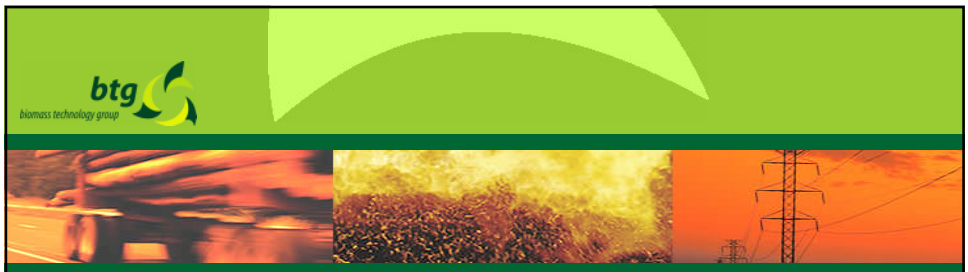


Module 1d

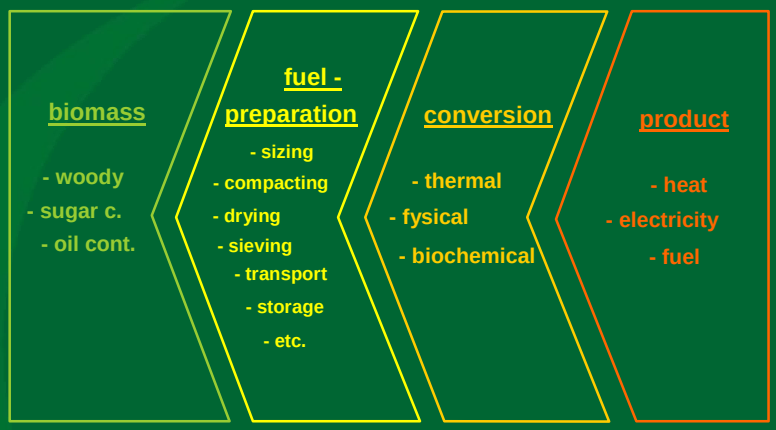
The Bioenergy Chain

Overview presentation

- introduction
- conversion-technologies
  - combustion
  - gasification
  - anaerobe digestion
  - bio transport fuels
- new technologies
  - HTU, supercritical gasification, pyrolysis
  - importance of energy condensed bio-fuels
- concluding remarks

introduction

bio-energy conversion chain



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introduction

bio-energy conversion chain

- **Biomass:** non-fossil material of biological origin
- **Biofuel:** fuel produced directly or indirectlyfrom biomass
- **Bioenergy:** energy derived from biofuels

Biomass resources → *Preparation* → *Biofuels* → *Conversion* → *Bioenergy*

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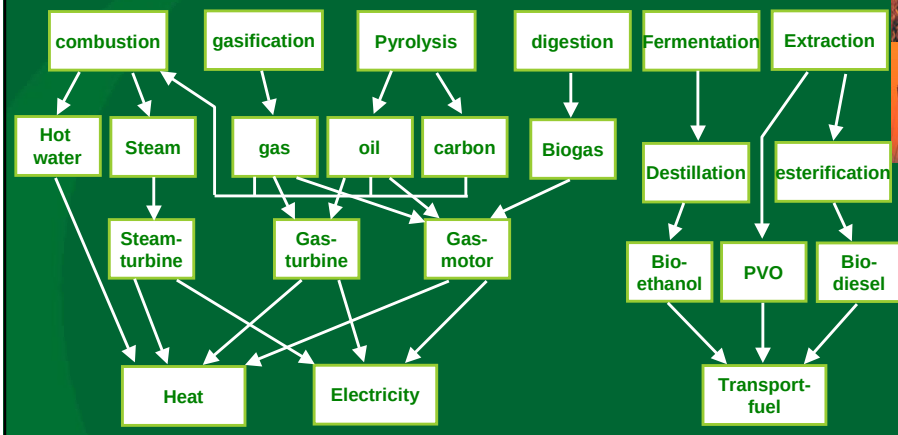
introduction

overview conversion-technologies



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Biofuel value chain

Biomass resources	*Supply systems*	*Conversion*	*End products*
Oil bearing plants Agricultural crops and residues Woody biomass Industrial and municipal waste	Harvesting, collection, handling, and storage	Chemical (transesterification) Physical chemical (extraction) Biochemical (fermentation) Thermochemical (gasification)	Transportation fuels (biodiesel, bioethanol) Solid fuels (wood pellets, charcoal) Heat Electricity High added-value chemicals (pharmaceuticals, polymers)

