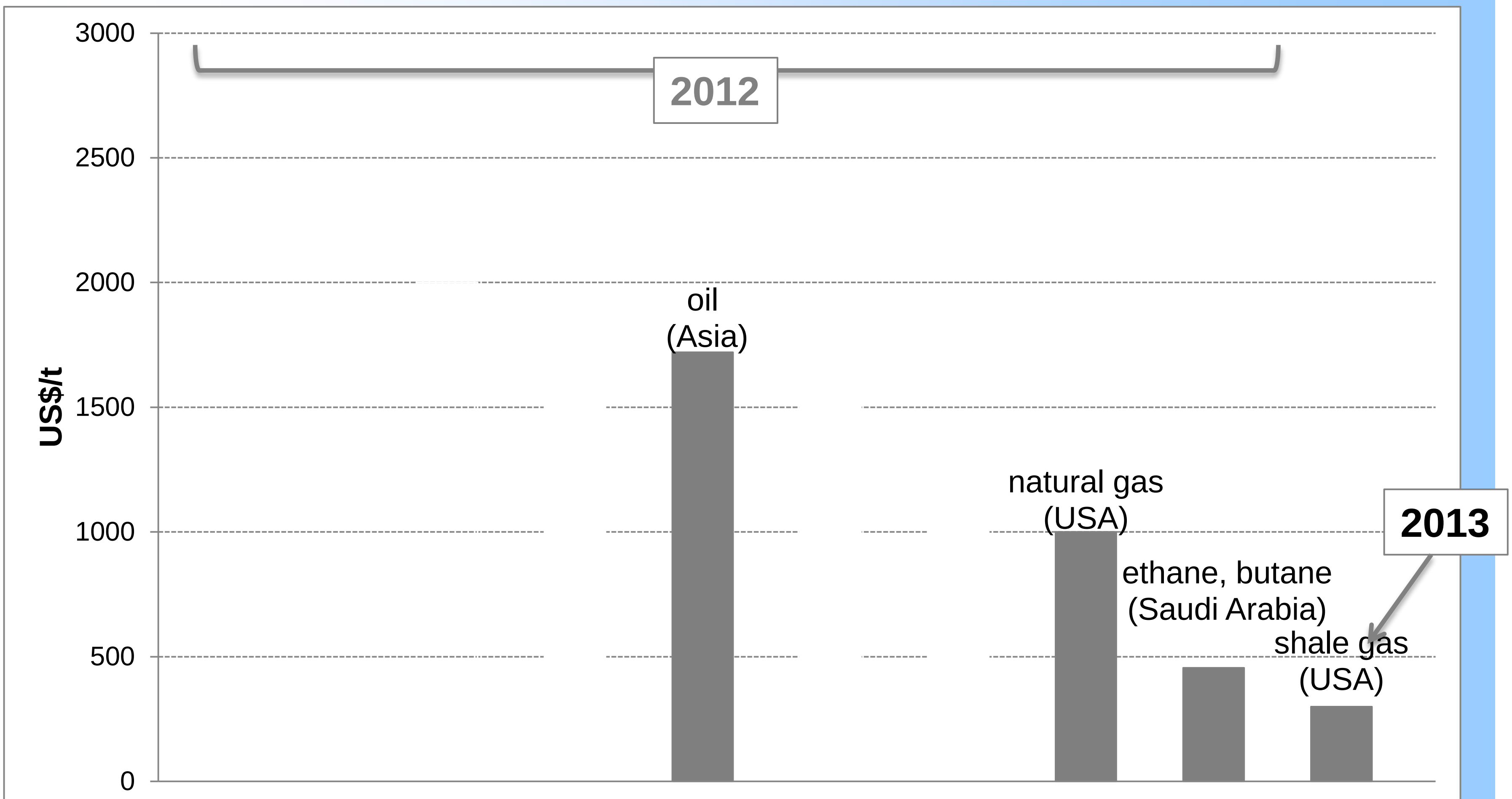



# Chemical Value Chains begin with Basic Chemicals



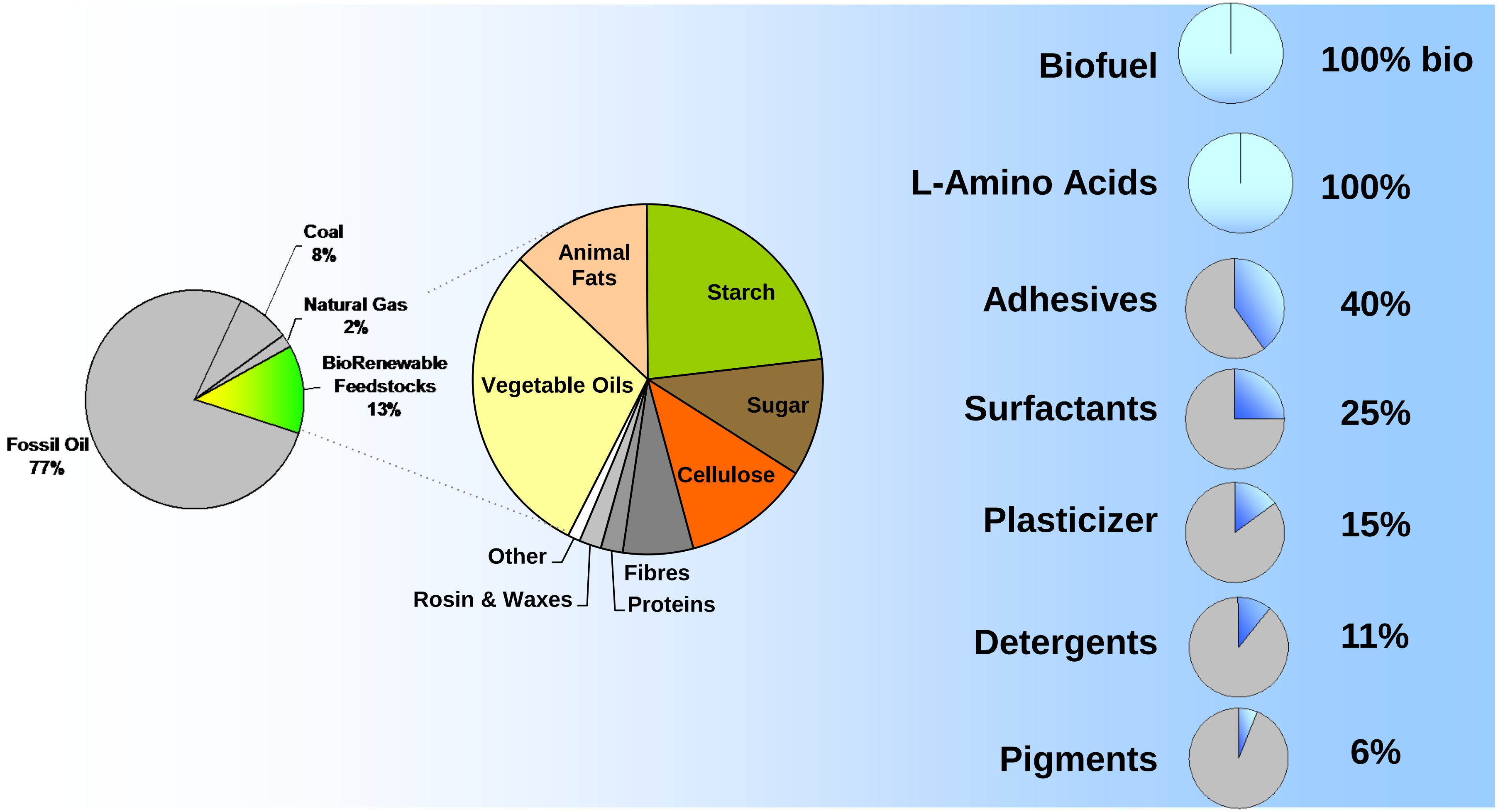

Germany; Stat. Bundesamt Fachserie 4, Reihe 3.1, Produzierendes Gewerbe nach Güterarten, 2006

# Ethylene Production Cost depend on Feedstock & Region




MIT Technical Review; Kevin Bullis;Shale gas will fuel a US manufacturing boom; 9.1.2013

