Bioeconomy opportunities – dutch perspective

Internat. Symp. Bioeconomy | FIESP/FAPESP Sao Paulo BR

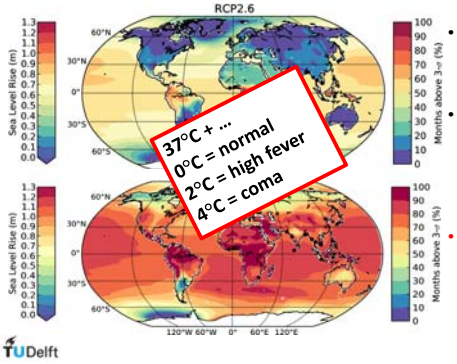
Luuk van der Wielen (TUD/BE-Basic) **| 09 12 2016**

http://www.be-basic.org/downloads

contents

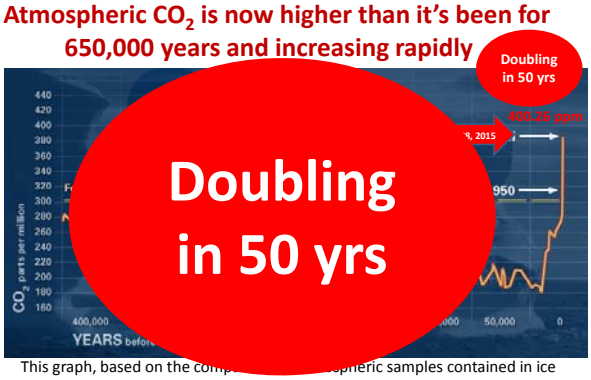
- urgency and drivers
- options and opportunities
- (macro) economic impact
- Brazilian BBE opportunity - roadmaps
- public-private partnerships: BE-Basic, AgroPolo, others,...

Projected sea-level rise and northern-hemisphere summer heat events in a 2°C world and a 4°C world



- Increased sea-level rise from 70 cm to more than a meter
- Increased frequency of extreme and unprecedented heat events
- ... and 75% of the poor in dev (agro) countries are hit first

Atmospheric CO_2 is now higher than it's been for 650,000 years and increasing rapidly



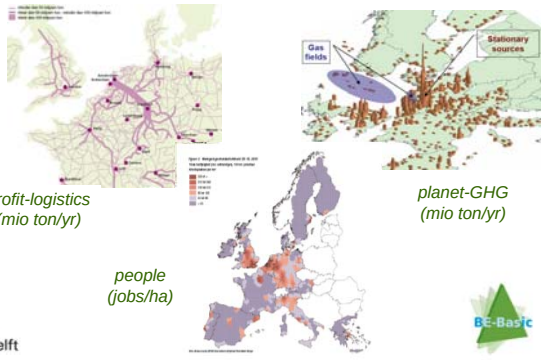
This graph, based on the com... ...spheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution. (Source: NOAA)

Global drivers for a BBE ?

- more people with more wealth
- less **nett** GHG emission (global warming)
  and/or climate adaptation
- politics (security of oil/gas supply)
- innovation, rural income and economic development
- increasing (*and decreasing*) prices of resources
- in time*, limited fossil reserves
- add sustainability to food chain
- add value to food chain and prevent hunger

Pick your personal selection !

People, planet and profit strongly interlinked



profit-logistics (mio ton/yr)

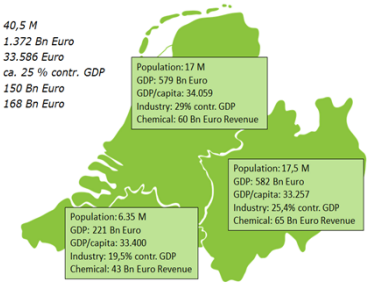
planet-GHG (mio ton/yr)

people (jobs/ha)

… this enables the largest industry

Regional priorities: chemical sector and transport w/o alternatives (aviation etc)

Population:	40,5 M
GDP:	1.372 Bn Euro
GDP/capita:	33.586 Euro
Industry:	ca. 25 % contr. GDP
Agro&Food:	150 Bn Euro
Chemical:	168 Bn Euro



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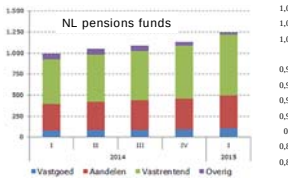
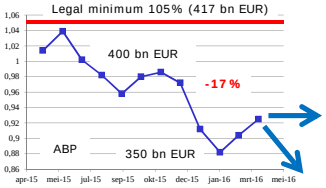
Impact on NL pension funds