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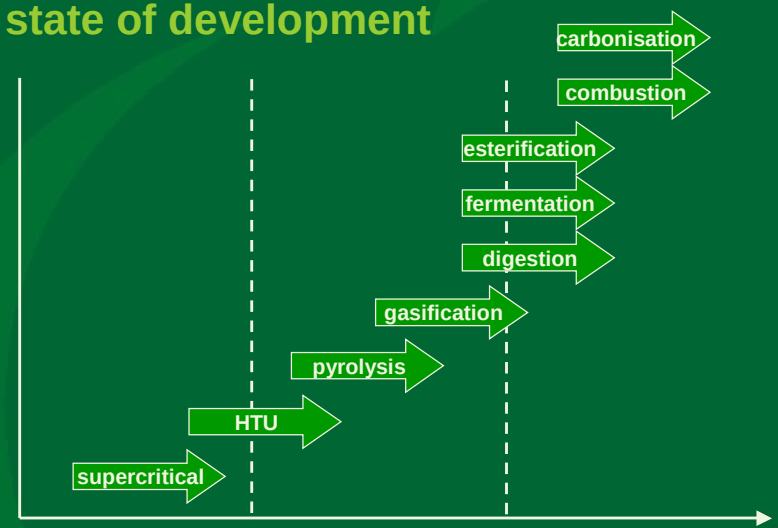
Conversion technologies

state of development



Air factor lambda (λ)

$$\lambda = \frac{actual \cdot amount \cdot of \cdot air(L)}{theoretical \cdot amount \cdot of \cdot air(L_0)}$$

Three options:

$\lambda < 1$ Combustion is incomplete (understoichiometric)

$\lambda = 1$ Combustion is stoichometric

$\lambda > 1$ Combustion with excess air

Pyrolysis, Gasification, Combustion

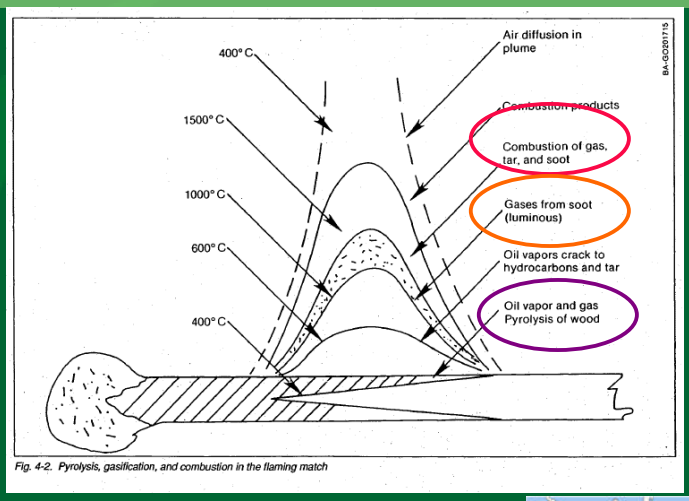


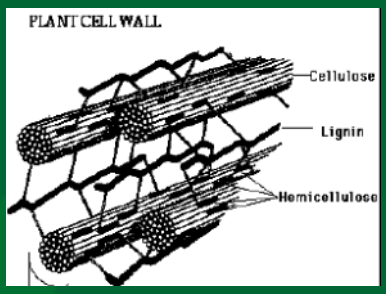
Fig. 4-2. Pyrolysis, gasification, and combustion in the flaming match