# The German Chemical Industry produces Bioproducts

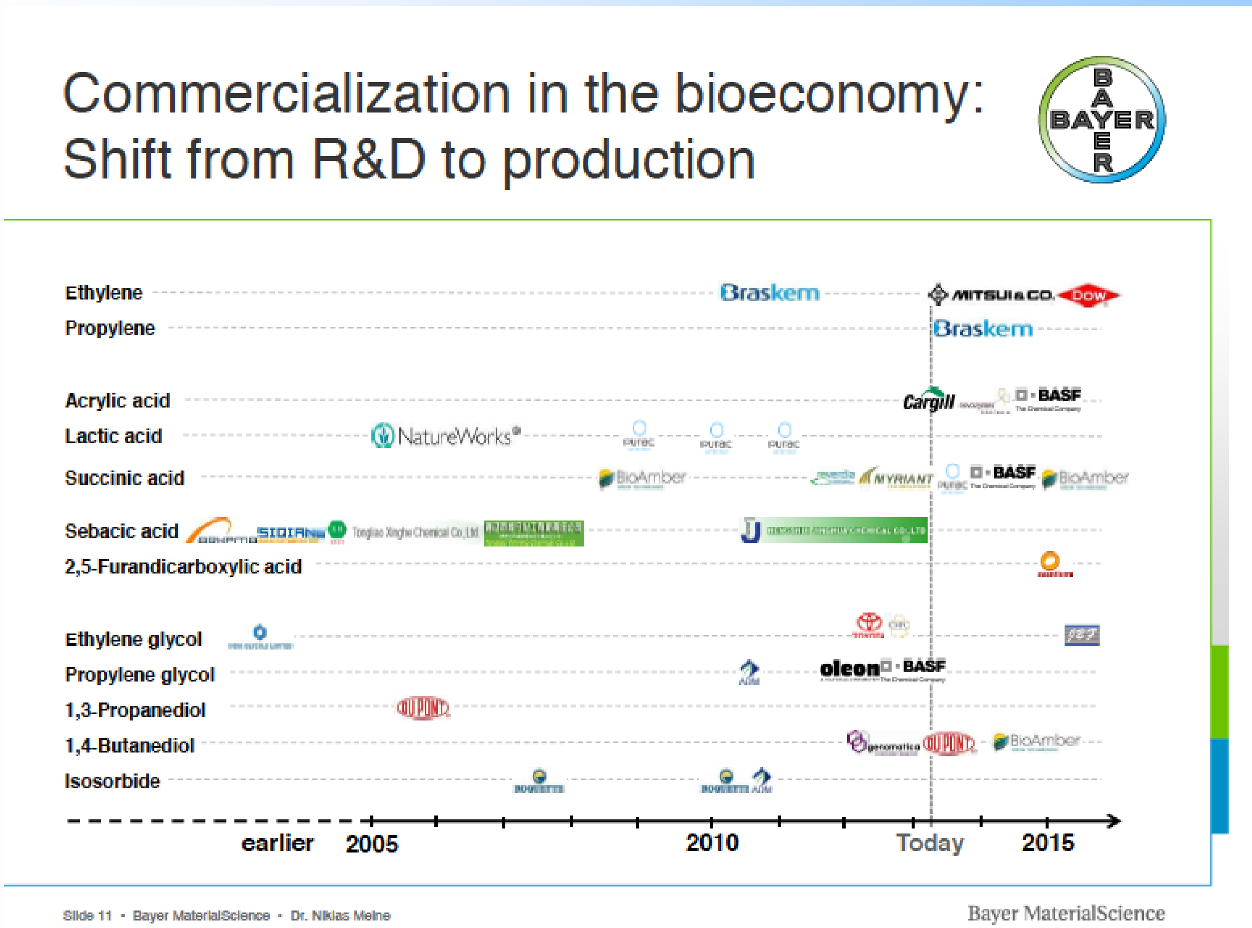



Germany 2008; Source: VCI

K.Hill, R Höfer; Biomass for Green Chemistry; in: R. Höfer (ed.) Sustainable Solutions for Modern Economies; RSCPublishing (2009)

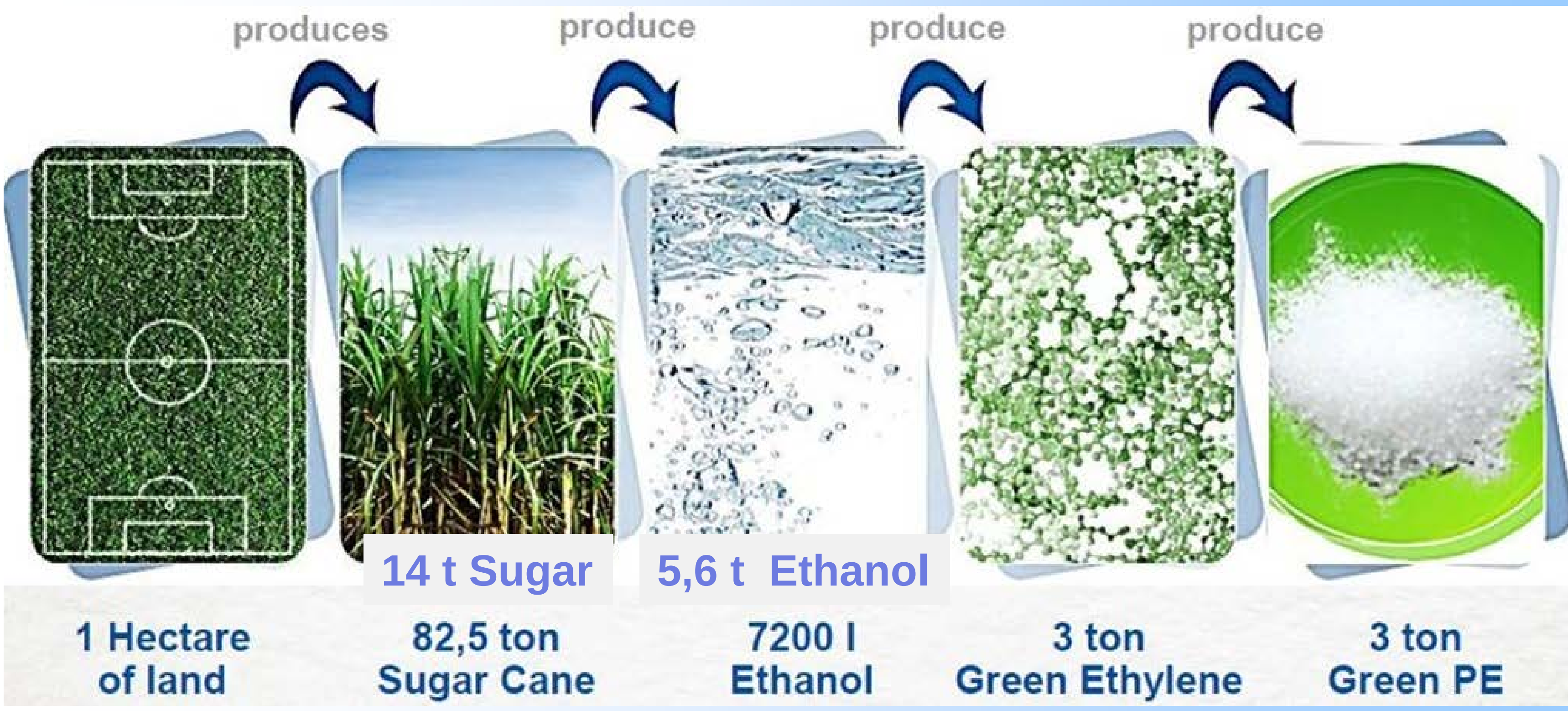
Paster M., J.Pellegrino; T. Carol, (2003) Industrial Bioproducts – Today and Tomorrow. Energetics Inc. Columbia, Maryland (modfied)

