



IC Bioenergy & Biochemistry 18 nov 2011 (v2)

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Ad Schoof (ELI),



innovation contract describes

- opportunities** for companies, ppp/R&D organisations & society (5 year horizon)
Industrial and societal innovation **demand** (5 year horizon)
relation to **milestones** BBE 2.0 (p.20)
- offer:** R&D&I agenda
connection for large industry / MKB / region / EU
- (financial) **instruments**
existing programs: fundamental / ppp / national (piloting) facilities
commitments
- Human Capital Agenda:** education, training, job market
- Process – deadline** 15 december



contents

1 opportunities

demand - industry (5 year horizon)

2 offer: R&D&I agenda in 3 boxes

(fundamental / precompetitive / competitive)

3 Instruments & commitments

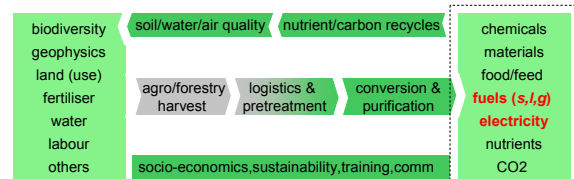
4 Human Capital Agenda: education, training, job market

5 Process – deadline 15 december



Biorenewables: economic sectors, climate, biodiversity, income

structured around *integral biomass value / sustainability*



- Bio-energy as key ingredient of optimised (economic/climate/...) portfolio → Techno/societal roadmap & macro-econ impact
- Sustainability is "license to operate"
- Need to connect players along value chain

WP Bioenergy & Biochemicals



portfolio of biobased products

ton biomass*	added € /ton biomass (eq)*	science & techn. fields
cellulose	chemicals 250 - 1000	agro-forestry (A&F)
lignin	materials 100 - 250	biorefinery (C,E)
	feed/food 100 - 250	thermal conversion (E)
protein	fuels 100 - 250	chem/cat conversion (C,E)
	power 50 - 100	indus/env. biotech (C,E,A)
nutrients	heat 50 - 100	process eng. (C,E)
	fertiliser 5 - 20	feed/food (A, E)
services ??		chem's/materials (C, E)
		fuel efficiency (E,M)
		power & heat (E)
		socio-econ./ecologies** (all)
		now € 130-180 mio/yr
		(50 % gov, 25 % private)

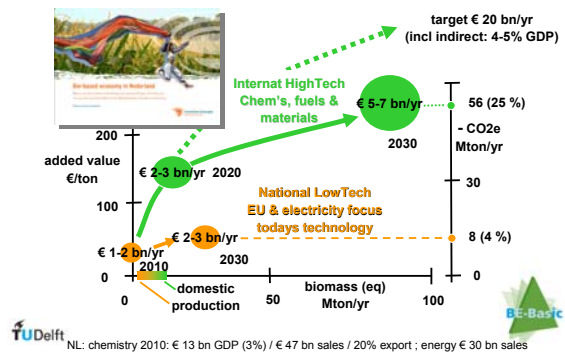
*eq: domestic, imports, derivatives (estim, Mck)

(advanced) liquid fuels
biogas / simple fuels
solid fuels (pellets 1.0 > 2.0)

10X larger volume



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



Bioenergie binnen de Biobased Economy

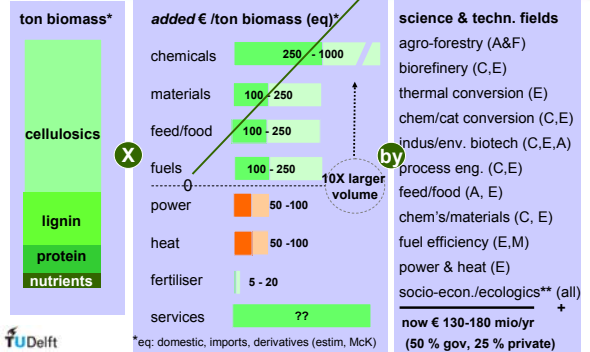
- Bioenergie = Electriciteit, Warmte, transportbrandstoffen, groen gas
- Bioenergie speelt een sleutelrol:
 - Aanjager / mobilisator van biomassastromen
 - Integraal onderdeel van biocascadering en bioraffinageconcepten
 - Parallele inzet (energiesector tenminste orde groter dan chemie-sector)
- Met opkomst hoogwaardiger toepassingen (eerst transportbrandstoffen, later chemie en fijnchemie) voor E&W verschuiving naar laagwaardiger biomassastromen en bioraffinage-reststromen
- Aan de bron biomassa opwerken tot energie-dichte bioenergiedragers (commodity grondstoffen), die zich goed voegen in bestaande logistieke systemen en conversie processen (naast lokale inzet van vooral natte stromen); hiermee ontkoppeling biomassa aanbod en inzet in plaats, tijd en schaalgrootte
- ECHTER: aantal vormen zijn op dit moment (olie/gas/kolenprijs) NIET economisch rendabel > ontwikkeling cascadering en bioraffinage is noodzaak om tot economisch rendabele systemen te komen.