Total: 150+ bn EUR capital loss

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BE-Basic

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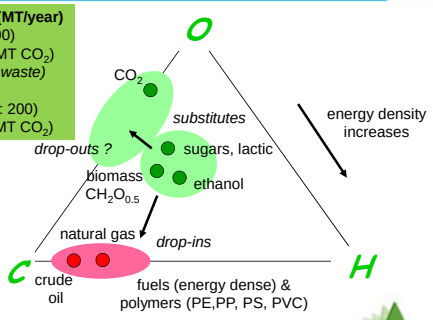
BE-Basic

mass yield: energy poor (O-rich) in materials*

global production (MT/year)

fuels	2000 (jet 300)
cement	3000 (600 MT CO_2)
food	*4000 (50% waste)*
glass	120
plastics	280 (big 5: 200)
steel	120 (200 MT CO_2)



mass composition biobased and fossil feedstocks and products

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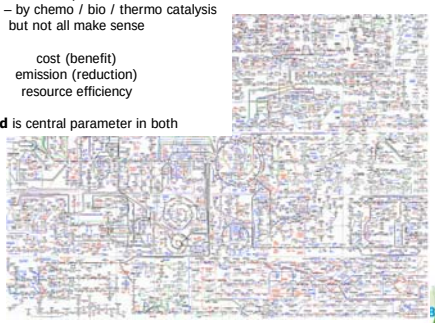
Biobased technology is/gets there

"any" chemical can be produced from biobased feedstocks – by chemo / bio / thermo catalysis but not all make sense

cost (benefit)
emission (reduction)
resource efficiency

yield is central parameter in both



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BE-Basic

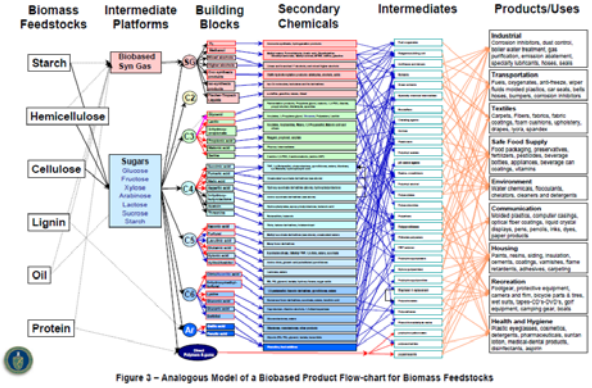

Figure 3 – Analogous Model of a Biobased Product Flow-chart for Biomass Feedstocks

Werpy & Peterson, 2004

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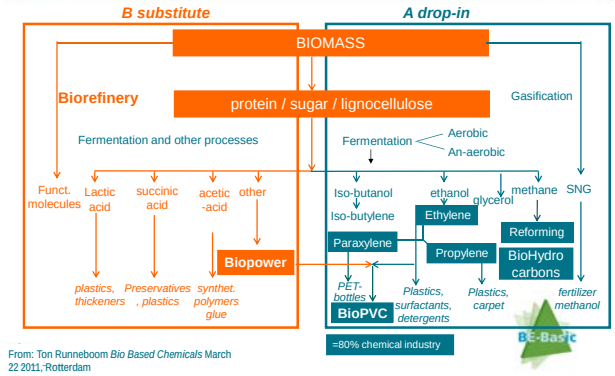
"Drop-in Greenification" of Chemical Industry



From: Ton Runneboom *Bio Based Chemicals* March 22 2011, Rotterdam

Aviation sector needs to green

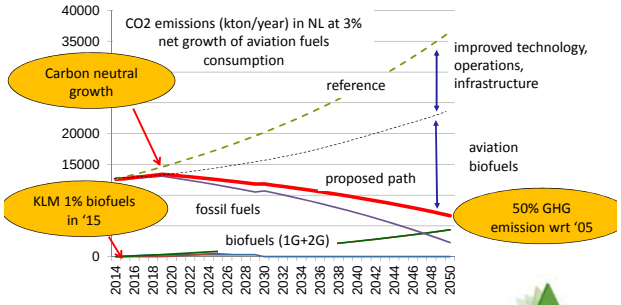
Implementing the Bioport Holland PPP concept

NL (bio)Fuelsmix 2050

Aviation 50%
Marine 33%
Road+rail 17%

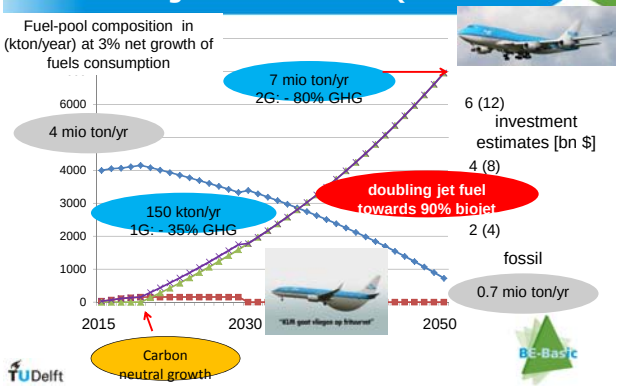
International setting is critical for globally operating industries (transport & chemical)