# Bioproducts
# enter Global Markets




6. Int. Congress on Industrial Biotechnology and bio-based Plastics and Composites; Cologne; 6.April 2013

# Bio-Feedstock
# enable Feedstock-Flexibility

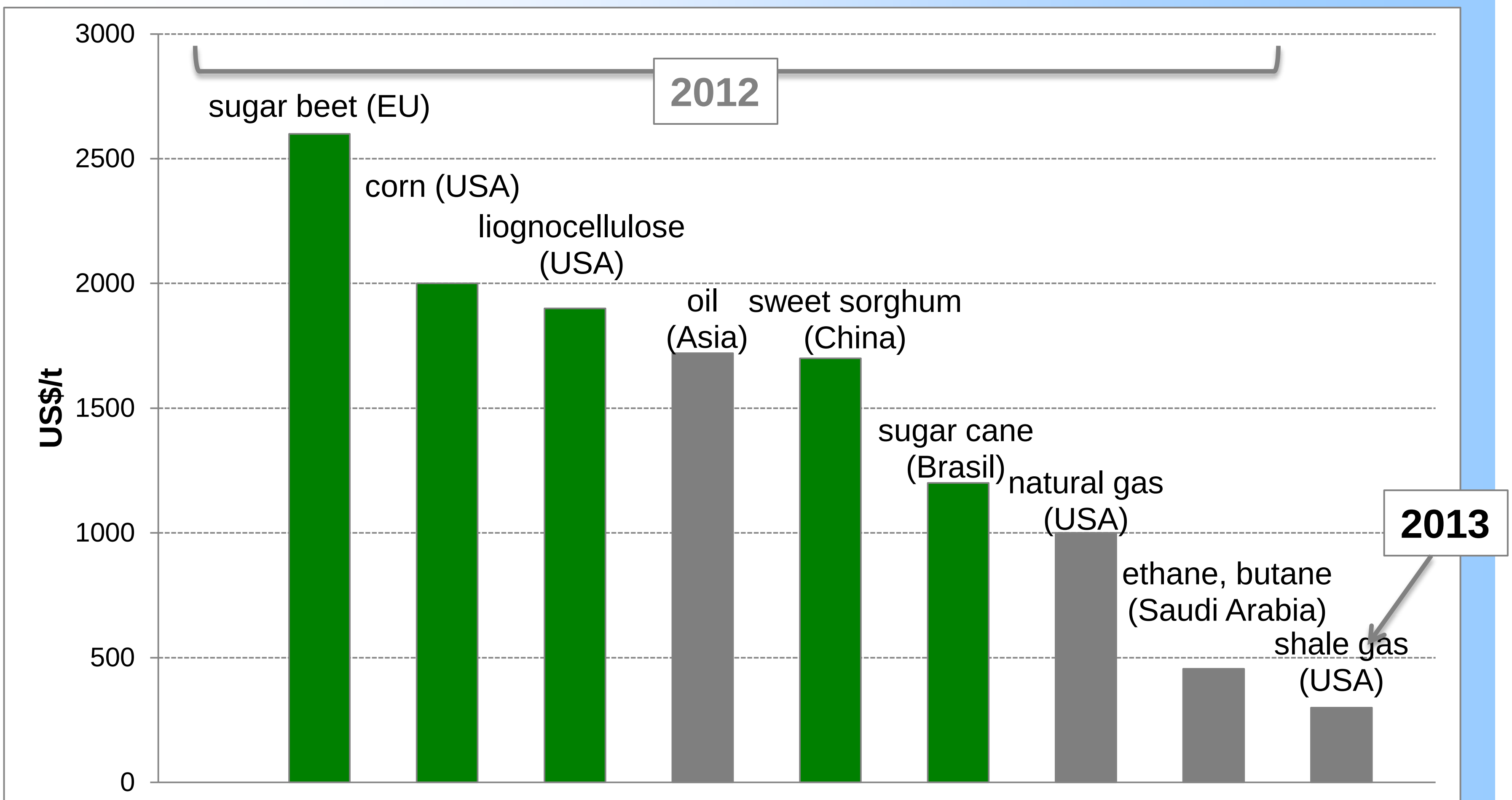


# Bioeconomy
# works with Mid-Size Plants


**Braskem**
**Triunfo; Brazil**
200.000 t Bio-Ethylene
requiring >280.000 t sugar
(equ. **118.000 t C)**

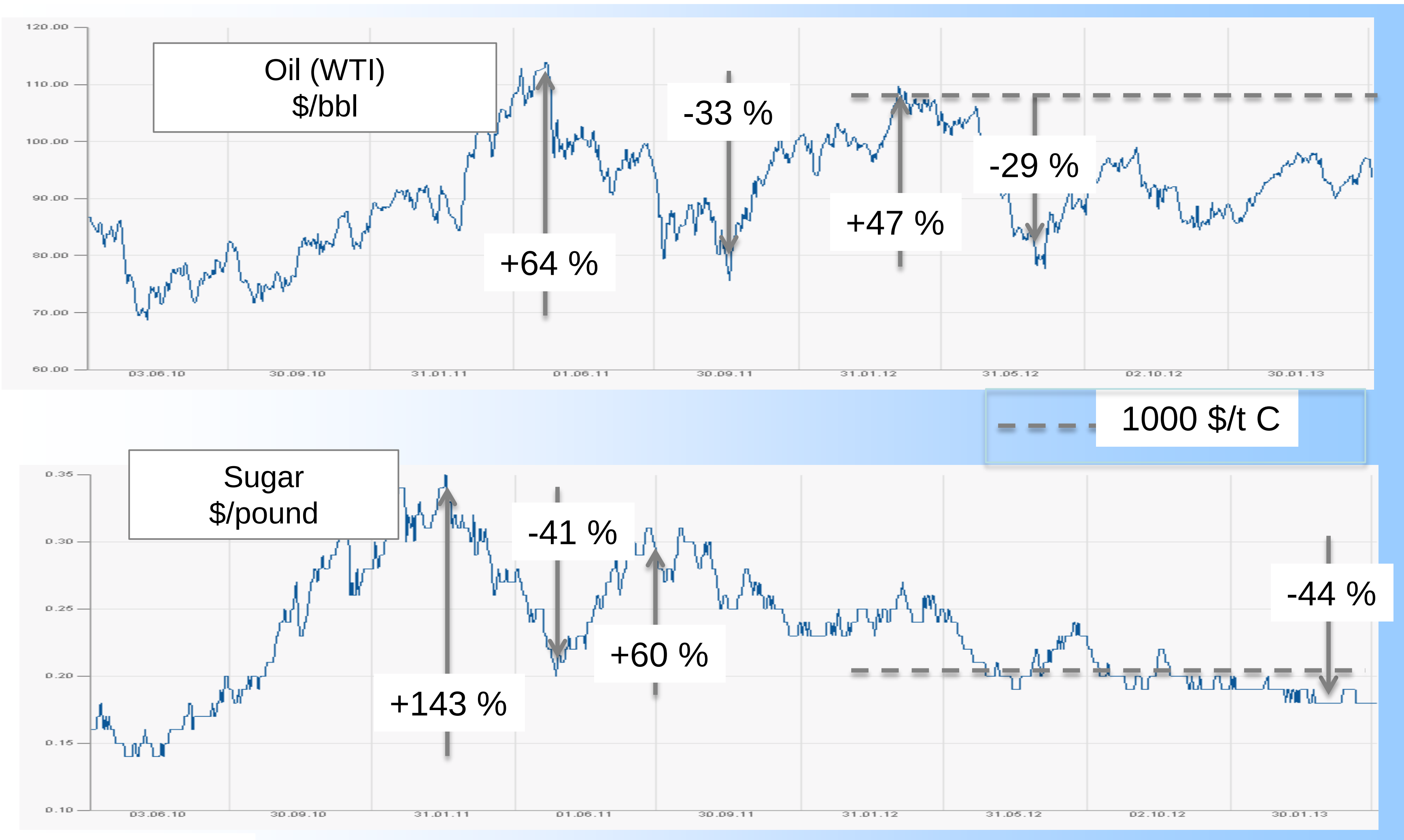
280.000 t sugar from
65.000 ha sugar cane
**(area with 100 km radius)**

# Success of Bio-Ethylene depends on Feedstock-Cost




MIT Technical Review; Kevin Bullis;Shale gas will fuel a US manufacturing boom; 9.1.2013

# Bio-Feedstock gains Competitiveness




www.finanzen.net

# Cutting
# Feedstock-Cost is Key

***Drivers***

Economical & Ecological
**Sustainability**

***Options***

Bio-Feedstock

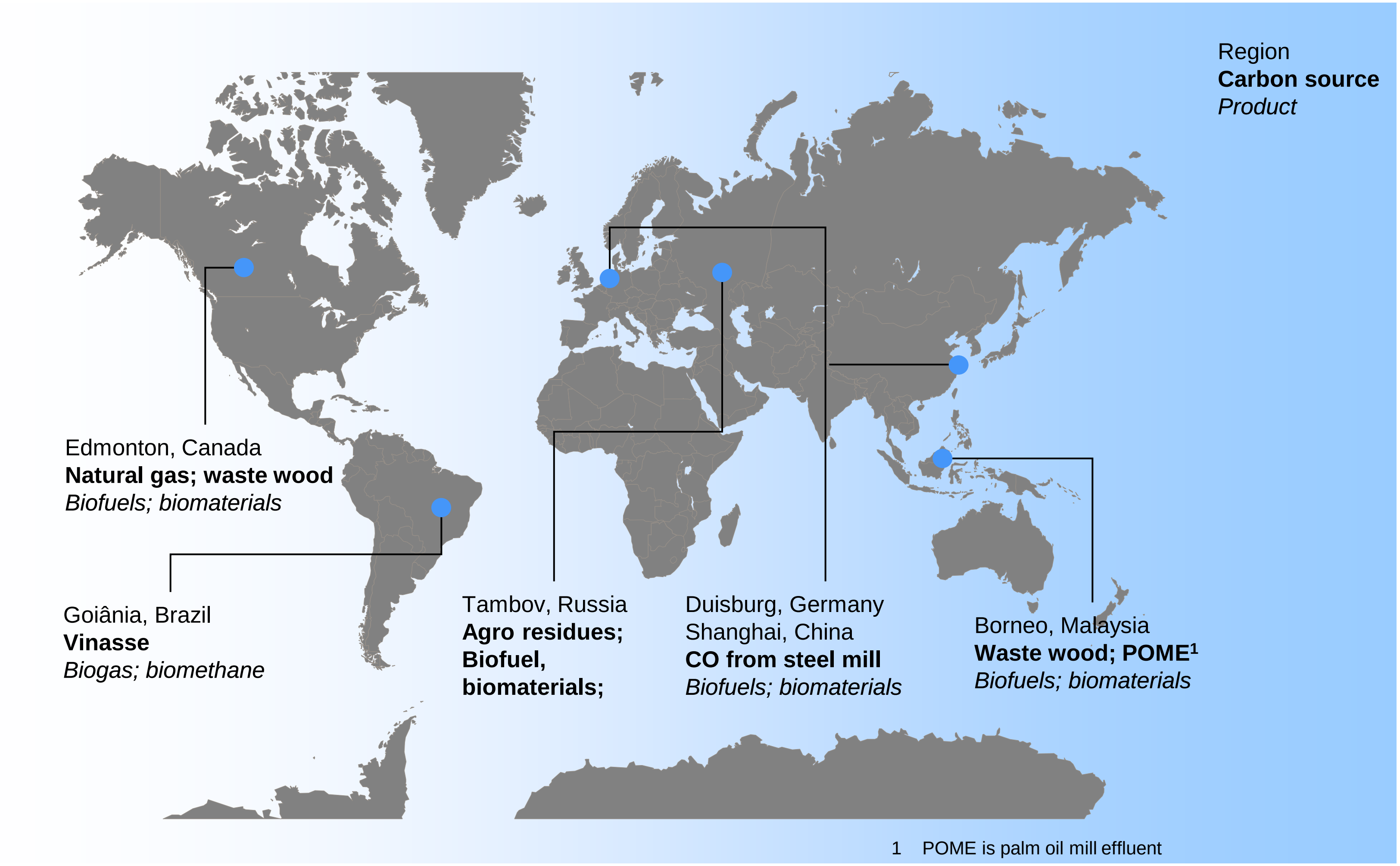
***Challenges***

Cost &
Economy of Scale
of renewable / fossil
Feedstock

Product & Process
**Innovation**

Renewable
**Feedstock**

# Process Innovation starts with Renewable Feedstock




1 POME is palm oil mill effluent

# Malaysia:
# Residual Biomass

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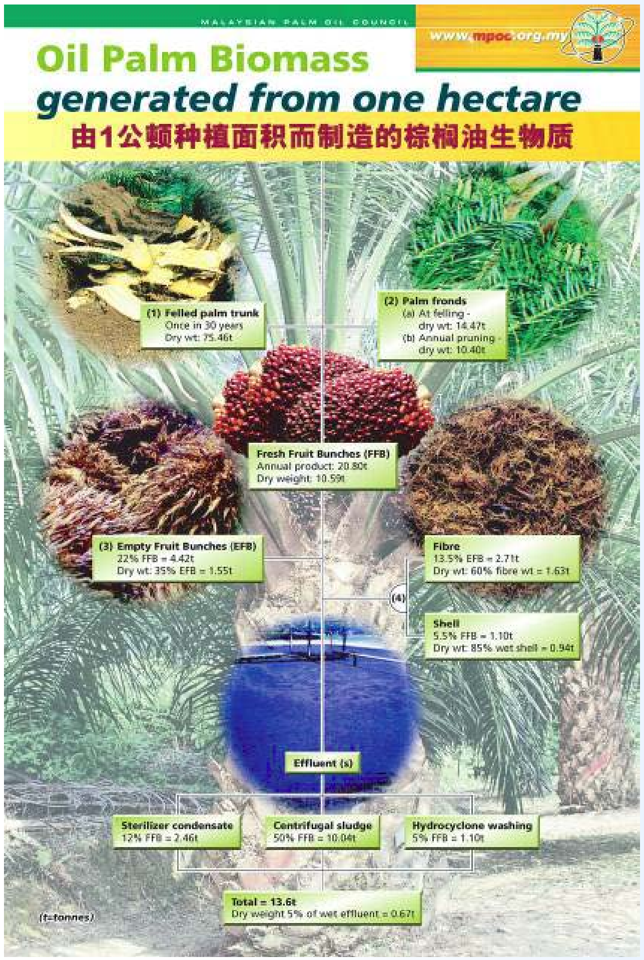