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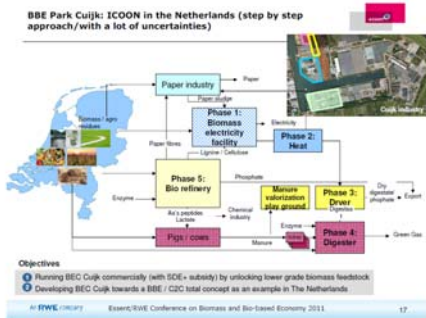
S&T for higher added value portfolio

(advanced) liquid fuels
biogas / simple fuels
solid fuels (pellets 1.0 > 2.0)



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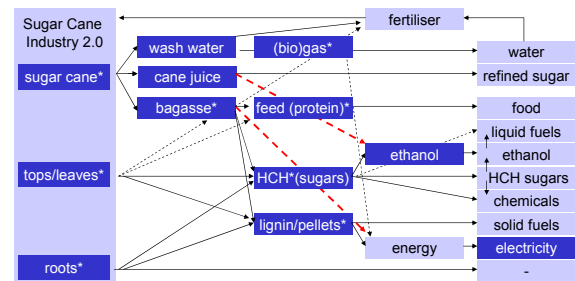
Power sector targets a higher added value portfolio



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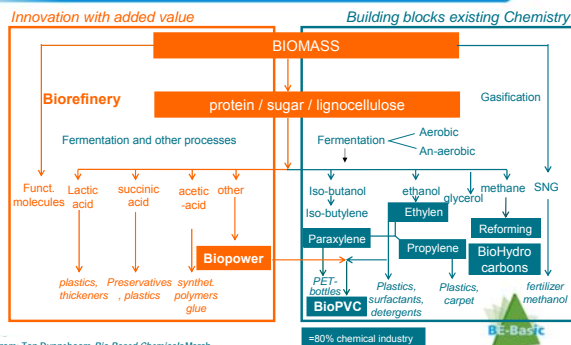
prepare for future biomass commodity platforms* and market structuring (example for sugar cane)



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"Drop-in Greenification" of Chemical Industry



From: Ton Runneboom Bio Based Chemicals March 22 2011; Rotterdam



**Global (non)food sustainability is integral element

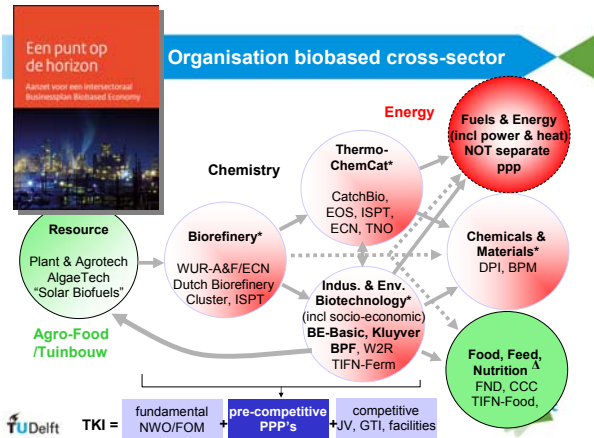


- Bioenergy/biorenewables can contribute to food / feed sustainability (Polman, 11/11)
- integral approach can restore natural balance
- international dimension critical to deliver economic and climate impacts

