Potenziale der Bioökonomie für die Landwirtschaft - und wie man sie am besten erschließen kann?

Dr. Stephan Piotrowski, Michael Carus, Roland Essel
nova-Institut GmbH, Hürth (Cologne), Germany

Bio-based Economy – Bio-based Chemistry and Materials

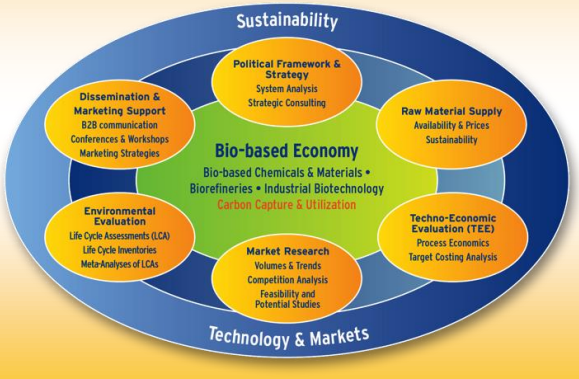
- Raw Material Supply
- Techno-Economic Evaluation
- Market Research
- Environmental Evaluation
- Dissemination
- Political Framework & Strategy

Since over 20 years in bio-based economy private and independent research institute

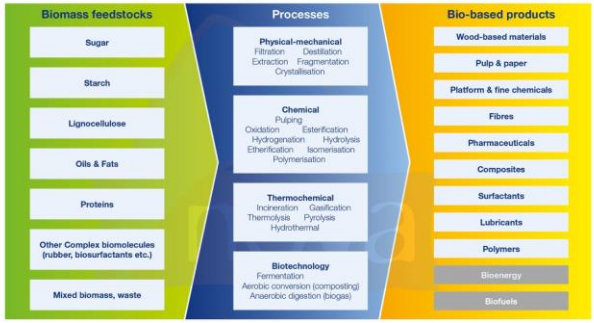
nova-Institut GmbH – SME

Revenue shares

- Research Projects
- Conferences & Dissemination
- Industrial & Political Consultancy



Bio-based Economy: feedstocks, processes and products (without food & feed)



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Facts and Figures about nova-Institute

- Founded 1994 as a private and independent research institute
- 25 employees – interdisciplinary, international team
- Turnover of over 2 Mio. € / year
- Member of various associations & committees

  CEN/TC 411, "Bio-based Expert Group" in DG Enterprise & Industry, technical group of the "bio-based panel" and advisory board of CLIB2021

Selected customers from industry, associations and public as well as political institutions

Automotive Industry: Brose, BMW, Mercedes/Daimler, Dräxlmaier, Faurecia, Ford, Johnson Controls, Quadrant, VW

Chemistry, plastics and other materials: Arizona Chemical, BASF, Corbion, ESE Expert, Evonik, FKuR, GreenFuture, Honeywell, IKEA, InfraServ, KOSCHE, LEIFHEIT, LOGOCOS, Teijin

Engineering: Coperion, FERROSTAAL, Reifenhäuser, Uhde-Inventa Fischer

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Associations / Clusters/ NGOs: AVK, CEFIC, CLIB2021, European Bioplastics, EIHA, IAR, VHI, WWF

Ministries & Institutions: BfN (DE), BMELV (DE), DBU (DE), DEFRA (UK), DECC (UK), European Commission, FAO, FNR (DE), GIZ (DE), KfW (DE), NIA (TH), UBA (DE), Netherlands Enterprise Agency (NL), Ministry of Economic Affairs (NL)

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Sources, Impacts & Solutions
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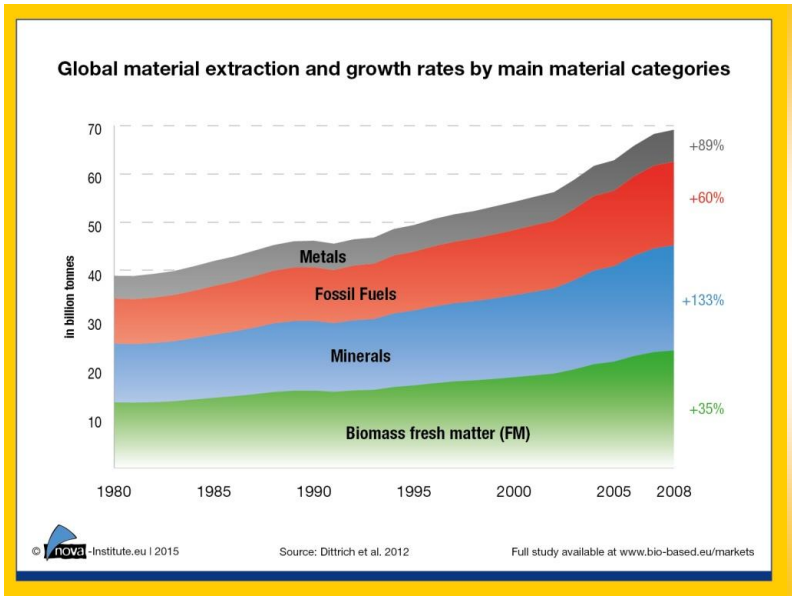
Background and methodology