## Conversion of Palm-based Resources

(70 million tons lignocellulosic residues)

| | revenue per MT | GDP-contribution bln RM | %GDP |
|---|---|---|---|
| **bioelectricity** | 231 | **0.8** | 0,1% |
| **biofuels*** | 453 | **3** | 0,5% |
| **biochemicals**** | 2500 | **26** | 4,2% |

margin: 5% (electric), 10% (fuels), 15% (chem’s)
*ethanol, ** lactic acid for plastics

Source OPBC

# Brasil:
# Processing Residuals


**Producing Methane Fuel from Vinasse**

(30 mio t/a equ. ~ GW range)

| | | |
|---|---|---|
| » | Optimize biogas process | Brazil,Germany |
| » | Adapt biogas plant | Brazil,Germany |
| » | Purify bio-methane | Germany |
| » | Build logistics | Brazil |

# Germany:
## Syngas & Industrial Flue Gas

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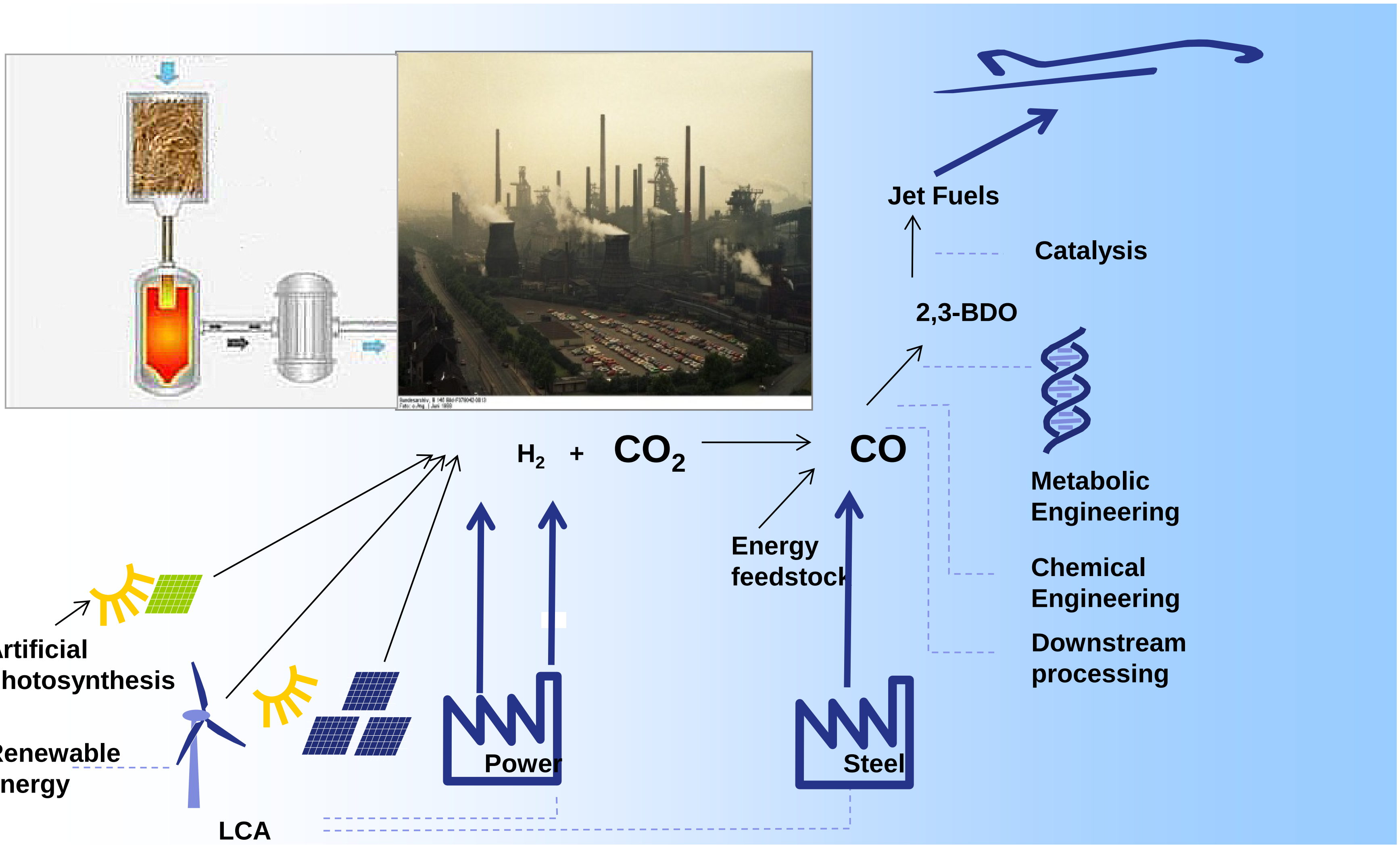


Source: Dr. Achim Marx (CLIB$^{2021}$)

# Industries
# take the Feedstock Advantage

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## Sugar-Carbon

**Reverdia**
Sugar Beet> Succinat

**Braskem**
Sugar Cane > Ethylene

**Dow**
~~Sugar Cane~~ > Propylene

## Lignocellulosic-Carbon

**Direvo**
Lignocellulose > PLA

**Novamonte**
Lignocellulose > BDO

**Dong**
Lignocellulose > Ethanol

## Industrial Residues Out of use/recycling

**Abengoa**
Municipal Waste > Ethanol

**Lanzatech**
Steel Mill CO/CO2 > Ethanol

**Enerkem**
Municipal Waste > Syngas

# Product Innovation starts with Biosynthetic Pathways

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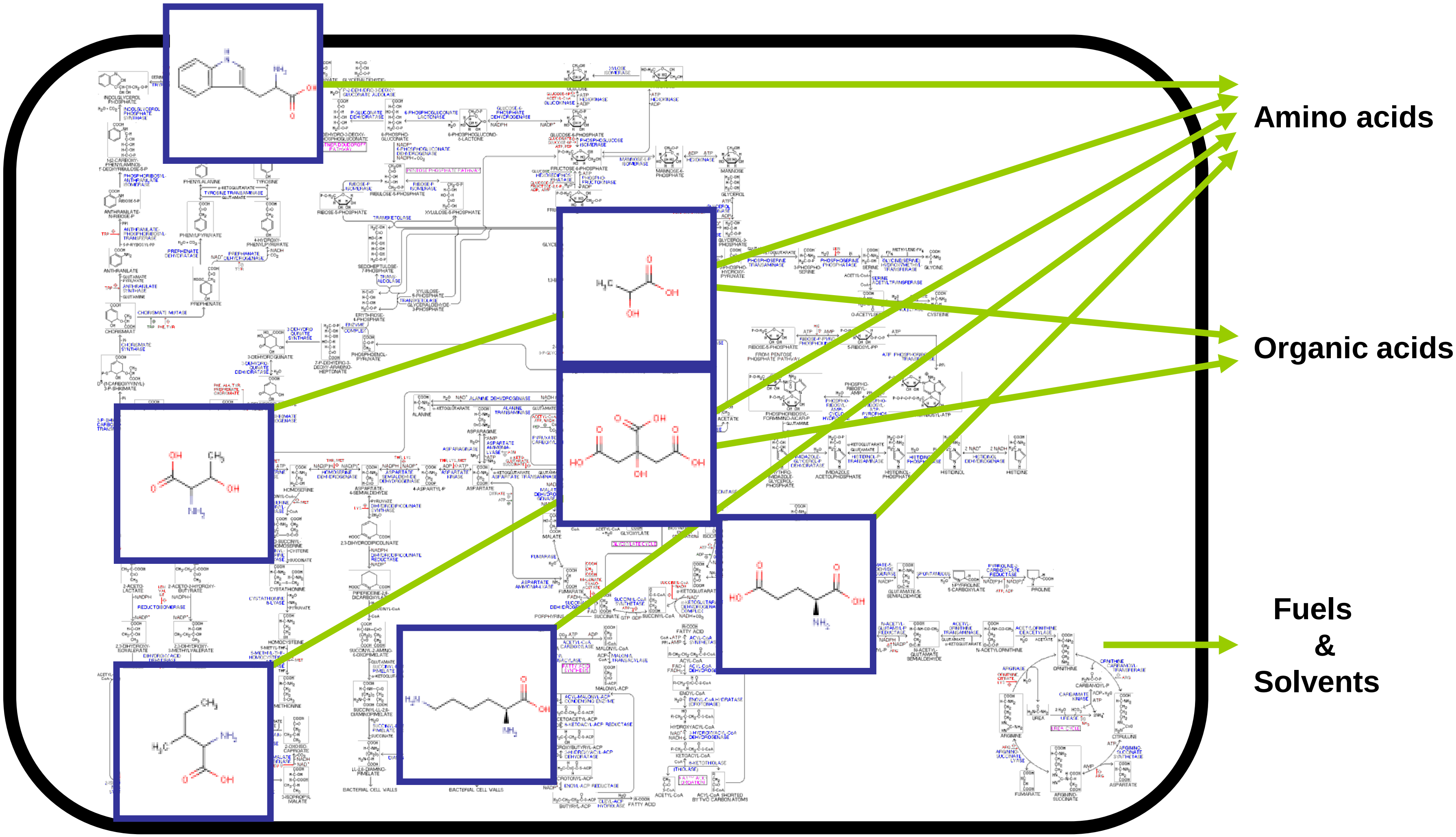
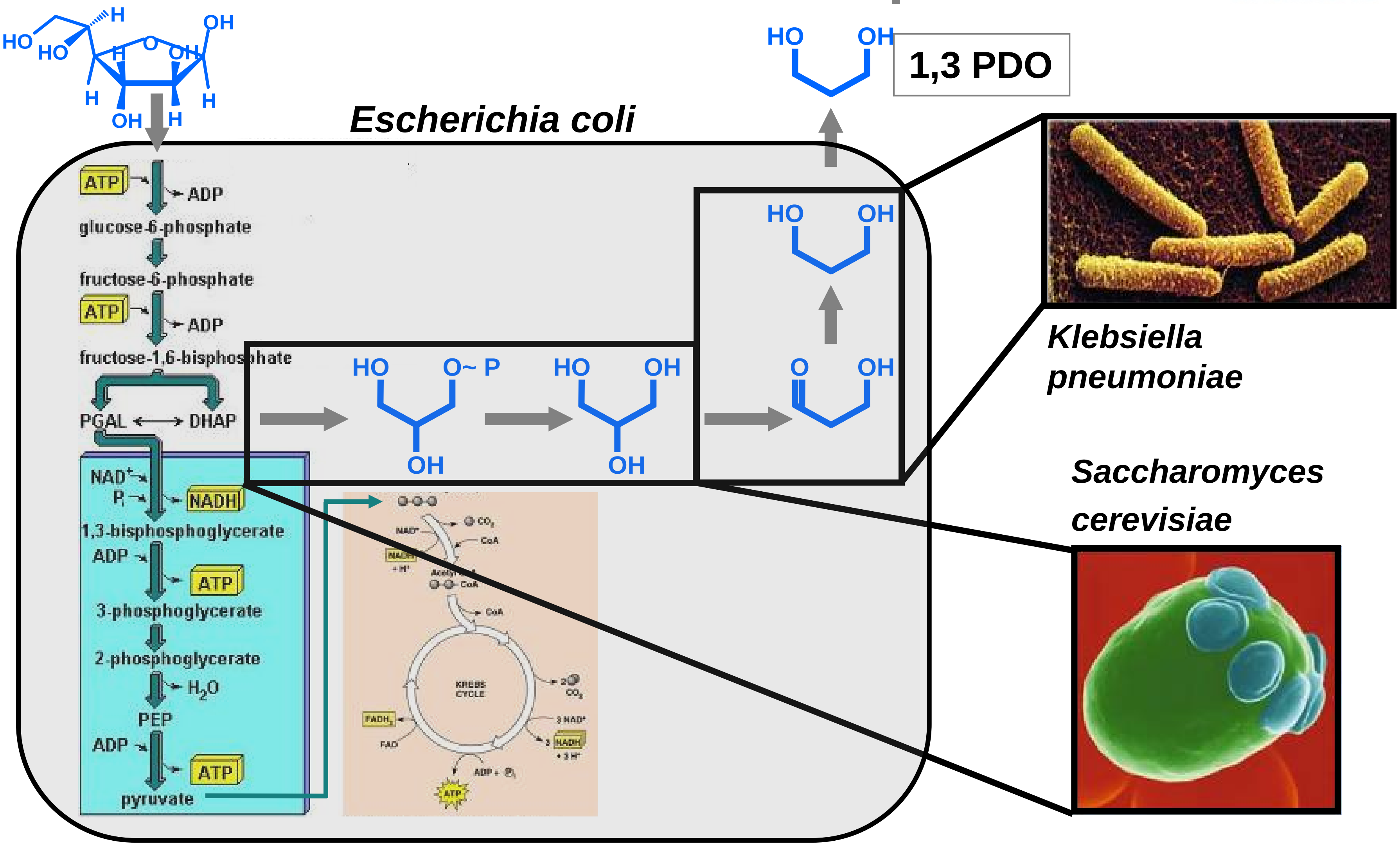