Aviation: GHG-reduction via TOI and jet biofuels



From "*Visie Duurzame Luchtvaart*". SER Report Van der Wielen et al. June 2014. adopting NL to ATAG ambitions

Introducing aviation biofuels (NL- numbers)



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- **options and opportunities (example)**
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Synthetic Biology in the real world?

glucose
xylose
arabinose
acetate
glycerol
furanics

Elimination of Glycerol Production in Anaerobic Cultures of a *Saccharomyces cerevisiae* Strain Engineered To Use Acetic Acid as an Electron Acceptor

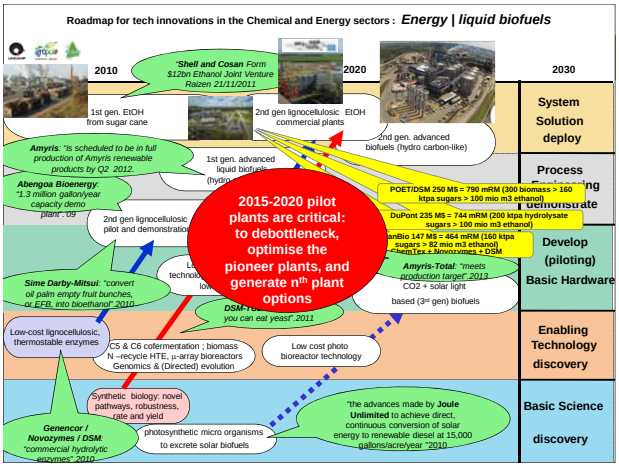
Novel Evolutionary Engineering Approach for Accelerated Utilization of Glucose, Xylose, and Arabinose Mixtures by Engineered *Saccharomyces cerevisiae* Strains

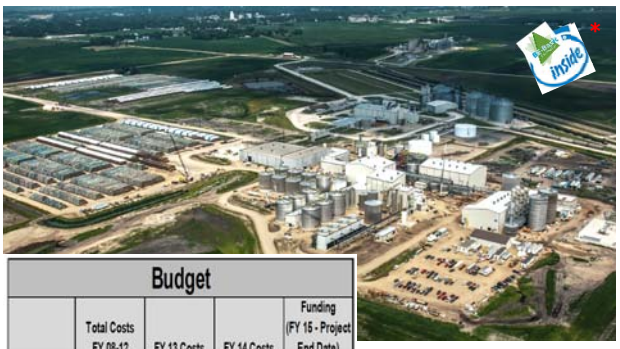
Press Information

All you can eat yeast

DSM-POET / GranBio

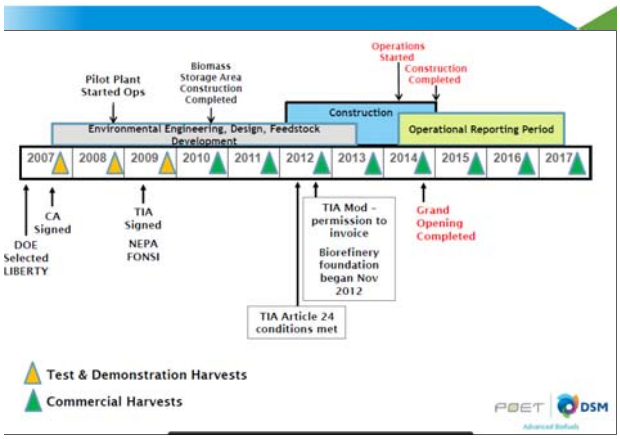
commercial product based patent portfolio



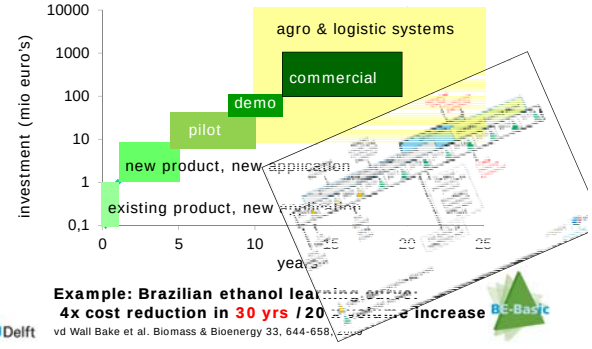


Budget				
	Total Costs FY 08-12	FY 13 Costs	FY 14 Costs	Funding (FY 15 - Project End Date)
DOE Funded	$ 13,730,470	$ 54,000,219	$ 29,790,385	$ 100,000,000
Project Cost Share	$25,605,329.33	$97,525,933.71	> $51,868,736	> $175,000,000