This study has been carried out for the German Federal Ministry of Food and Agriculture (BMEL) and the German Federal Ministry for Economic Affairs and Energy (BMWI). Further scenarios have been developed for the 4th SCAR Foresight Exercise (Mathijs et al. 2015).
We can easily model YOUR scenarios too.

2011:
- Biomass supply by type in tonnes dry matter
- Biomass demand by sectors
- Challenge is matching both!
  Nobody tried this before (as far we know)

Scenarios for supply and demand in 2050:
- Simple calculation model
- Solid and confirmed (and transparent) data and assumptions
- Based on 100 parameters on supply and demand

Project results will be available soon at http://bio-based.eu/ecology


Global material extraction and growth rates by main material categories
70
60
50
40
30
20
10
in billion tonnes
Metals
Fossil Fuels
Minerals
Biomass fresh matter (FM)
+89%
+60%
+133%
+35%
1980
1985
1990
1995
2000
2005
2008
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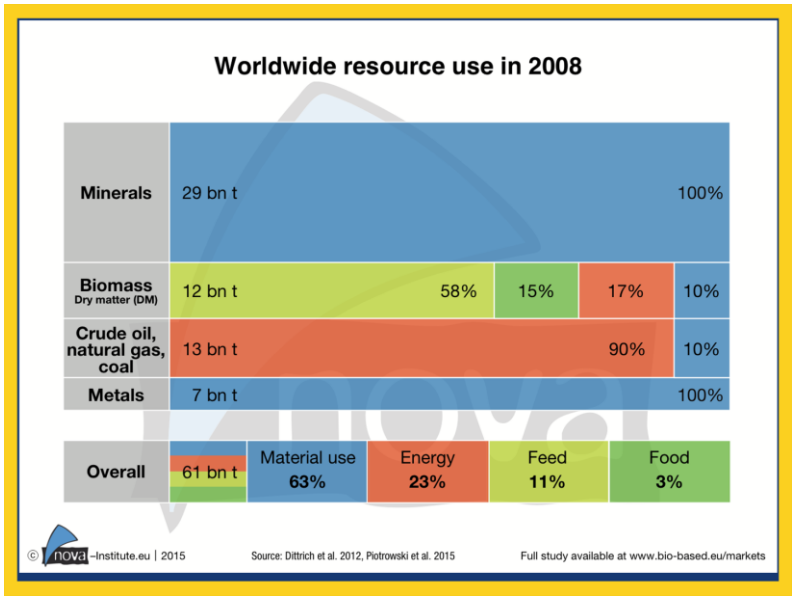
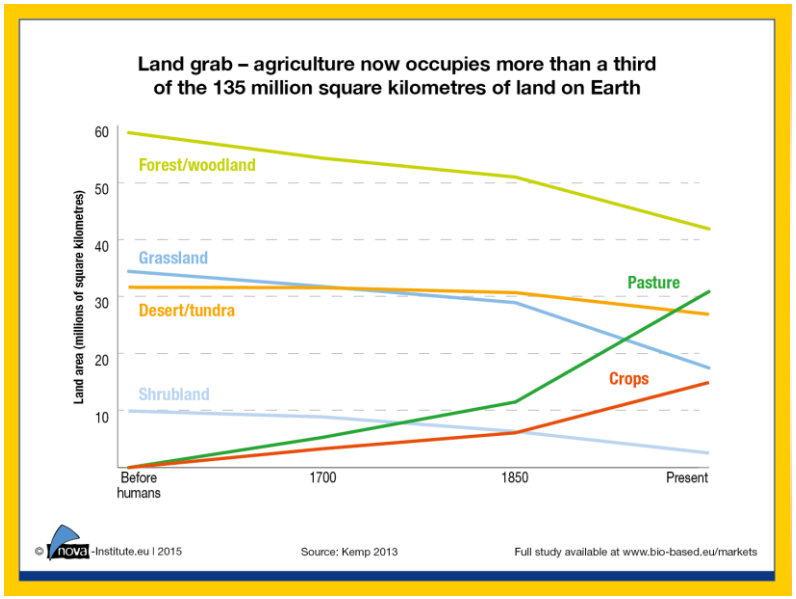
Source: Dittrich et al. 2012
Full study available at www.bio-based.eu/markets