# Synthetic Biology enables man-made Bioproducts



# Biochemicals
# restart the Innovation Cycle

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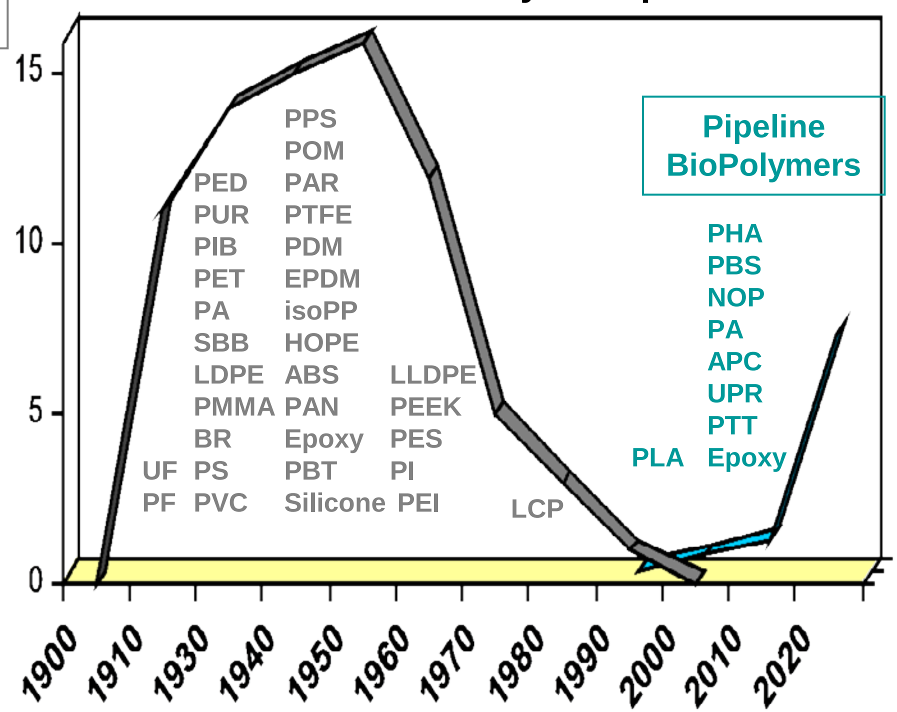
**Petrochemical C-Sources**