POET DSM Advanced Biofuels



'decades' : process / agro / logistics are slow industries



Example: Brazilian ethanol learning curve: 4x cost reduction in 30 yrs / 20 x volume increase

vd Wall Bake et al. Biomass & Bioenergy 33, 644-658, 2009

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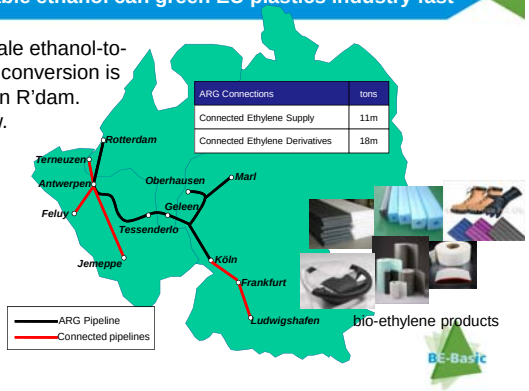
sustainable ethanol can green EU plastics industry fast

Large scale ethanol-to-ethylene conversion is feasible in R'dam. tomorrow.



bio-ethylene products

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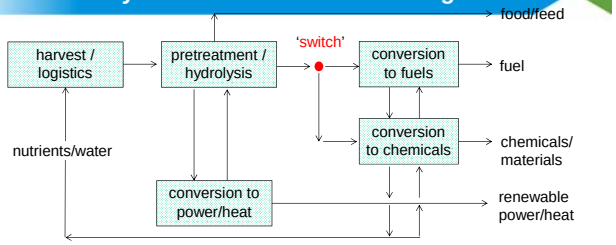
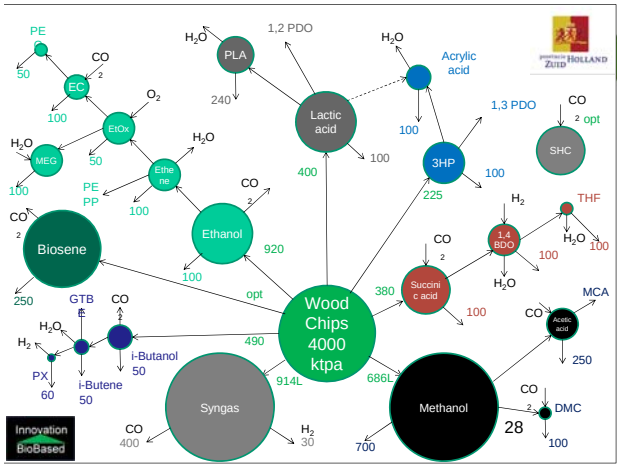
BBE roadmap and (direct) economic impact ('08)

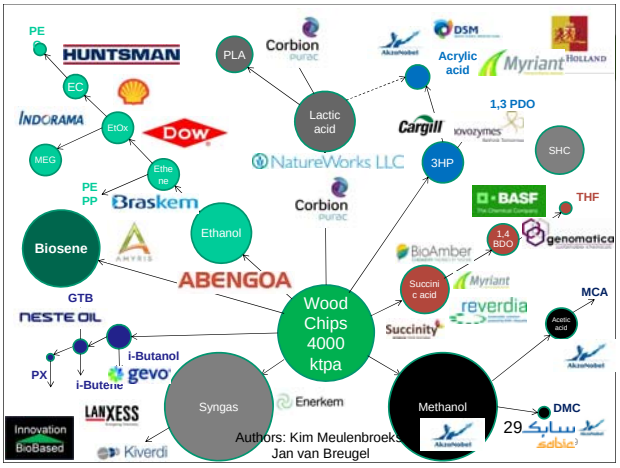
NL chemistry 2010: € 13 bn GDP (3%) / € 47 bn sales / 20% export ;
NL energy € 11.2 bn GDP (2.2%) / € 30 bn sales

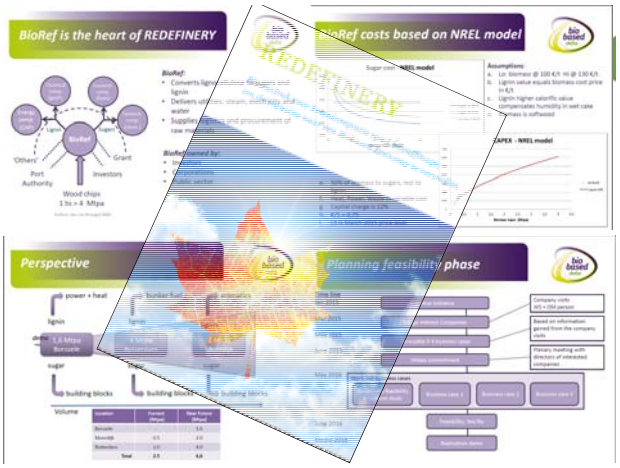
Biorefinery structure - biomass to integral value



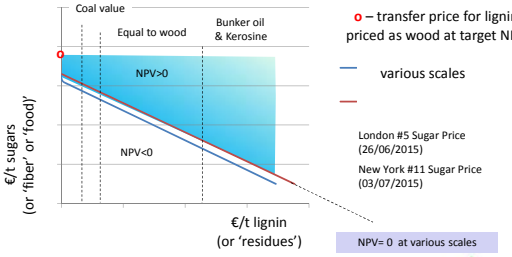
- tune portfolio value renewable energy/fuels/chemicals
- counter-acting scale effects of logistics (5-10% for bagasse, 30% for palm oil biomass) and conversion costs
- energy/heat, water, and nutrient integration need for cross-industry sector collab's (JVs, trade, co-op's,...)