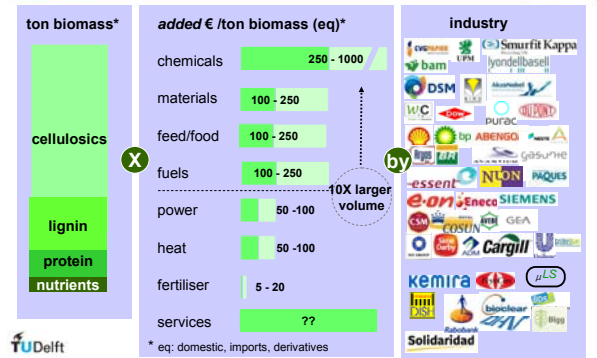
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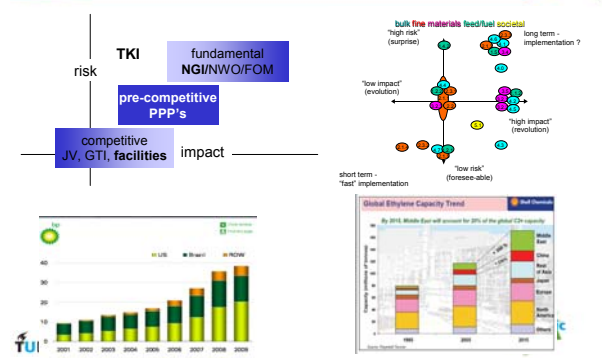
- 1 **opportunities /demand / industry** (5 year horizon)
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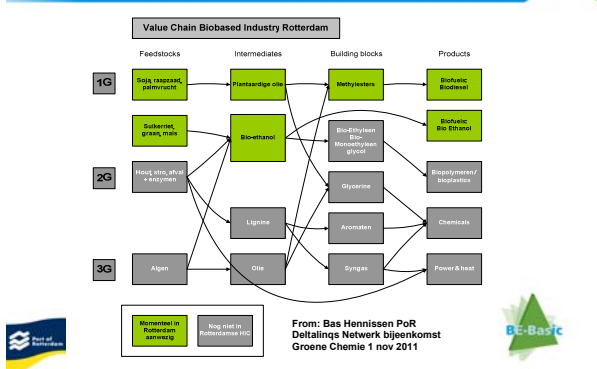
1 demand side: industries



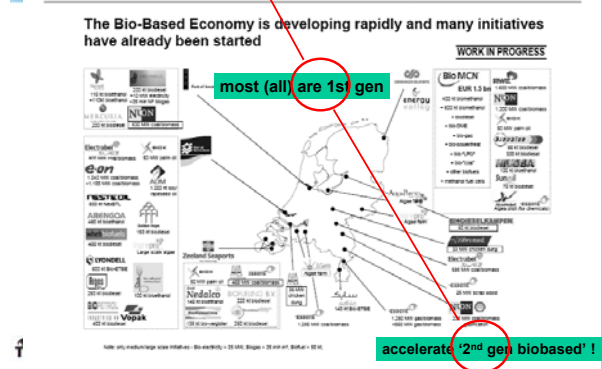
Balanced R&D&I portfolio development (in view of global / national developments)



BioPort Industry Complex



Private investments > 5-10 billion €





1 Industry demand: high level business cases (RCI Green Chemistry Workshop, nov 1'11, WPC R'dam)

1	Integrate Energy and Chemistry	Pellets 2.0, HCH, EtOH/MeOH-feedstock
2	CO2 as a feedstock	e-HCOOH, aliphatic-C
3	Agro-food-feed residues as feedstock	Proteins/nutrients from soy-residue, ethanol from DDGS, ...
4	Byproducts biofuels as feedstock	Glycerol, biopropane, free FA,
5	Advanced biofuels	BioJet, 2nd gen biodiesel, ...
6	Drop-in biochemicals	Bio-PET, Bioethene, bioPVC, ...
7	Advanced bioplastics	Bio-PEF, PHA, ...
8	Bioconstruction materials	BiogROUT & biocement
9	(Unconventional) Biogas	High-pressure
10	Waste-to-wealth	W2C, FA platform, PHA, Paques

1.1 Integrate energy and chemistry (vb)

Inventarisatie 2011:

- 1.000.000 ton beschikbaar aan houtige biomassa
- verwachte groei naar 7.000.000 ton in 2020