Worldwide resource use in 2008
Minerals
29 bn t
100%
Biomass
Dry matter (DM)
12 bn t
58%
15%
17%
10%
Crude oil, natural gas, coal
13 bn t
90%
10%
Metals
7 bn t
100%
Overall
61 bn t
Material use
63%
Energy
23%
Feed
11%
Food
3%
© nova-Institute.eu | 2015
Source: Dittrich et al. 2012, Piotrowski et al. 2015
Full study available at www.bio-based.eu/markets


Land grab – agriculture now occupies more than a third of the 135 million square kilometres of land on Earth
Land area (millions of square kilometres)
60
50
40
30
20
10
Forest/woodland
Grassland
Desert/tundra
Shrubland
Pasture
Crops
Before humans
1700
1850
Present
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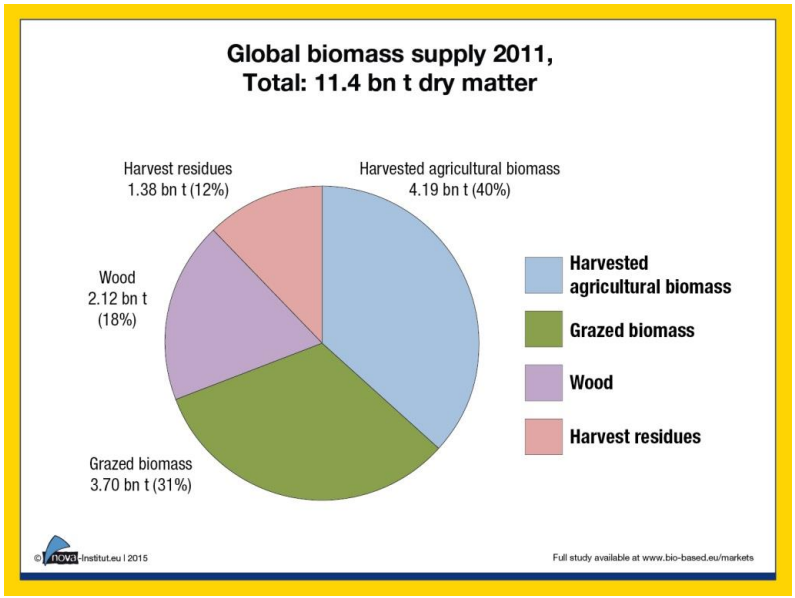
Source: Kemp 2013
Full study available at www.bio-based.eu/markets


Global biomass supply 2011, Total: 11.4 bn t dry matter
Harvest residues 1.38 bn t (12%)
Harvested agricultural biomass 4.19 bn t (40%)
Wood 2.12 bn t (18%)
Grazed biomass 3.70 bn t (31%)
Harvested agricultural biomass
Grazed biomass
Wood
Harvest residues
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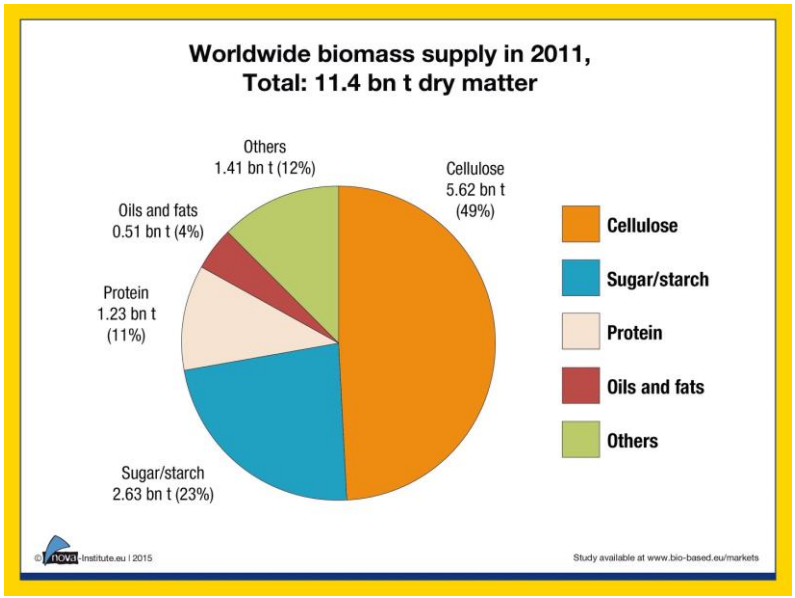
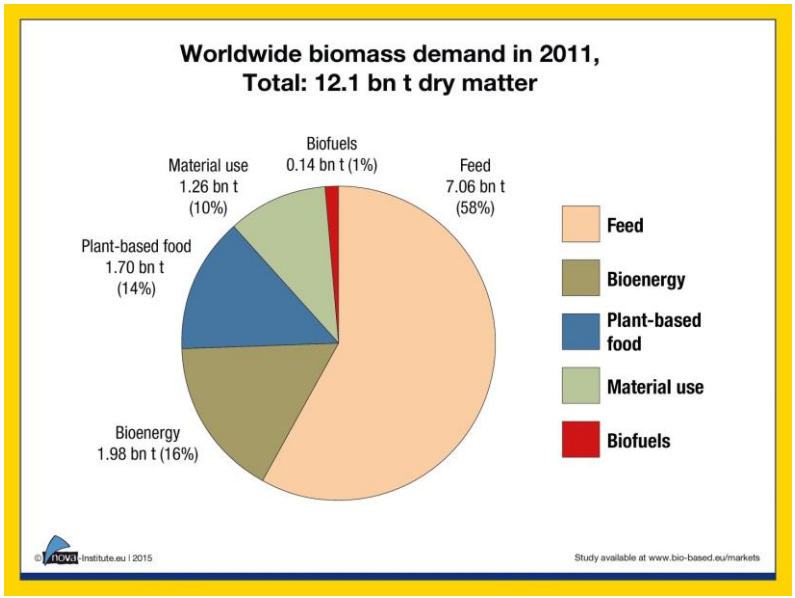