Economics of a multiproduct REDEFINERY

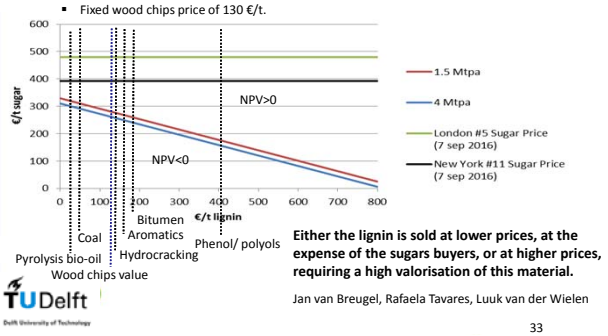


wood chips at 'mid price'
cost of /return on capital at market conform pricing included

Presentation based on public data

Transfer prices

- Study on costs distribution among the final products, lignin and sugars, for Central plant;
- Project feasibility: net present value of zero at year 10, IRR 12 %;
- Fixed wood chips price of 130 €/t.



Either the lignin is sold at lower prices, at the expense of the sugars buyers, or at higher prices, requiring a high valorisation of this material.

Jan van Breugel, Rafaela Tavares, Luuk van der Wielen

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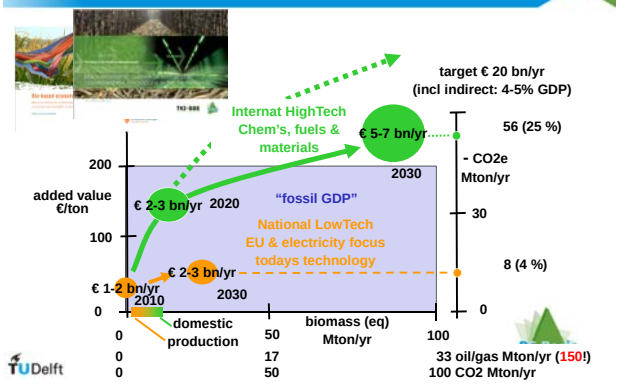
NL Reference numbers

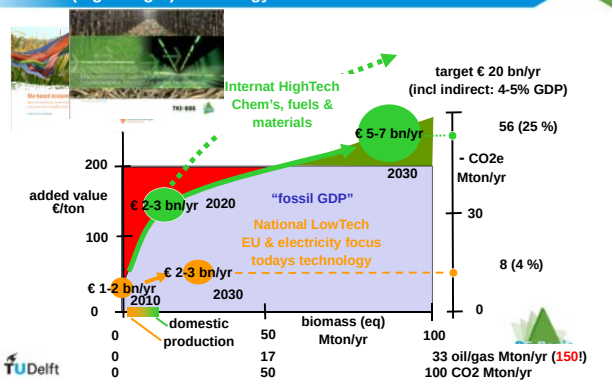
- Biomass 15 PJ/MT 1
- Oil/gas 45 PJ/MT 3 (150 MT)
- GDP energy 15 bn EUR
- GDP chemicals 15 bn EUR ~ 200 MEUR/MT
- CH2 (1) + 1.5 O2 -> CO2 (3) + H2O
- CH2O (1) + O2 -> CO2 (1.5) + H2O

- Kerosene (NL): 4 (2015) >> 7 MT/yr (2050)
- Kerosene ('EU') ~ 12 (2015) >> 24 MT/yr (2050)

BBE and fossil displacement (MEV I ('08), MEV II ('16)



BBE displaces fossil: requires investment & differential GDP (high + right) technology & volume



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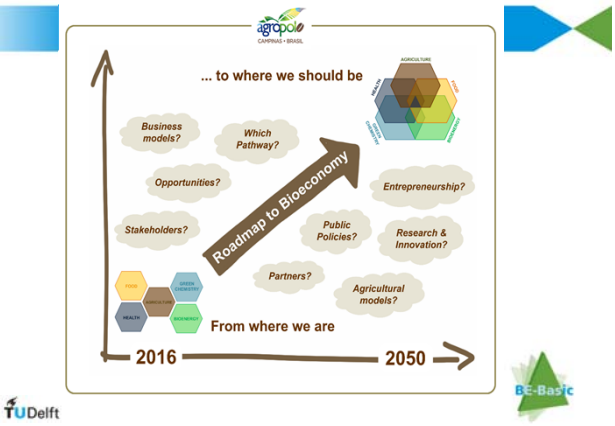