Relevante business cases

- Case 1 Ligno cellulose>bio-ethanol>bio-ethene
- Case 2 Houtvezels voor productie bioplastics
- Case 3 Pyrolyse voor bio-oliën



present at 1 nov workshop WPC Rotterdam

Cluster 1: Energie & chemie uit vaste biomassa

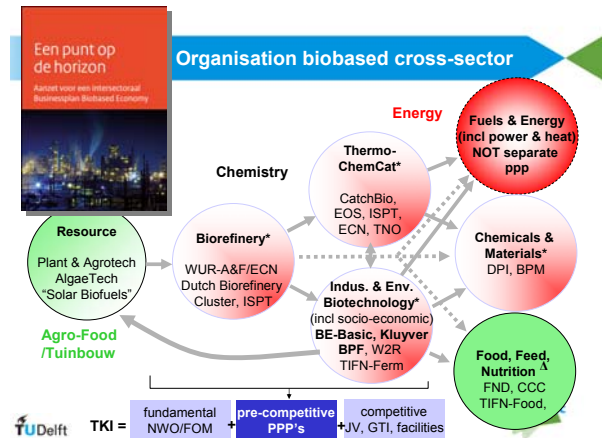
Huidige situatie in de Rotterdamse haven is al zo'n 3.000.000 ton beschikbaar aan houtige biomassa (papier, hout en reststof). Deze markt zal naar verwachting een flinke groei kunnen laten zien. De restmaterialen aan vaste biomassa dienen als bijproduct voor de opwekking van elektriciteit in energiecentrales. Door bijstook direct toe te passen, worden in de huidige biomassa reststof ook gewonnen.

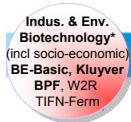
Isoleren: De papierindustrie maakt al gebruik van zeel, maar ook in de chemie is deze groene grondstof interessant, als filler in de productie van bioplastics.

Case 3 Pyrolyse voor bio-oliën: Pyrolyse technieken zijn beschikbaar op pilot en commerciële schaal, waarbij uit vaste biomassa zogenaamd bio-olie wordt gewonnen, met een opbrengst van 80%. Pyrolyse is een vergasingsmethode van het hout, zonder zuurstof. Deze gassen worden dan weer gecondenseerd tot vloeistof, bio-olie. De nevenproducten van deze techniek zijn coke en ras. Bio-oliën worden gebruikt als vervanger van fossiele brandstof.

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broad bio-sciences basis



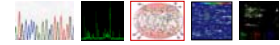
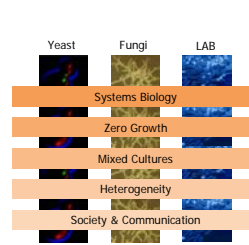
BE-Basic and KCG (NG) develop and test sustainable industrial and environmental biotechnology solutions for the chemical (€60 bn*), construction (€45bn*), energy (€30 bn*), food (€40 bn*) -industries and as well as for monitoring, controlling and improving the environment (€10 bn*) and quality of life - all at the same genomics basis.

BE-Basic and KCG are public-private partnerships of 35 (inter)national companies, universities and institutes.

E-Basic: BE-Basic and KCG will merge to **1-stop-shop from pot →pilot → plant** with european-level ambitions



Fundamental box (Kluwyer Center): genomics & synthetic biology for industrial biotechnology



- expand feedstock range
e.g. *agricultural residues*
- expand product range
e.g. *monomers, pharmaceuticals*
- increase robustness
e.g. *product tolerance*
- increase yield and productivity
e.g. *reduce biomass formation*
- improve product quality
e.g. *nutraceuticals, flavours*



Highlights KCG projects 2008-2011

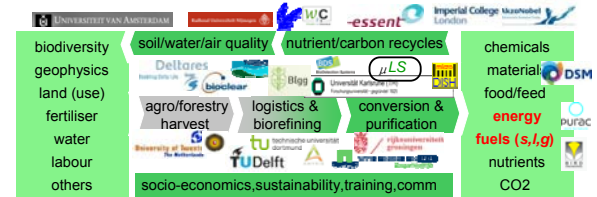


- Novel quantitative metabolomics approaches for industrial micro-organisms based on ¹³C-labeling
- Breakthroughs in 2nd generation bioethanol production (fermentation of mixed substrates, elimination of glycerol as bioproduct)
- Laboratory evolution of plant isolates of lactic acid bacteria leading to 'dairy strain' characteristics analysed at the genome level
- Unlocking the genomes of important filamentous fungi (*Aspergillus niger*, *Penicillium chrysogenum*, *Schizophyllum commune*)
- Novel strategy for selection of high-yielding microbial mutants
- Active role in globe-spanning initiatives on societal impact of large-scale implementation of biofuels