Worldwide biomass supply in 2011,
Total: 11.4 bn t dry matter
Others
1.41 bn t (12%)
Cellulose
5.62 bn t
(49%)
Oils and fats
0.51 bn t (4%)
Protein
1.23 bn t
(11%)
Sugar/starch
2.63 bn t (23%)
Cellulose
Sugar/starch
Protein
Oils and fats
Others
Study available at www.bio-based.eu/markets


Worldwide biomass demand in 2011,
Total: 12.1 bn t dry matter
Biofuels
0.14 bn t (1%)
Material use
1.26 bn t
(10%)
Feed
7.06 bn t
(58%)
Plant-based food
1.70 bn t
(14%)
Bioenergy
1.98 bn t (16%)
Feed
Bioenergy
Plant-based food
Material use
Biofuels
Study available at www.bio-based.eu/markets

Use of biomass in the Chemical Industry

Feedstock of the Chemical Industry	EU 2011 in 1,000 t	EU 2011 in %	World 2010 In Million t	World 2010 in %
Total	**90,310**	**100%**	**590**	**100%**
Mineral Oil derivatives	61,210	68%	400	68%
Natural Gas	19,200	21%	125	21%
Coal	1,340	1%	6	1%
Renewables	**8,560**	**9%**	**59**	**10%**
- Vegetable Oils	1,570	18%	14	24%
- Animal Fats	500	6%	4	7%
- Chemical Pulp	890	10%	4	7%
- Starch				
- Sugar	1,560	18%	8.6	15%
- Bioethanol (Starch eq)	1,590	19%	8.8	15%
- Bioethanol (Sugar eq)				
- Natural Rubber	1,240	14%	11	19%
- Glycerol	470	5%	3	5%
- Others	740	9%	5	8%

Sources: CEFIC 2014, OPEC 2013, nova 2014

Explorative biomass supply scenarios for 2050

Low: Very moderate development in terms of agricultural intensification and land use changes

No significant changes in the area and composition of forests

BAU: "Business-as-usual", in principle an extrapolation of current trends (yields, MCI etc.)

Current trend of deforestation continues until 2030 and then comes to a halt as internationally declared (Council of the European Union 2009)

Trend of increasing area of planted forest continues until 2050

High: Demand-driven, very high intensification of agriculture and concurrent land use changes, incl. more intensive forestry and expansion of planted forests

We can model any different scenario easily too!