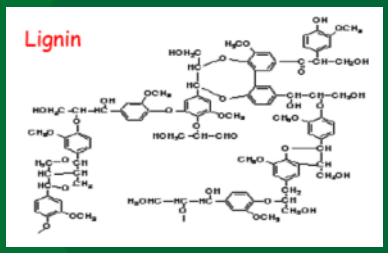
Residence time τ and temperature

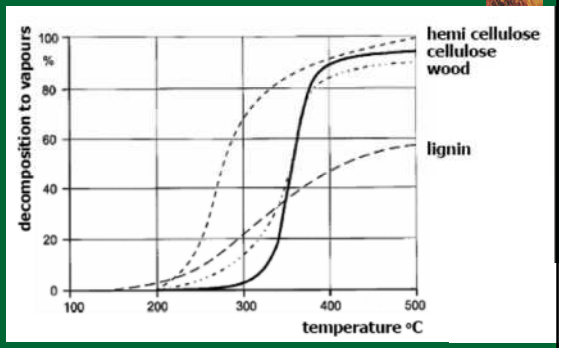
$$\tau = \frac{V_{reactor}[m^3]}{\phi_{v,biomassa}\left[{}^{m^3}/_{s}\right]}[s]$$

Process	Products		
	"Oil"	Char	Gas
„Fast Pyrolysis“ • medium temperature (400 °C - 600 °C) • short residence time (~ 1 s)	75 %	12 %	13 %
„Carbonisation“ • low temperatur (350-450 °C • long residence time (several hours)	30 %	35 %	35 %
„Gasification“ • high temperature (800 °C - 1300 °C) • variable residence time (10 s - 30 min)	5 %	10 %	85 %

Chemical reactions: very complex outside the scope







Overview of Biofuel Production Technologies

First Generation of Biofuels

Biofuel type	Specific name	Feedstock	Conversion Technologies
Pure vegetable oil	Pure plant oil (PPO), Straight vegetable oil (SVO)	Oil crops (e.g. rapeseed, oil palm, soy, canola, jatropha, castor, …)	Cold pressing extraction
Biodiesel	- Biodiesel from energy crops: methyl and ethyl esters of fatty acids	- Oil crops (e.g. rapeseed, oil palm, soy, canola, jatropha, castor, …)	- Cold and warm pressing extraction, purification, and transesterification
	- Biodiesel from waste	- Waste cooking/frying oil	- Hydrogenation
Bioethanol	Conventional bio-ethanol	Sugar beet, sugar cane, grain	Hydrolysis and fermentation
Biogas	Upgraded biogas	Biomass (wet)	Anaerobic digestion
Bio-ETBE		Bioethanol	Chemical Synthesis

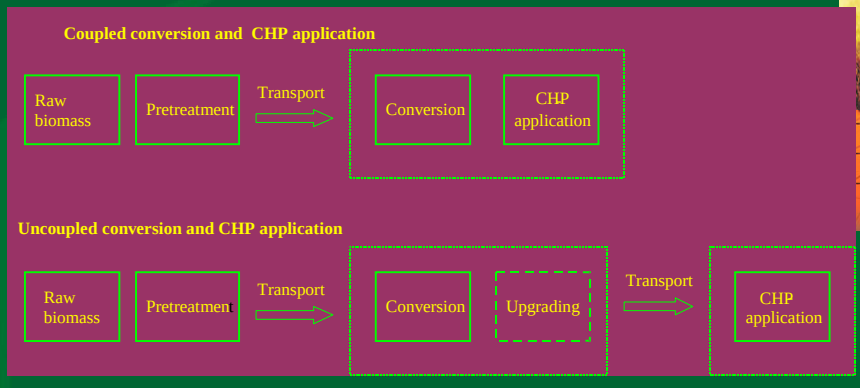
Overview of Biofuel Production Technologies