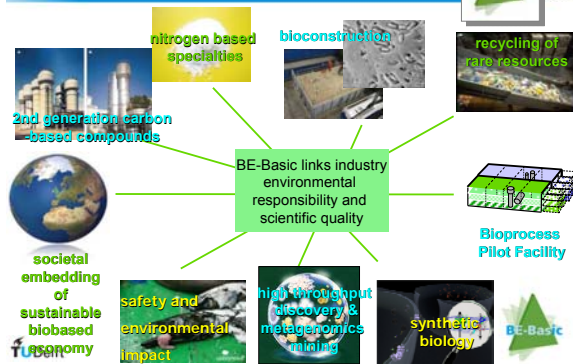


BE-Basic - partners and affiliates

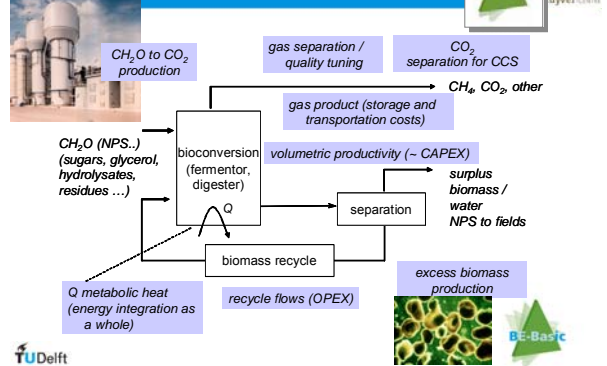
structured around integral biomass value / sustainability



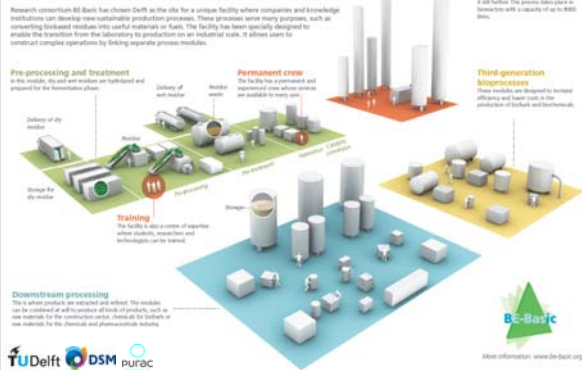
(Applied) PPS-Box : "BE-Basic" - broad life sciences basis for industrial/enviro biotech



Low cost, integrated bioconversion technology



Delft pilot facility for innovations in sustainable bioprocesses



2 Thermal-chemical-catalysis

- CatchBio



Bioenergie – ‘thermische’ onderzoeksthema's

- Biomassa opwerking (upgrading) tot vaste/vloeibare bioenergiedragers
 - Droge/natte torrefactie (Pellet 2.0)
 - Pyrolyse
- Transportbrandstoffen via biochemische (fermentatie) en thermochemische (vergassing) routes
- Groen gas via vergisting en vergassing
- Stand-alone E&W productie
 - Verbreden biomassa-benuttingsvenster bestaande technologie
 - Specifieke technologie voor specifieke biomassastromen
- Biomassa mee-/bijstook
 - Mee/bijstook in hoge percentages (>50%) in nieuwe eenheden
 - Inzet laagwaardiger biomassastromen en bioraffinage-reststromen
- Systeemintegratie: bioenergie als integraal onderdeel van bioraffinageconcepten



2 Process engineering / biorefinery

- See "Integrated biorefinery" / IC Chemie / Procestechnologie
- Interface of Biotech/Catalysis /Process engineering – joint projects and facilities (Plant One, BPF, AlgaeParc etc)



3 Finances and instruments

- ...