Scenario assumptions for land cover changes

Global land cover in Billion ha	2011	2050 Low	2050 BAU	2050 High
Agricultural area	**4.91**	**4.81**	**4.83**	**4.89**
Arable land	1.40	1.31	1.52	1.73
Land for permanent crops	0.15	0.14	0.16	0.18
Permanent meadows and pastures	3.36	3.36	3.14	2.98
Forest area	**4.03**	**4.03**	**3.90**	**3.90**
Primary forest	1.45	1.45	1.21	1.21
Other naturally regenerated forest	2.29	2.29	2.20	2.00
Planted forest	0.29	0.29	0.49	0.68
Other land	**4.08**	**4.18**	**4.30**	**4.23**
Deserts and barren land	2.75	2.85	2.98	2.91
Ice and cold deserts	0.78	0.78	0.78	0.78
Coastal fringes	0.43	0.43	0.43	0.43
Wetland	0.09	0.09	0.05	0.05
Urban/built up land	0.03	0.03	0.06	0.06

Scenario results for biomass supply

Table 1: Biomass supply of the world 2011 and 2050 in different scenarios (based on Piotrowski et al. 2015), billion tonnes dry matter

Sector	Status 2011	Scenario 2050: LOW	Scenario 2050: BAU	Scenario 2050: HIGH
Harvested agricultural biomass	4.2	5.1	6.2	7.8
Harvest residues	1.4	1.5	3.3	5.1
Grazed biomass	3.7	3.7	3.2	2.9
Wood	2.1	2.1	5.5	9.4
Total	11.4	12.4	18.2	25.2

Explorative biomass demand scenarios for 2050

Low: Demand matches Low supply scenario

BAU: Demand matches BAU supply scenario

Bio-based: As BAU, but with stronger demand growth for the material use of biomass, bioenergy and biofuels

Bio-based High:

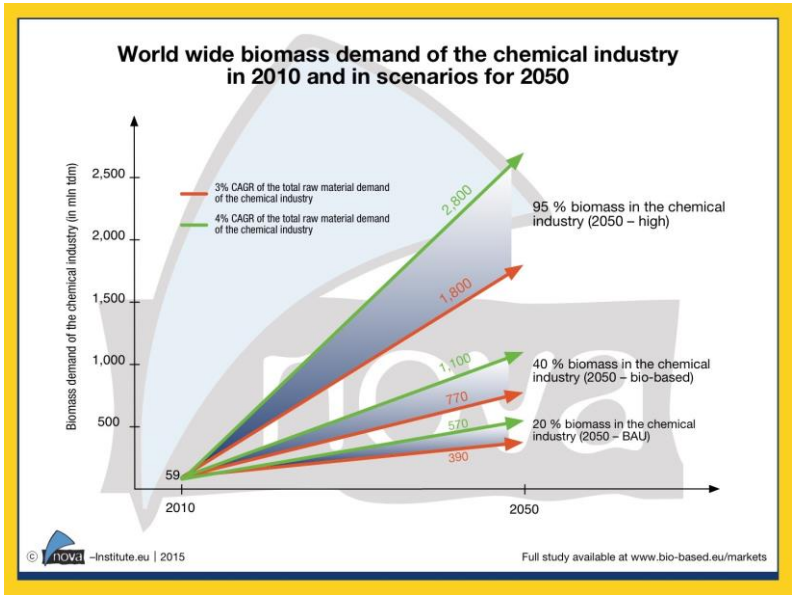
As Bio-based, but with very high demand for biomass in the chemical industry

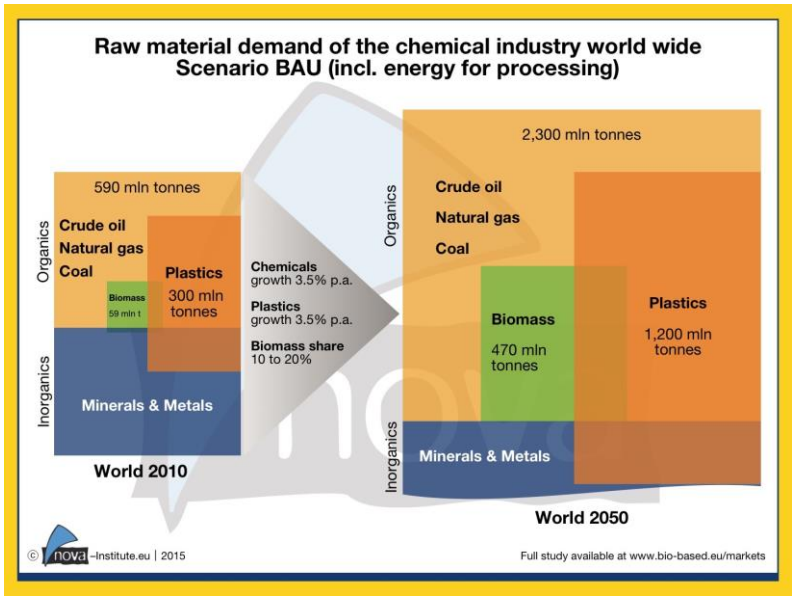
High growth – low pressure:

Demand is the same as in the „Bio-based High“ scenario, but the demand is less covered by biomass but by other renewables and especially solar energy.