- Ethylene
- Propylene
- Butadiene
- Benzene
- Toluene
- Xylene
- Methanol

**Number of New Polymers per Year**

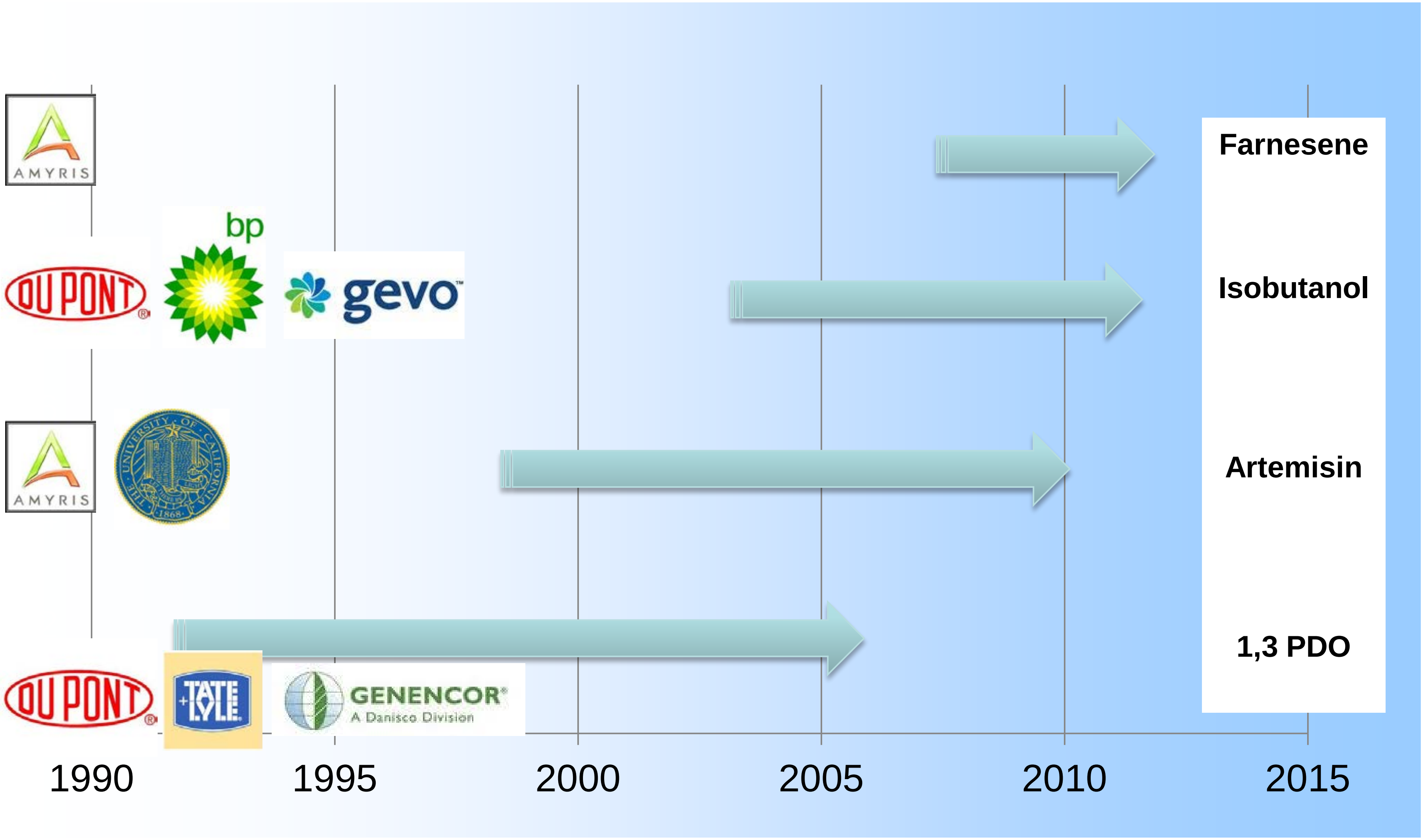



**BioRenewable C-Sources**

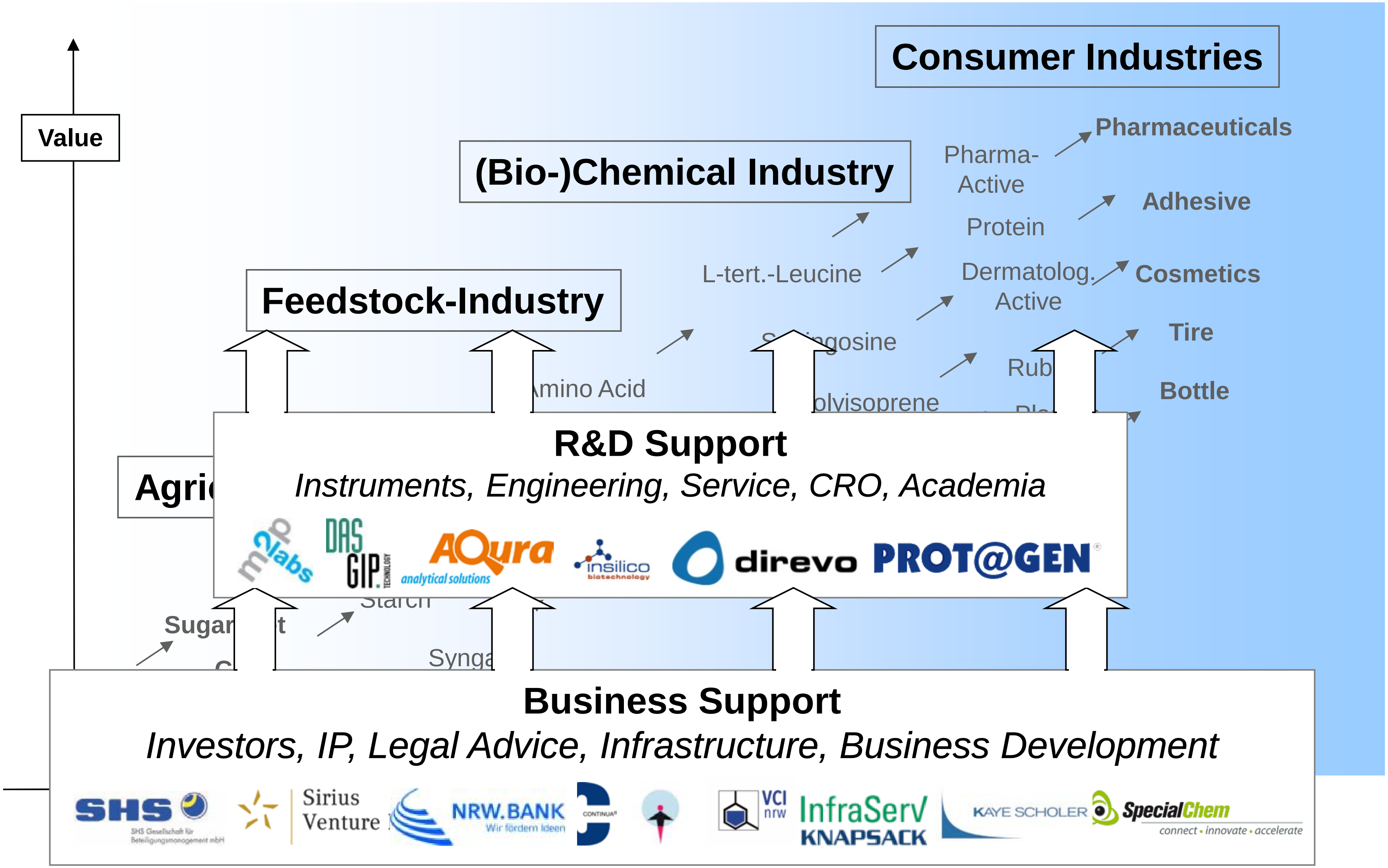
- Propandiol
- Succinic acid
- Lactic acid
- Vegetable oils
- Hydroxy alkonoates
- Xylene
- Isosorbid

Source: DSM

# Modern Biotechnology shortens Time-to-Market



# Production & Innovation Value Chains to be adressed



# Innovation in Technologies & Value Chains

***Options***

***Solution***

***Challenges***

Economical & Ecological
**Sustainability**

Bio-Feedstock

Cost &
Economy of Scale
of renewable / fossil
Feedstock

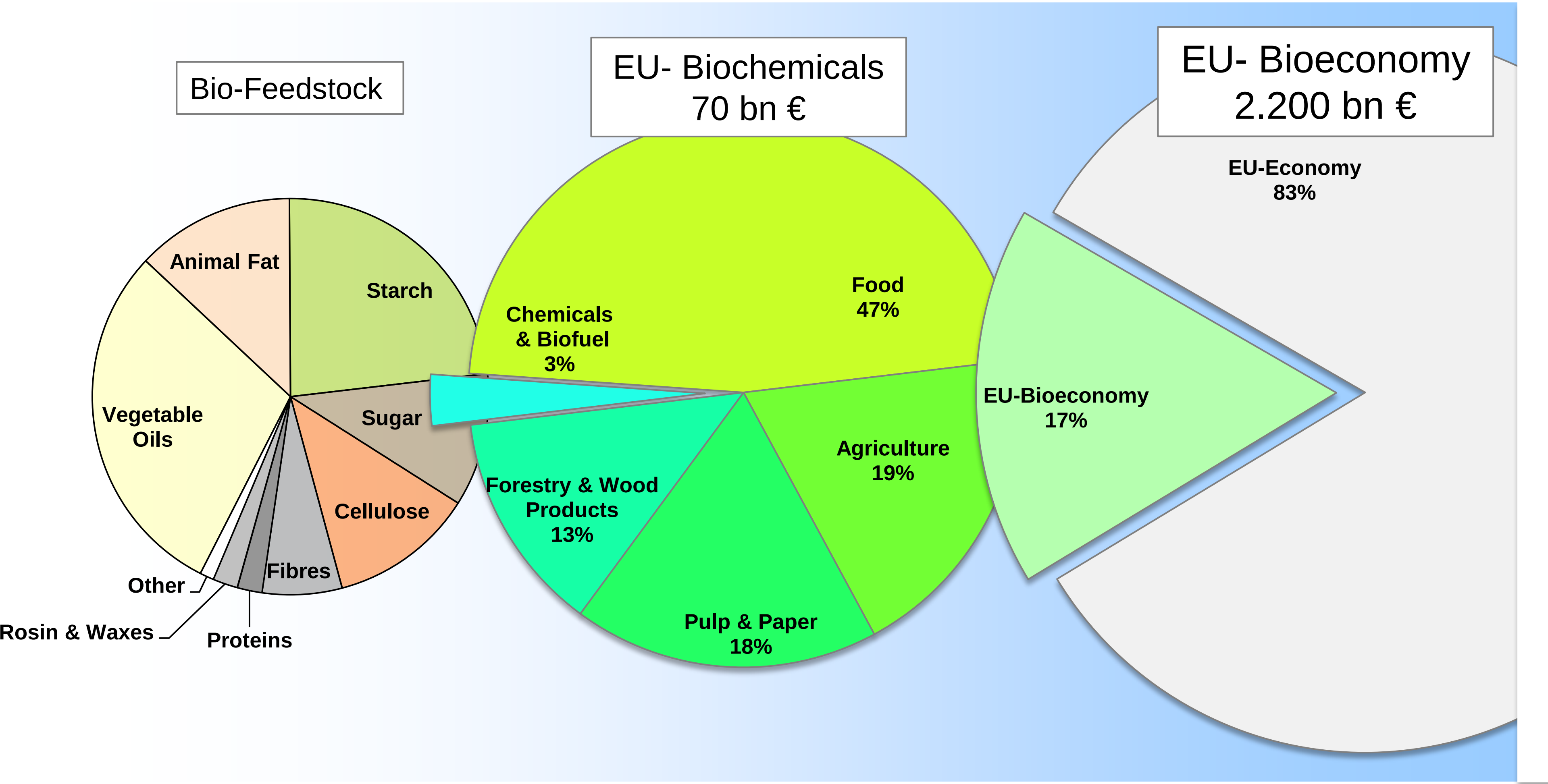
Product & Process
**Innovation**

Feedstock Processing
& Transformation

Unusual Value Chains
Time-to-Market

Renewable
**Feedstock**

# Modern Bioeconomy competes with Established Sectors



# Modern Bioeconomy steps into Feedstock Markets

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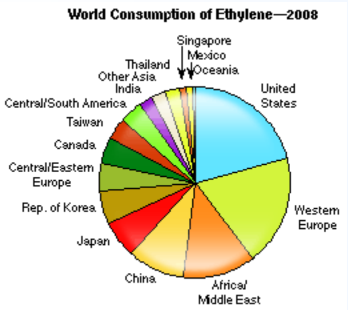


**World**: 140 mio t **ethylene** - equ. **120 mio t C**
165 mio t **sugar** - equ. **69 mio t C**

**EU:** 20 mio t **ethylene** - equ. **17 mio t C**
18 mio t **sugar** - equ. **8 mio t C**

## TOP 10 ETHYLENE PRODUCERS[1]

Table 4

| | Company | Sites[2] | Capacity, tpy: Of wholly owned complexes | Capacity, tpy: Of partially owned complexes |
|---|---|---|---|---|
| 1 | Saudi Basic Industries Corp. | 15 | 13,392,245 | 10,273,759 |
| 2 | Dow Chemical Co. | 21 | 13,044,841 | 10,529,421 |
| 3 | ExxonMobil Chemical Co. | 20 | 12,515,000 | 8,550,550 |
| 4 | Royal Dutch Shell PLC | 13 | 9,358,385 | 5,946,693 |
| 5 | Sinopec | 13 | 7,895,000 | 7,275,000 |
| 6 | Total AS | 11 | 5,933,000 | 3,471,750 |
| 7 | Chevron Phillips Chemical Co. | 8 | 5,607,000 | 5,352,000 |
| 8 | LyondellBasell | 8 | 5,200,000 | 5,200,000 |
| 9 | National Petrochemical Co. | 7 | 4,734,000 | 4,734,000 |
| 10 | Ineos | 6 | 4,656,000 | 4,286,000 |