4 Human capital agenda

- See "Maatschappelijke aspecten BBE 2.0" / P Osseweijer cs
Annex 1. Summary "Education Development for a Bio-Based Economy"



Simplified overview of subjects that together form the bio-based economy (copyright by J. Tromper & J.M. van Baten)

innovation contract describes

- opportunities** for companies, ppp/R&D organisations & society (5 year horizon)
Industrial and societal innovation **demand** (5 year horizon)
relation to **milestones** BBE 2.0 (p.20)
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next steps for bioenergy & biochemicals

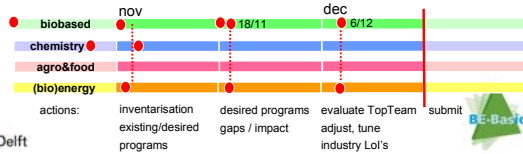
- **targets:** + € 2 → 7 (→20?) bn extra (in)direct GDP and jobs (MES*)
- 8 → - 56 Mton CO2e emission reduction
 - integral picture: chemistry & energy & materials & foods x
 - international critical: resource, market, science & technology
- ✓ **Inventory existing** fundamental / applied/piloting R&D programs
specific 'bio-energy' ~ 30-40% of € 392 mio gov / 742 mio programs
 - ✓ **Inventory desired** programs ("energy & chem ind" 16/11; 'biobased' industry ws 18/11)
 - ✓ **Fundamental** in NWO/FOM and ppp's (e.g. genomics, synth biology, ...)
 - ✓ **Precompetitive** in relevant ppp's (see back-up slides), institutes, pilot* facilities
in key technologies (process, catalytic, biotech, materials, ...) and societal fields
 - ✓ **Competitive** in institutes, joint ventures & pilot facilities (BPF, Plant One, ...) etc
 - **Funding gap** for urgent area's (see "Punt op de Horizon")
 - Synthesize in **Integral "biobased" plan**
 - **Evaluate** by relevant Topteams
 - private commitments (LoI's) and **submit IC Bioenergy** mid dec'11

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* MES macro-economic/ecological study to separate fact / fiction

team & timing – align to "biobased"

- Luuk van der Wielen (TUD, BE-Basic)
 - Bert Weckhuysen (UU, CatchBio)
 - Jaap Kiel (ECN)
 - Hans Gosselink (Shell, CatchBio)
 - ... (secretariat)
- RCI /Deltalinqs/HbR Werkgroep Groene Chemie (George Brouwer cs)
 - Mees Hartvelt (ex-v Gelder, Biobased-lead)
 - Herman van Wechem (ex-Shell, regiegroep Chemie, ppp-chair)
 - Jaques Joosten (materials), Tjeerd Jongsma (process technology), ...
 - Patricia Osseweijer (TUD), Hans van Meijl (LEI) - socio-economics/sustainability



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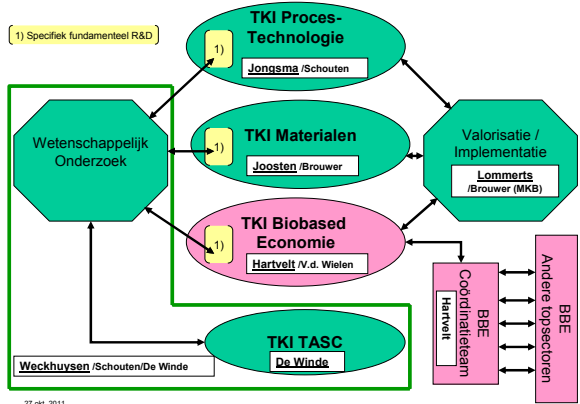
Appendices

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Innovatietafels chemie

(1) Specifiek fundamenteel R&D



27 okt 2011

Bioenergy: Topsector Energy targets & programs (→)

● → ●	20% GHG (CO2e) reduction	agree on count method
● → ●	14% renewable energy	agree on count method
● → ●	utilisation energy efficiency potential	fossil → renewables
● → ●	competitive energy pricing	form / portfolio dependence
● → ●	strengthen leading commercial position	area/sector dependent
● → ●	improve competitive of sustainable energy	criteria ?
● ●	logistic position	Port of R'dam, A'dam, Gron
● → ●	resource position	
● ●	scientific / technology position	Leading ppp-'s
● → ●	return on investment	International investment

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1.1 Integrate energy and chemistry

Inventarisatie 2011:

- 1.000.000 ton beschikbaar aan houtige biomassa
- verwachte groei naar 7.000.000 ton in 2020

Relevante business cases

- Case 1 Ligno cellulose>bio-ethanol>bio-etheen
- Case 2 Houtvezels voor productie bioplastics
- Case 3 Pyrolyse voor bio-oliën



1.2 CO2 as a feedstock

Inventarisatie 2011:

- Commitment 50% CO2 reductie in 2025
- Consortium voor CO2 infrastructuur in Rotterdam
- Productiebedrijven met 100% zuivere CO2

Relevante business cases

- Case 1 Productie van mierenzuur door elektrochemische conversie van CO2
- Case 2 Productie van building blocks met carbonaaffunctionaliteit
- Case 3 Productie van superkritisch CO2



1.3 Agro-food-feed residues as feedstock

Inventarisatie 2011:

- 600.000 ton beschikbaar aan plantaardig restmateriaal uit o.a. de voedingsmiddelenindustrie en agrarische sector.
- Distillers Dried Grains & Solubles (DDGS), biermafval, restmateriaal van tuinders, 'meal' uit crushing van rapzaad, soja en palmoliebonen.

Relevante business cases

- Case 1 Extractie van eiwitten en mineralen
- Case 2: Tweede generatie bio-ethanol uit lignocellulose materiaal



1.4 Byproducts biofuels as feedstock

Inventarisatie 2011:

- Capaciteit biodieselproductie via transesterificatie: 650.000 ton >bijproduct 65.000 ton glycerine als additioneel building block
- Biodiesel uit Nextgen technologie: bijproduct propaan, building block voor propeen.

Relevante business cases

- Case 1 Glycerol Tertiary Butyl Ether (GTBE)
- Case 2 Valorisatie van propaan
- Case 3 Valorisatie van free fatty acids



1.5 Advanced biofuels

Inventarisatie 2011:

- Luchtvaartindustrie kijkt naar duurzame biokerosine.
- Samenstelling moet voldoen aan verbrandingseisen vliegtuigmotoren en aan cold flow properties.

Relevante business cases

- Case 1 Bioparaffinen
- Case 2 V-Biokerosine
- Case 3 Biodiesel uit used cooking oils, dierlijke vetten
- Case 4 Olie uit algen
- Case 5 Cold flow properties
- Case 6 Ethanol uit lignocellulose



1.6 'Drop-in' bioplastics

- Wereldwijde productiecapaciteit bioplastics groeit tot 2015 jaarlijks zeker 20%.
- PET: van 100 miljard flessen in 2010 (50% op basis van PET) naar 200 miljard in 2020.
- Let op ecologische footprint van bioplastics in de keten.

Relevante business cases

- Case 1 Vergroenen van Polyethylene Terephthalate (PET).
- Case 2 Vergroenen van Polyvinylchloride (PVC)
- Case 3 De ontwikkeling van Bioethylene uit Bioethanol



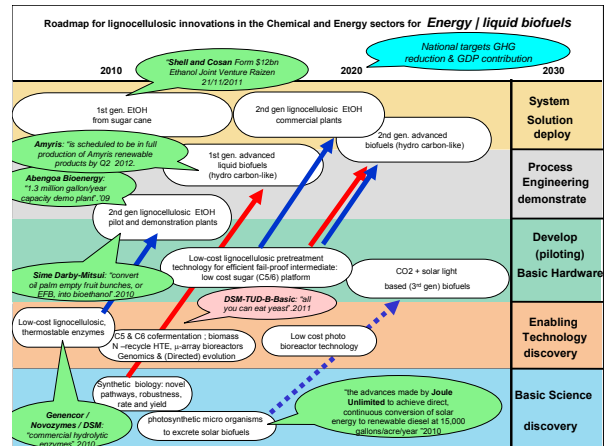
1.7 Advanced bioplastics

- Wereldwijde productiecapaciteit bioplastics groeit tot 2015 jaarlijks zeker 20%.
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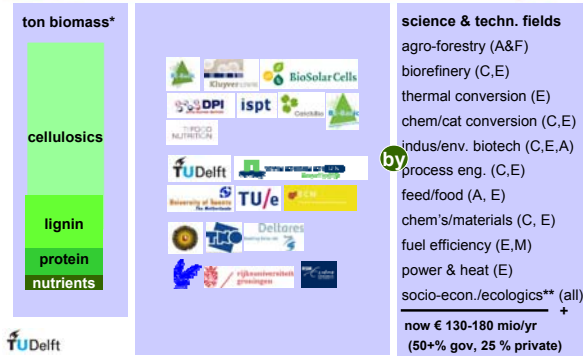
> Case 4 De ontwikkeling van biodegradeerbare polyhydroxy alkanooaten (PHA)