In all scenarios we assumed the following “Compound Annual Growth Rates”:

Chemical and plastics industry: CAGR = 3.5%
Textile industry: CAGR = 3%
Energy/fuels: CAGR = 1.5%




Raw material demand of the chemical industry world wide
Scenario BAU (incl. energy for processing)
590 mln tonnes
Organics
Crude oil
Natural gas
Coal
Plastics
300 mln tonnes
Biomass
59 mln t
Inorganics
Minerals & Metals
World 2010
Chemicals
growth 3.5% p.a.
Plastics
growth 3.5% p.a.
Biomass share
10 to 20%
2,300 mln tonnes
Organics
Crude oil
Natural gas
Coal
Biomass
470 mln tonnes
Plastics
1,200 mln tonnes
Inorganics
Minerals & Metals
World 2050
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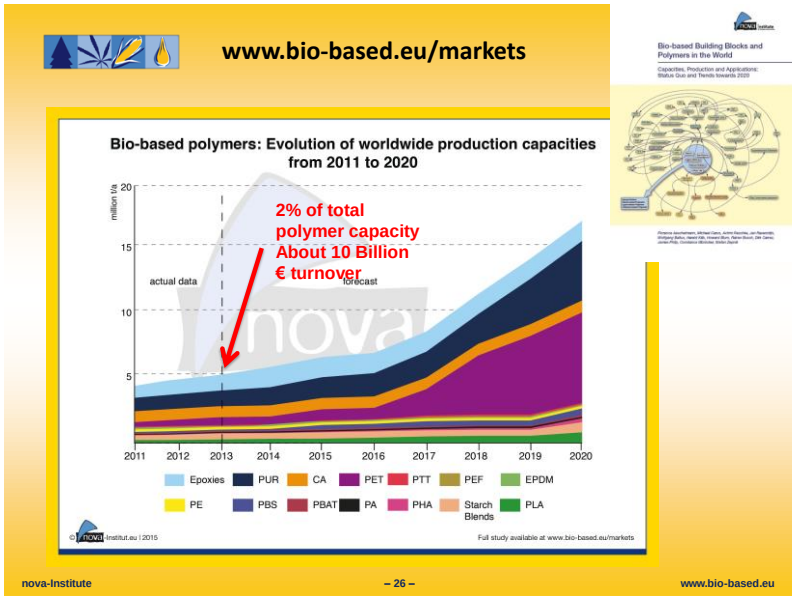
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Bio-based polymers: Evolution of worldwide production capacities
from 2011 to 2020
million t/a
20
15
10
5
actual data
forecast
2% of total
polymer capacity
About 10 Billion
€ turnover
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Epoxies
PUR
CA
PET
PTT
PEF
EPDM
PE
PBS
PBAT
PA
PHA
Starch Blends
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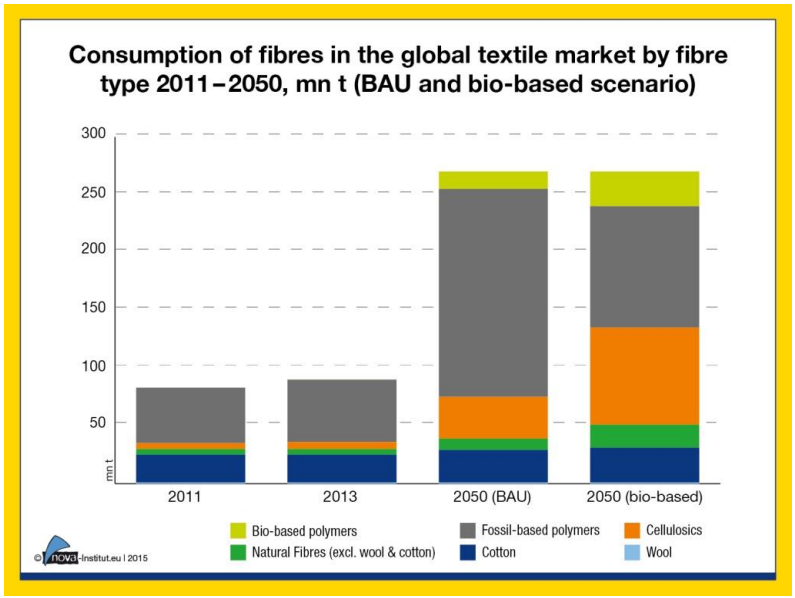
Consumption of fibres in the global textile market by fibre type 2011 – 2050, mn t (BAU and bio-based scenario)
300
250
200
150
100
50
mn t
2011
2013
2050 (BAU)
2050 (bio-based)
Bio-based polymers
Natural Fibres (excl. wool & cotton)
Fossil-based polymers
Cotton
Cellulosics
Wool
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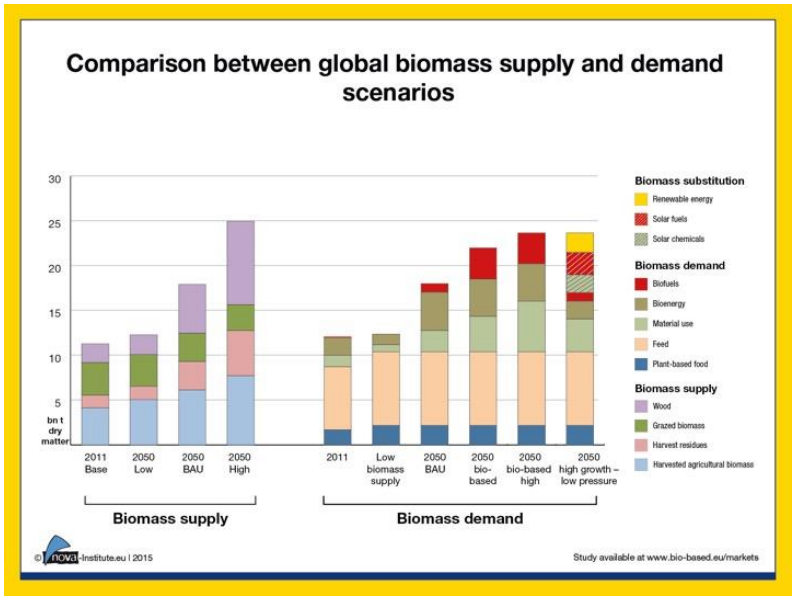
Comparison between global biomass supply and demand scenarios
30
25
20
15
10
5
bn t dry matter
2011 Base
2050 Low
2050 BAU
2050 High
2011
Low biomass supply
2050 BAU
2050 bio-based
2050 bio-based high
2050 high growth – low pressure
Biomass supply
Biomass demand
Biomass substitution
Renewable energy
Solar fuels
Solar chemicals
Biomass demand
Biofuels
Bioenergy
Material use
Feed
Plant-based food
Biomass supply
Wood
Grazed biomass
Harvest residues
Harvested agricultural biomass
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Results and messages