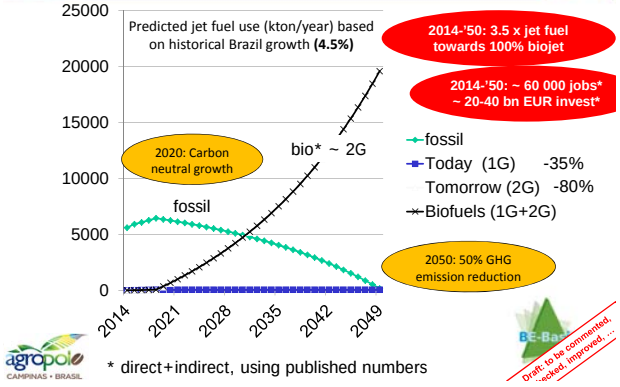
PRESS RELEASE

Unlocking the Brazil potential for Biojet fuel production – roadmap to deliver over 25 Million ton sustainable aviation and marine fuels.

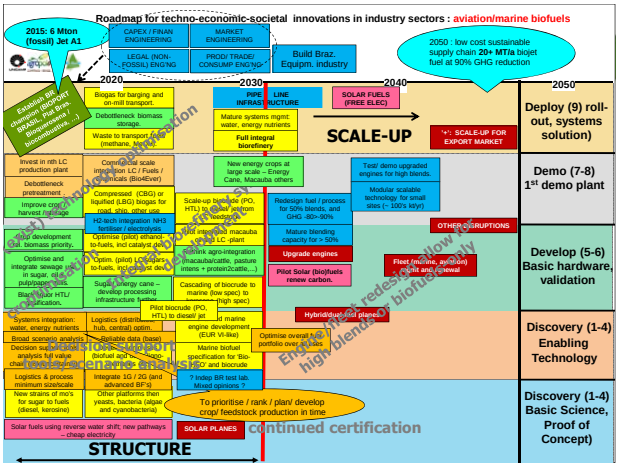
Campinas, 18 October 2016 – Industrial and academic partners of Brazil and The Netherlands agreed to join forces in defining the most effective path to produce sustainable advanced biofuels.

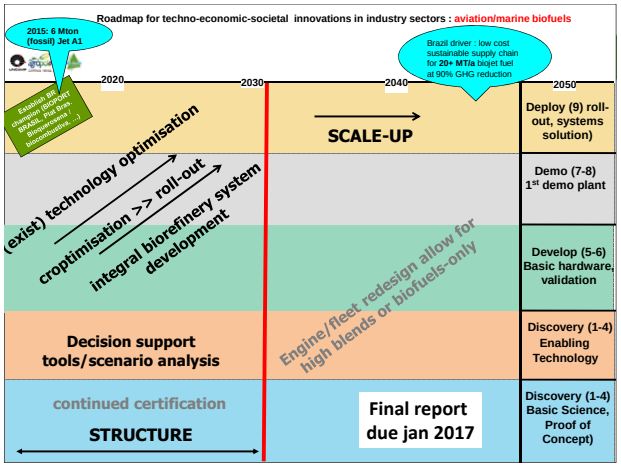
Over 100 representatives of industry and public institutes participated in the workshop, coordinated by professors Telma Franco (UNICAMP) and Luuk van der Wielen (TU Delft). The workshop was organised as part of the Agropolo Campinas-Brasil initiative to build a roadmap aiming to double Sao Paulo State GDP income and half Green House Gas (GHG) emissions by 2050.

Underlying bio/fossil aviation fuel scenario in Brazil



* direct+indirect, using published numbers





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BE-Basic

* PPP-models for bioeconomy

Type	Players	example
R&D / testing / technological innovation	academia & industry, industry-industry	BE-Basic, EBI, CLIB, IAR, TWB, testing / pilot facilities
Market development	auctions, cooperatives, market place, commodity / stock exchanges, blending mandates, launching costumer	(wood) pellets, sugar, agro-commodities, flowers, vegetables, Etanol (BR)
Infrastructure	industry & government, ngo (ecosystems services), agri-cultural	Rotterdam port extension, agri-zoning, land consolidation*
Sustainability criteria / certification	industry, ngo, academia, (gov.)	RSB + 100's others, SCOPE / IPCC / Lorentz BioPanel
Investment/ implementation	(institutional) investors, industry, governments (state-owned, subsidy), development banks (regional, EIB), Worldbank Group	many (most) 2nd lignocellulosics plants multifunctional landscape (restoration) projects WB

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conclusions

- biorenewables can play critical role in chemical & materials industry, far 'beyond bioethanol' and
- in sustainable (people, planet, profit) development
- no premiums & subsidies: need to be integral part of chemicals/ fuels/ food/ energy /logistics system (**> 2030**)
- fuels with priority for sectors w/o alternatives
- public-private partnerships are required to speed-up development and implementation, in professional setting