> Case 5 De ontwikkeling van biodegradeerbaar polymelkzuur (PLA)

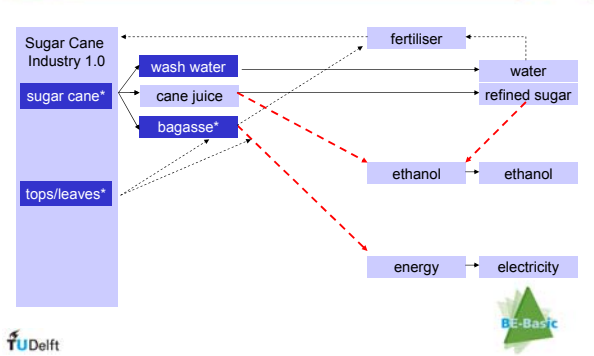
> Case 6 Furanen voor nieuwe generatie groene grondstoffen en brandstoffen, zoals voor groene PEF-flessen.



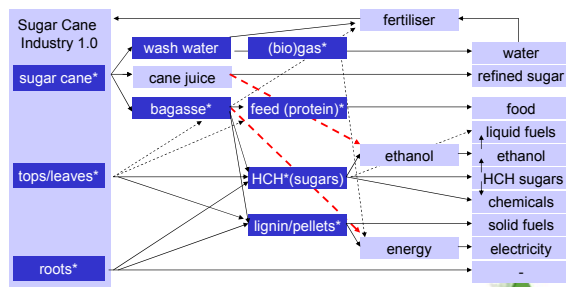
2 Offer: academic and research organisations



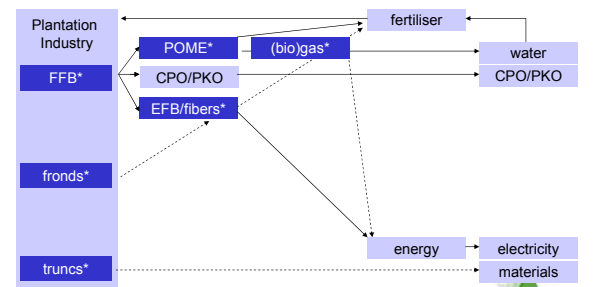
Sugar Cane Industry 1.0



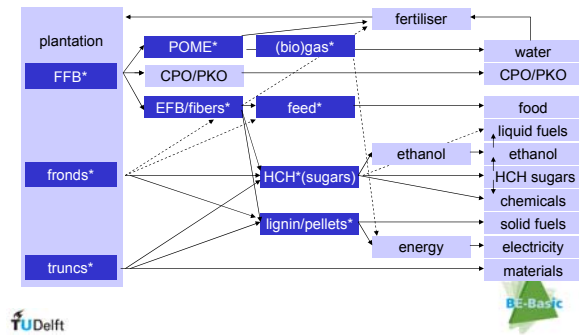
Sugar cane platforms* and economic sectors



Oil palm Industry 1.0



Oil palm platforms* and economic sectors



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BE-Basic

Luuk van der Wielen

- UT Chem Eng, prof. TUD biotechnology
- U San Carlos (Philippines), U Tech Malaysia, UNICAMP (Brazil)
- 2007 sabbatical Principle scientist Biotechnology Shell / Biodomain strategy
- B-Basic (€ 50 mio), BE-Basic (€ 120+ mio), BPF (€ 80mio) – 35% private integral technology development and societal agenda (10%)
- NL: PGG, Macro-Economic/Ecological Impact study BBE NL (2008)
- EU: Steering committee Bio4EU biotechnology cost-impact study
- M'sia: Nat Biomass Strategy (McK), Macro-econ Study (BE-Basic), environmental impact study > Oil Palm Biomass Center,
- Brazil: BIOEN / BE-Basic

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BE-Basic