World
With growing agricultural land, increasing plantation forest, growth in yields and higher MCI, the supply of biomass in the BAU scenario in 2050 compared to 2011 can be almost doubled - in the high scenario even more than twice.
In the Low scenario in which there is no expansion of arable land and hardly yield increases, the biomass supply in 2050 around the same level as in 2011.
Demand is growing in the material sector with an average of 2-4% more than in the energy sector with about 1% - means that the proportion of use of material will grow in the petrochemical and bio-economy (oil: from today 5-10% to 20-30% in 2050).
In the scenarios BAU and "bio-based", the total demand for food, feed, material and energy can be covered and biofuels can expand too. In the supply-scenario "low" biomass, however is only enough for food and feed.
The demand scenario "bio-based high" it comes to competition between chemistry (and other material sectors) and biofuel on biomass. Only the supply scenario “high” can cover this demand – also additional biomass sources can be utilized.
In the scenario “High growth – low pressure” we need a strong investment in renewable energies such as solar and wind, and the Carbon Capture & Utilization (CCU) technologies to produce CO_2-based fuels and chemicals.

Your assumptions will be different!

nova-Institute offers

Ministries, Associations, NGO and companies to

- **Develop their own assumptions based on 100 parameters on supply and demand until 2050.**
- **The calculated scenarios and the interpretation of the results will show in detail the impacts of the assumptions.**
- **The procedure starts with an one day workshop to understand the 100 parameters, which are mainly influence our bio-based future on our planet. Also very new developments can be covered.**
- **If you are interested, please send me an email: michael.carus@nova-institut.de**