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Back-up slides

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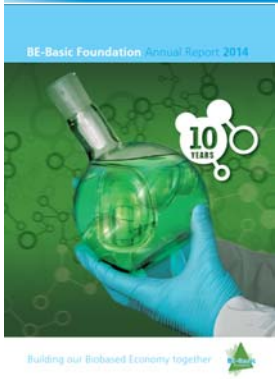
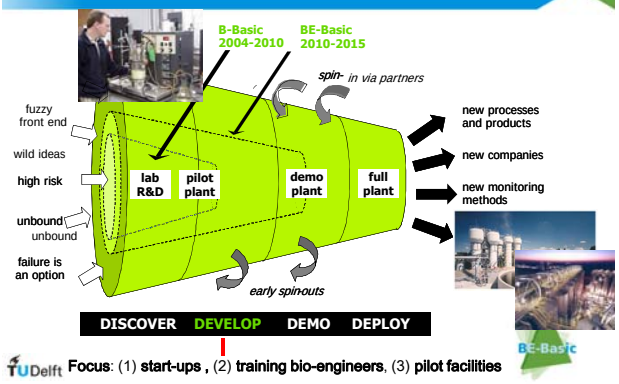
About us: *www.BE-Basic.org/downloads* *



RD & Innovation strategy



TUDelft **Focus**: (1) **start-ups ,** (2) **training bio-engineers**, (3) **pilot facilities**

BE-Basic

biobased technologies & systems (push)

- *F9 Societal embedding (incl Integrat.biofuels/plastics project)*
- *F8 Environ impacts of biobased products/processes*
- *F5 Bioprocess Engineering*
- *F6 Synthetic Biology & F10 Genomics*
- *F7 Metagenomics mining & F10 Genomics*

F1 Carbon | *F2 Nitrogen* | *F3 Recycle* | *F4 Biomat.*

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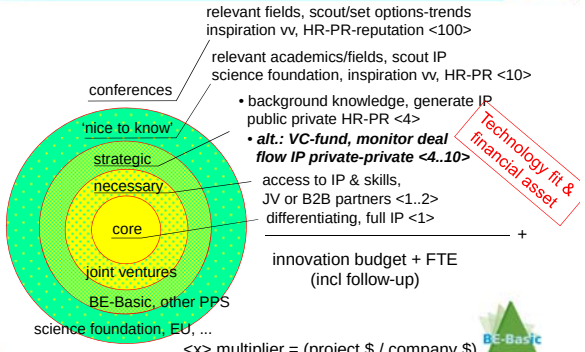
Open innovation model in shells



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<x> multiplier = (project $ / company $)
budget : risk – impact mapping

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Bioprocess Pilot Facility at Delft Biotech Campus N

operational since mid 2012, while being renovated (www.bpf.eu)

Bioprocess Pilot Facility at Delft Biotech Campus N

operational since 2012, renovation complete 2014 (www.bpf.eu)

- SCOPE / UNEP / UNESCO
- 137 authors from 24 countries of 82 institutes, peer reviewed, 800 p
- BE-Basic: 9* of 21 chapters
- Launches 2015: Sao Paulo (FAPESP), Nairobi (UN), W'ton DC (Worldbank), Brussels (EU)

Revisited Report
RAP – SCOPE 2016-2017
To be presented at BBEST 2017

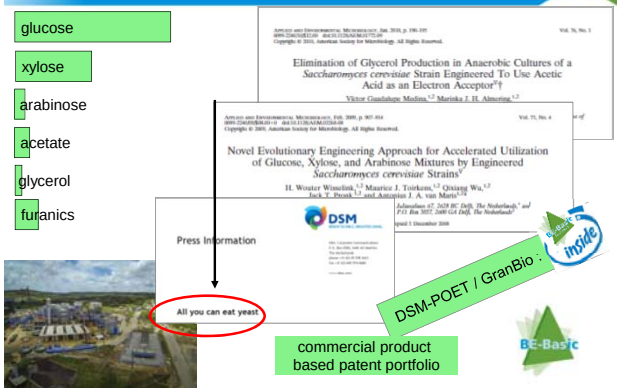
…stainable '*bioenergy*' **can** improve security …y, income & food, environment and climate by

improved agricultural management, balanced residue use while maintaining soil quality/carbon accumulation, biodiversity replacing traditional (solid) biomass use by modern (liquid & gas, chemicals & materials), and applying cascading principles

Download: http://bioenfapesp.org/scopebioenergy/index.php

BE-Basic 10 years

Synthetic Biology in the real world?



Successful SME's in BE-Basic (Q1 2013)

TUD-spin-out discovered FDCA-technology for sustainable PET-replacement ('09), developed in BE-Basic ('10-'11) for further commercialisation in Purac (mar'13)

Corbion purac

WUR-starter pioneer in chemicals from waste streams, closes series A investment with Horizon3 and DGF* (5 apr 2013)

WasteToChemicals

TUD starter (oct'12) with BPF, TUD, VC develops advanced biorenewables processes

BPF

… and more to come !