[1]As of Jan. 1, 2012. [2]Wholly owned plus partially owned.

http://www.ogj.com/content/dam/ogj/print-articles/Volume%20110/July%202/global-ethylene-t4.jpg

# Biomass will be short
# Biomass will gain Value

*Fossil Feedstock consumed*

- **11** bn t of Carbon used
  - oil, gas, coal

*Renewable Feedstock produced*

- **7** bn t Carbon fixed by agriculture
  - 14 bn t of biomass

# Modern Bioeconomy moves into Global Biomass Regions

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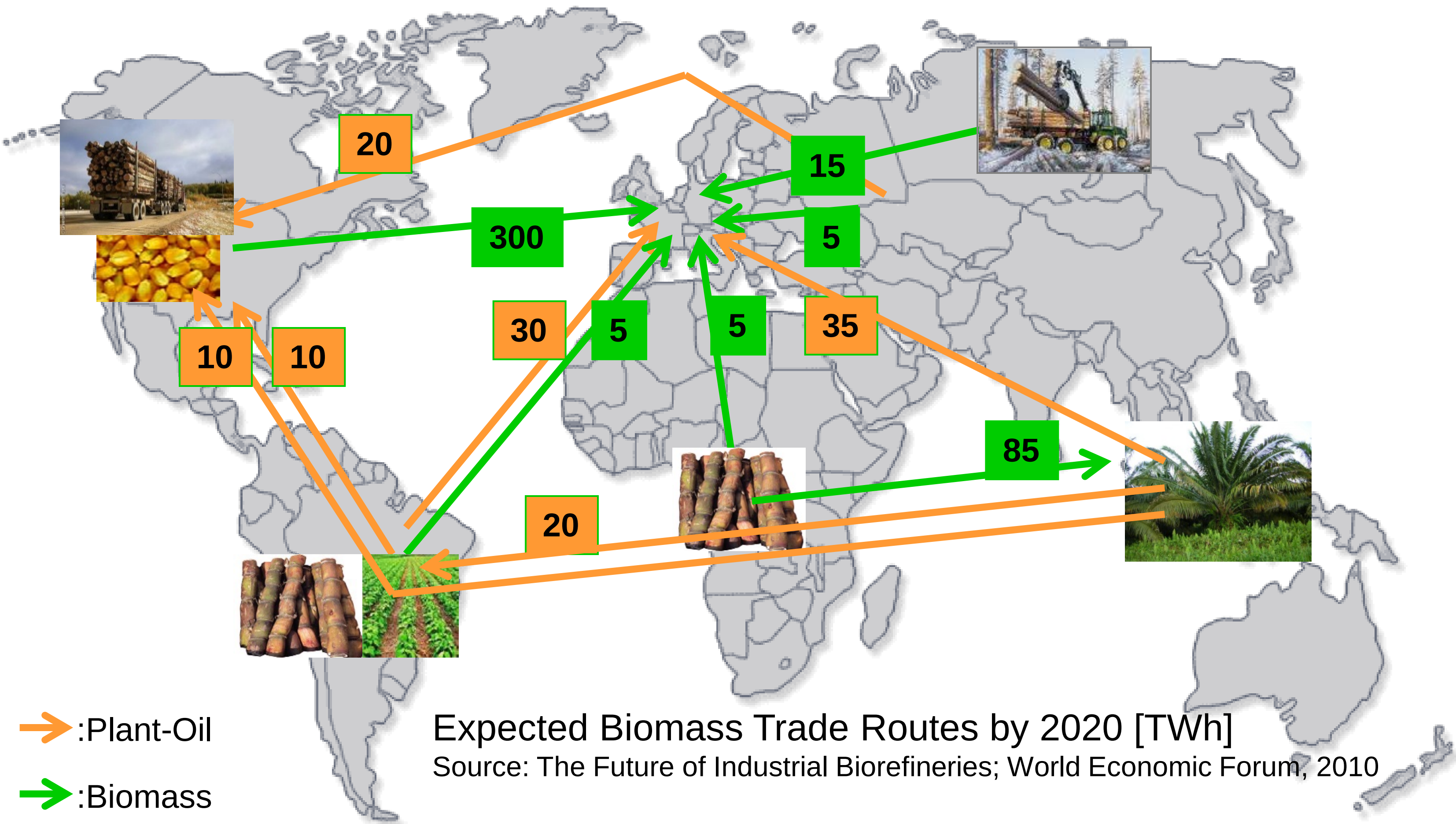


:Plant-Oil

:Biomass

Expected Biomass Trade Routes by 2020 [TWh]

Source: The Future of Industrial Biorefineries; World Economic Forum, 2010

# CLIB is a Global Radar
# Russia: Technology Platform Biotech 2030


CLIB office
Moscow, Russia

Skolkovo Innovation Village

# CLIB is a Global Radar
# Malaysia: Biomass Strategy

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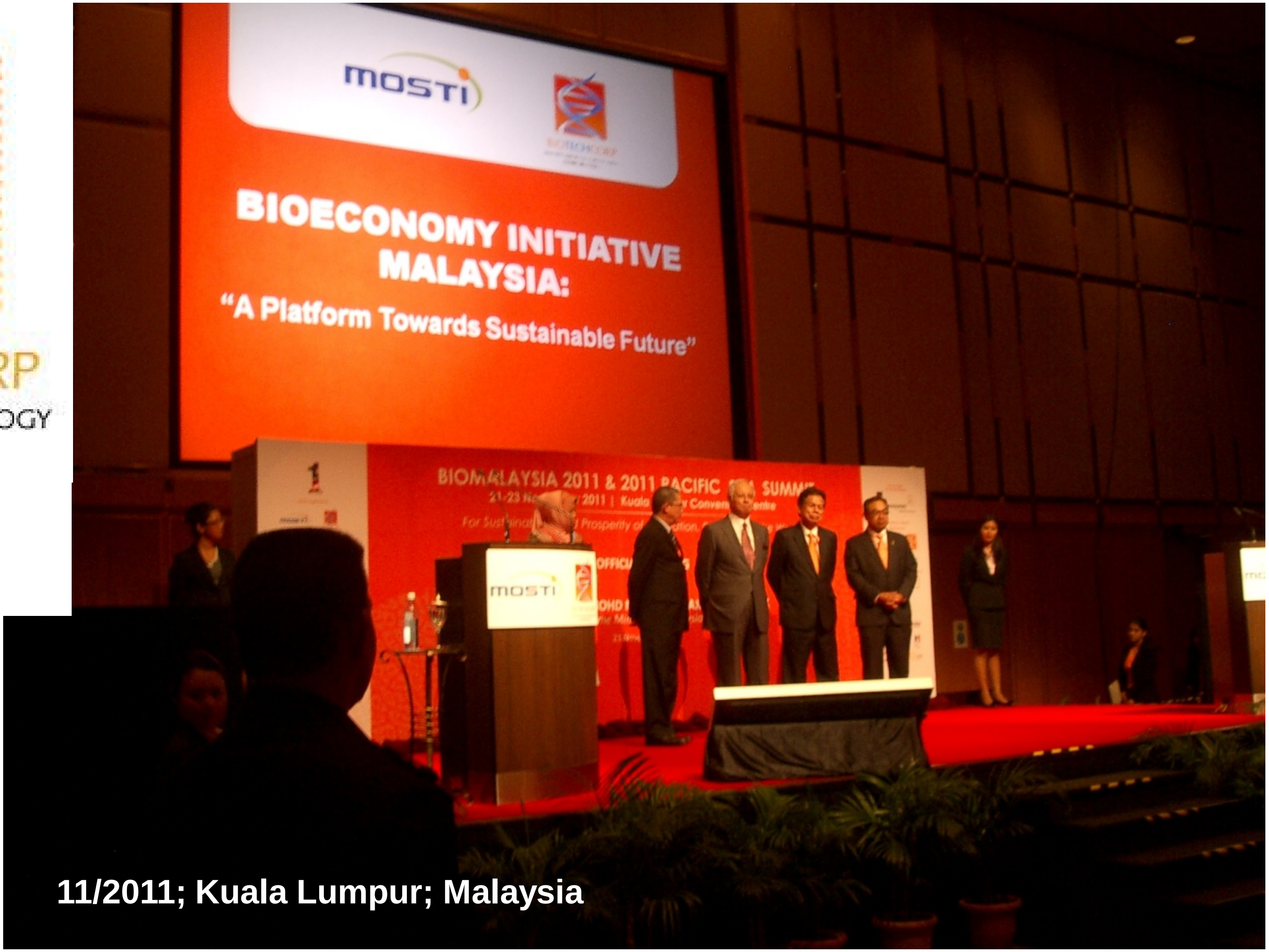
BIOTECHCORP
MALAYSIAN BIOTECHNOLOGY