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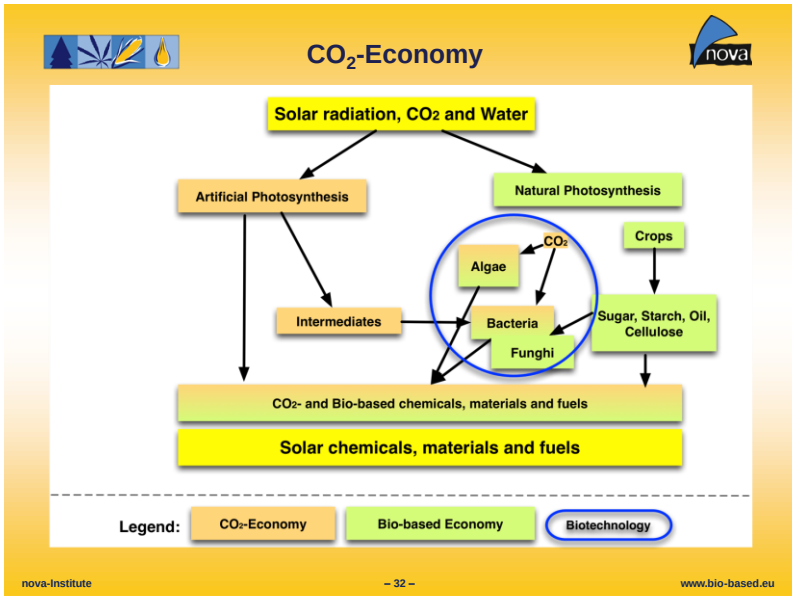
CO_2-Economy
nova
Solar radiation, CO_2 and Water
Artificial Photosynthesis
Natural Photosynthesis
Crops
CO_2
Algae
Intermediates
Bacteria
Funghi
Sugar, Starch, Oil, Cellulose
CO_2- and Bio-based chemicals, materials and fuels
Solar chemicals, materials and fuels
Legend:
CO_2-Economy
Bio-based Economy
Biotechnology
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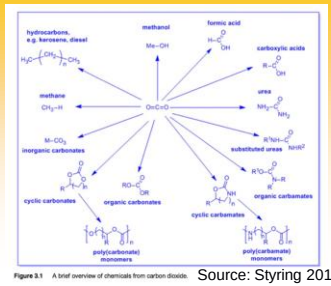
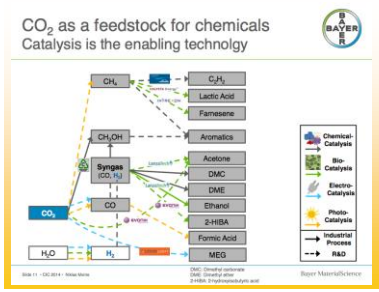
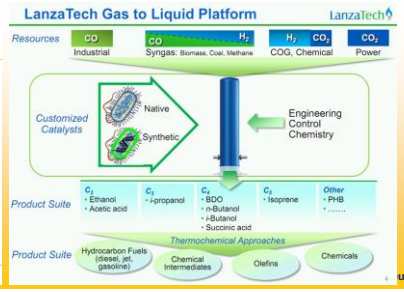


Figure 3.1 A brief overview of chemicals from carbon dioxide.

Source: Styring 2011

Different pathways and technologies to a full range of different chemicals, polymers and fuels





Solar (PV) – CO_2-based Methane and Kerosene Production

	Solar energy per m² and year (in GJ)	Solar energy per m² and year (in kWh)	Production of PV-CO_2-based Methane tonnes per km² (PV efficiency 10 – 20%)	Production of PV-CO_2-based Kerosene tonnes per km² (PV efficiency 10 – 20%)
Middle Europe	3.6 – 4.3	1,000 – 1,200	2,500 – 6,000	2,200 – 5,200
Deserts	7.9 – 9.0	2,200 – 2,500	5500 – 12,500	4,800 – 10,900
Average	7.6	2,100	5,300 – 10,600	4,600 – 9,200

Chemical Industry in 2050: 2,300 mln tonnes carbon demand
With 2,100 kWh/m²*year and 20% PV efficiency an area of 220,000 km² (= 1% of the global desert area) would be needed to cover the global carbon demand of the Chemical Industry via Methane.

CO_2 economy: Summary and outlook

- **Solar energy utilizing 5-10% of the global desert area can cover the total demand for energy and chemicals & polymers in 2050** – including the losses in grid and storages. Wind, geothermal and ocean energy give additional potential.
- **CCU is a crucial technology to utilize solar and other renewables also for fuels and chemicals & polymers**, as well as serving as a **high density and long time energy storage**.
- Renewables and CO_2 are **everywhere available, abundant resource with nearly unlimited volume**; CCU is a recycling of CO_2.
- **Very low environmental and CO_2 footprint for renewable CO_2-based fuels, chemicals & polymers** compared to petrochemicals (and also to bio-based)
- **Ultimate, sustainable source for fuels and a wide range of chemicals and polymers – forever.**
- **High land-efficiency** compared to biomass; no issues with direct or indirect land use changes (LUC and iLUC) such as biomass, no feedstock competition. **Very low impact on food, land, water or biodiversity**.

- **Renewables and CCU mean nothing less than a sustainability revolution for all energy and raw material supply.**

Thank you for your attention!

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