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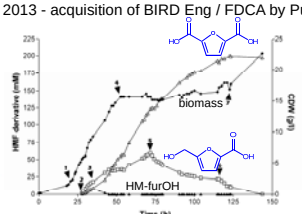
The other 70% : FDCA for "Bio*PEF*"

- Top-12 value-added chemicals from biomass
- Platform chemical - market size 4-12 bn $/yr
- Replace terephthalate in 15 mio ton polymers
- Concept in B-Basic (TUD/TNO - '09) – FDCA direct production from lignocellulosic HMF
- indust biocat (BIRD Eng /TUD-'09) – bioprocess (BIRD –'10) – invest round - piloting (BE-Basic-'11)
- 2013 - acquisition of BIRD Eng / FDCA by Purac

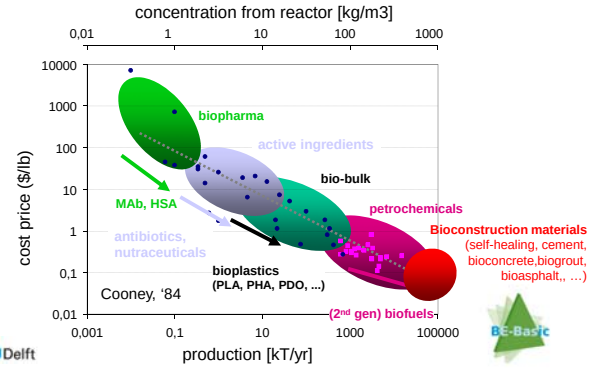


TUDelft purac BIRD

plantbottle

Coca-Cola

trends in biobased production



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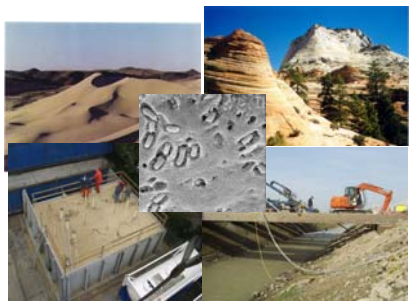
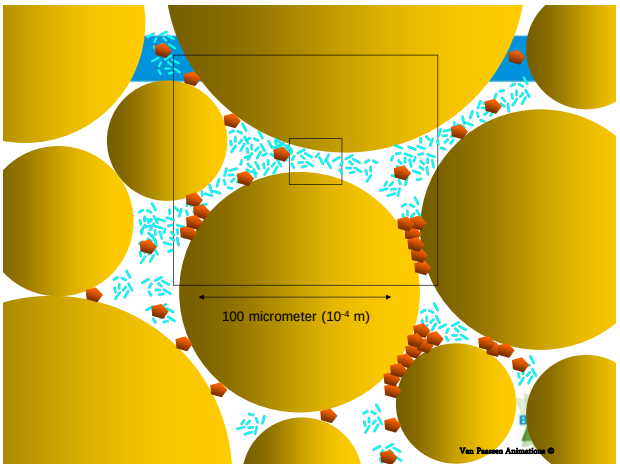
Biogrout & bioconcrete: from soft soil to rock solid

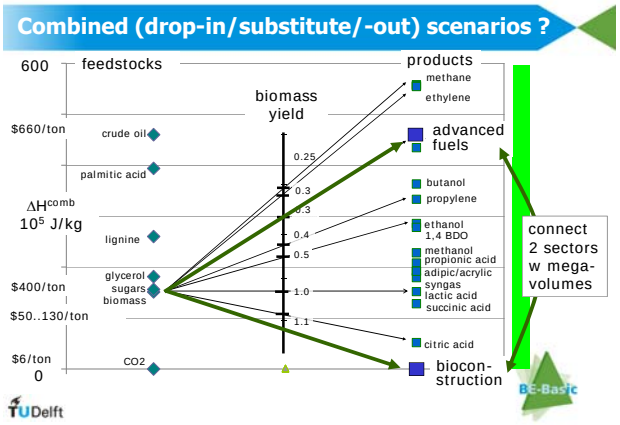


In-situ concrete by carbonate fixation

TUDelft Deltares

BE-Basic


100 micrometer (10-4 m)
Van Passen Animations ©


Combined (drop-in/substitute/-out) scenarios ?
600
feedstocks
products
biomass yield
$660/ton
crude oil
palmitic acid
ΔHcomb
10^5 J/kg
lignine
glycerol
sugars
biomass
$400/ton
$50..130/ton
$6/ton
0
CO2
0.25
0.3
0.3
0.4
0.5
1.0
1.1
methane
ethylene
advanced fuels
butanol
propylene
ethanol 1,4 BDO
methanol
propionic acid
adipic/acrylic
syngas
lactic acid
succinic acid
citric acid
biocon-struction
connect 2 sectors w mega-volumes
TUDelft
BE-Basic