**CLIB office Kuala Lumpur, Malaysia**




**11/2011; Kuala Lumpur; Malaysia**

# CLIB is Global Radar
# Brazil: BioInnovation Hub

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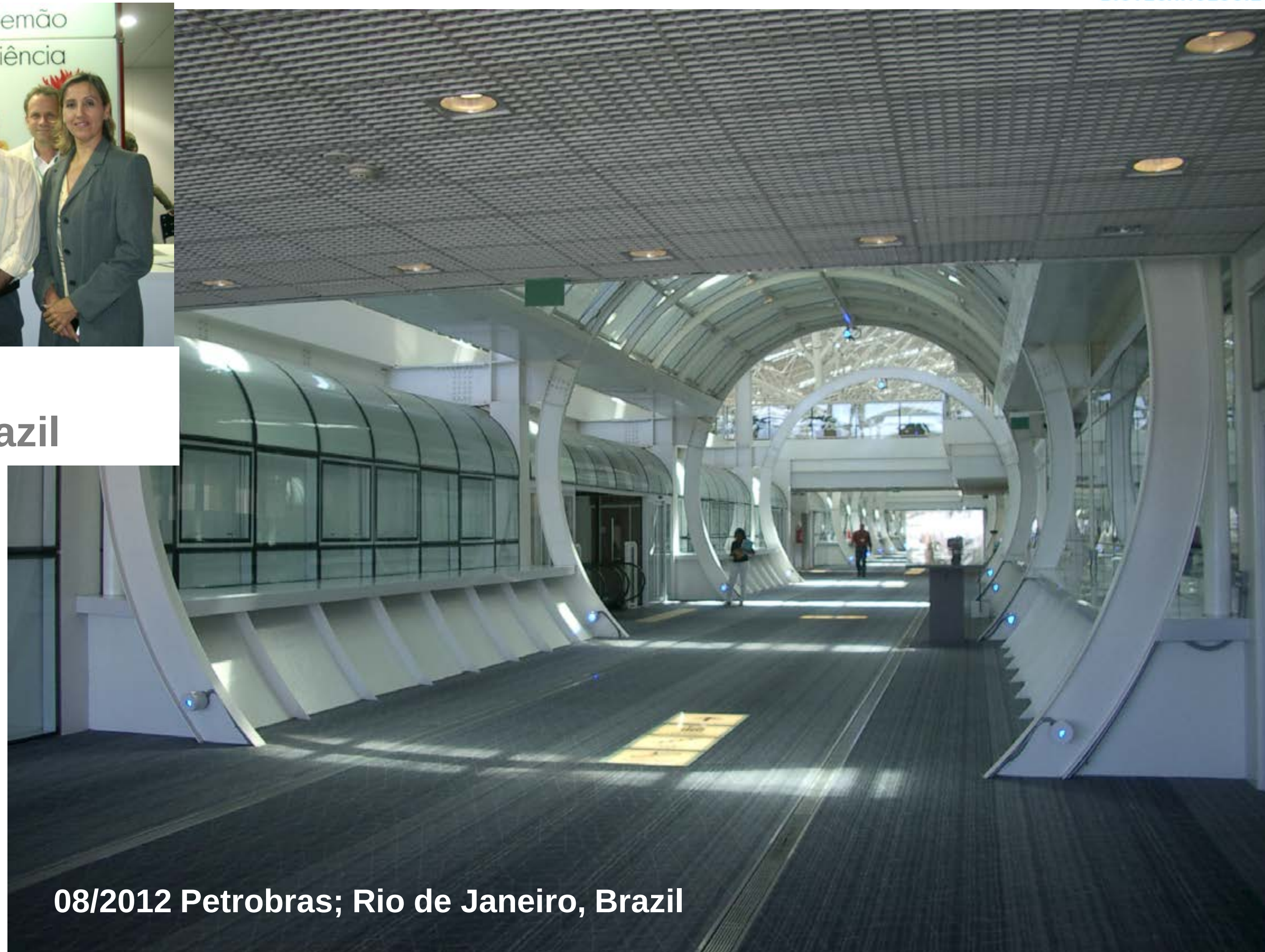
**CLIB office**
**Sao Paulo, Brazil**



**08/2012 Petrobras; Rio de Janeiro, Brazil**

# CLIB is a Global Radar
# Canada: Biorefining Conversions Network

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BIOTECHNOLOGIE


**CLIB office**
**Drayton Valley, Canada**


**BIO-MILE**
**Drayton Valley, Canada**

# Feedstock-Flexibility
# Industrial Drivers

| | | | |
|---|---|---|---|
| ***Drivers*** | Economical & Ecological<br>**Sustainability** | Product & Process<br>**Innovation** | Renewable<br>**Feedstock** |
| ***Options*** | Bio-Feedstock | Feedstock Processing<br>& Transformation | Bio-Feedstock<br>Flexibility |
| ***Challenges*** | Cost &<br>Economy of Scale<br>of renewable / fossil<br>Feedstock | Unusual Value Chains<br>Time-to-Market | Access to Feedstock<br>Global Infrastructure |

# Global, Continental & Regional Markets for Fossil- and Bio-Feedstock

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**Oil:
Global Market**

**Gas:
Continental Markets**


**Bio-Feedstock:
Regional Markets**

Amsted-Maxion Sugar Wagon; São José do Rio Preto SP, Brazil

# Biomass Processing & Transformation advantegous in Biomass Regions

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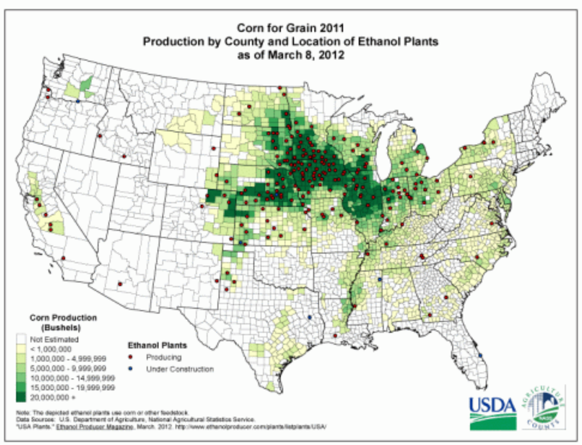


www.nass.usda.gov/Charts_and_Maps/
Ethanol_Plants/U._S._Ethanol_Plants


http://www.greenfuels.org/en/industry-information/plants.aspx

# CLIB
# builds Bioeconomy Value Chains

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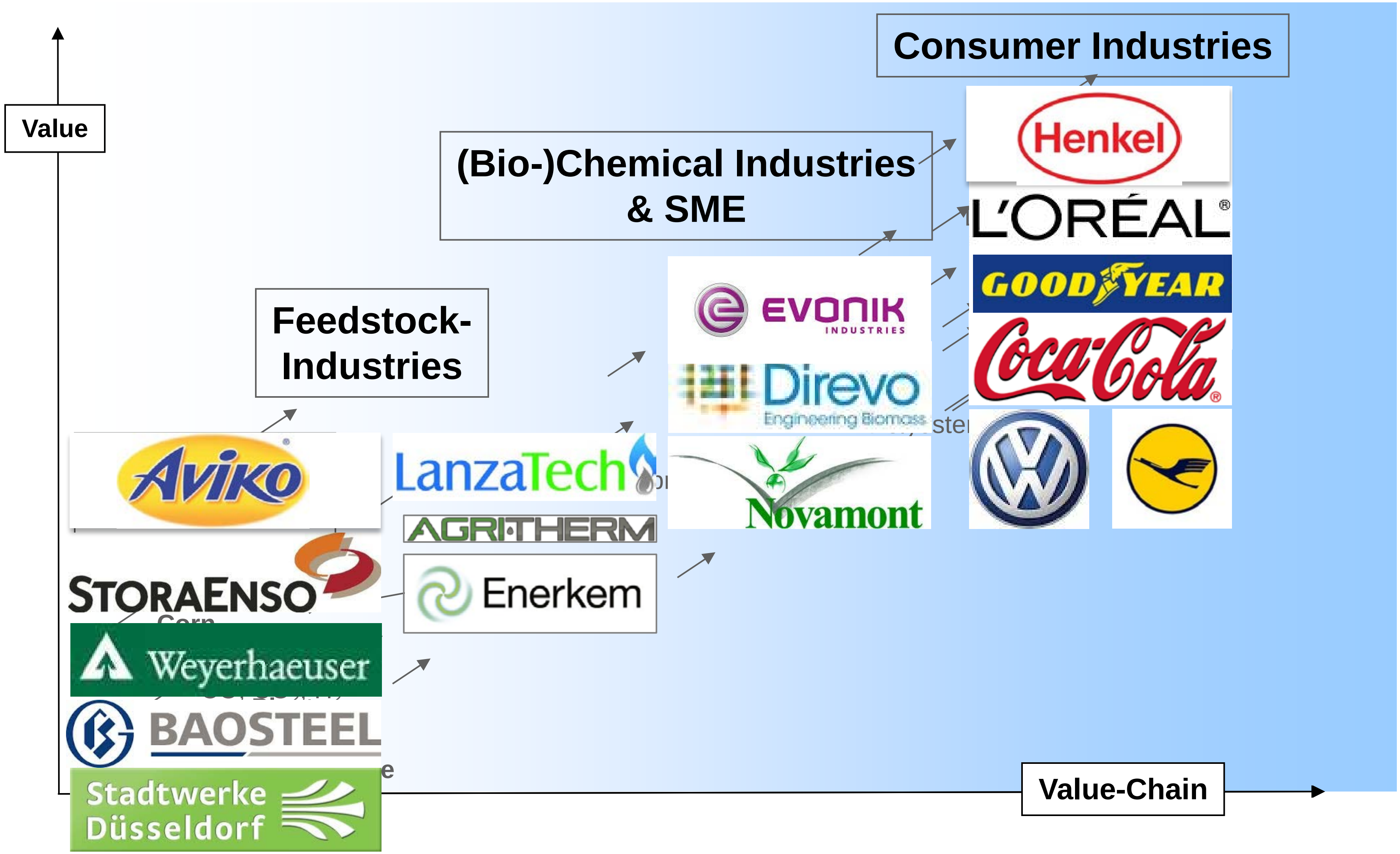

10th Annual
# World Congress on Industrial Biotechnology

*linking biotechnology, chemistry + agriculture to create new value chains*

June 16-19, 2013
Montréal, Canada

Bio

## *How to Build a Large-Scale Bioeconomy Megacluster Region*

Monday, June 17, 2013 | 2:30 pm-4:00 pm

**Manfred Kircher** (Germany)
**Luuk van der Wiele**(Netherlands)
**Dato' Issace Jebasingam John** (USA)
**Debi Durham** (USA)
**Ludo Diels** (Belgium)

## *Techno-Economic Analysis of Renewable Chemicals and Fuels*

Tuesday, June 18, 2013 | 2:30 am-4:00 pm

**Manfred Kircher** (Germany)
**Daniel Klein-Marcuschamer** (Australia)
**Viondette Lopez** (USA)
**Jamie Stephen** (Great Britain)
**Richard Gustafon** (USA)