Second/Third* Generation Biofuels

Biofuel type	Specific name	Feedstock	Conversion Technologies
Bioethanol	Cellulosic bioethanol	Lignocellulosic biomass and biowaste	Advanced hydrolysis & fermentaion
Biogas	SNG (Synthetic Natural Gas)	Lignocellulosic biomass and residues	Pyrolysis/Gasification
Biodiesel	Biomass to Liquid (BTL), Fischer-Tropsch (FT) diesel, synthetic (bio)diesel	Lignocellulosic biomass and residues	Pyrolysis/Gasification & synthesis
Other biofuels	Biomethanol, heavier (mixed) alcohols, biodimethylether (Bio-DME)	Lignocellulosic biomass and residues	Gasification & synthesis
Biohydrogen		Lignocellulosic biomass and biowaste	Gasification & synthesis or biological process

*Use GMO as a feedstock to facilitate hydrolysis / technologies for hydrogen production

De-coupling biomass resources and utilisation



Comparison of technologies
Technology aspects

Biofuel option 2nd generation	Current stage of development: Concept / Lab	Current stage of development: Pilot/ Demo	Techn. Effort[a]	Expected plant capacity[b] [MW_{bf}]	Overall efficiency[c] [%]	Distri-bution[d]	Use[d]
				10.....1,000	0.....80		
Liquid							
Bioethanol	→	→	++			+++	+++
FT-Fuels	→	→	+				
Methanol	→		++				
Gaseous							
Biogas	→	→	++++			+++	+++
Bio-SNG	→	→	+++			+++	+++
Dimethylether	→		++			++	++
Hydrogen	→		++(+)			+	+

Many different concepts for biofuel options of the 2nd generation; associated with appropriate benefits and bottlenecks along the pathway.

[a] regarding system complexity (+ less promising….++++ very promising)
[b] related to biomass feedstock
[c] according state of development (many different concepts) only theoretical values
[d] suitability for current distribution and use (+ less promising….++++ very promising)

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Source: IEE Leipzig, 2007

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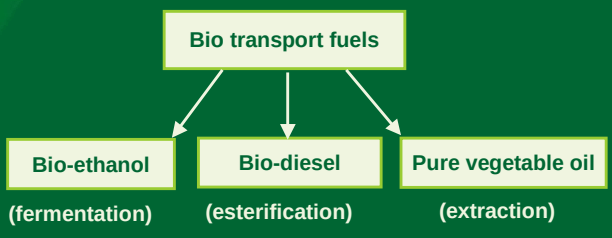
conversion-technologies
bio transport fuels

> Bio transport fuels: group of fluid fuels that can be used as substitute to fossil petrol or diesel.



> EU-guidelines for use of bio-transport fuels
  - 2% in 2006, 5.75% end 2010
  - in NL: ca 150,000 ha required (16% of all agricultural land)

> limitations remain the very high costs of CO_2 reduction per ha and the limited CO_2 saving potential per ha.

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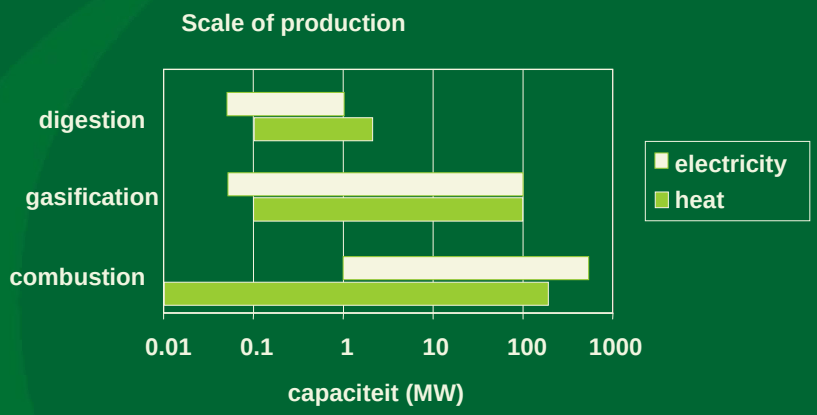
Comparing conversion technologies

scale of production - heat and electricity



technologies

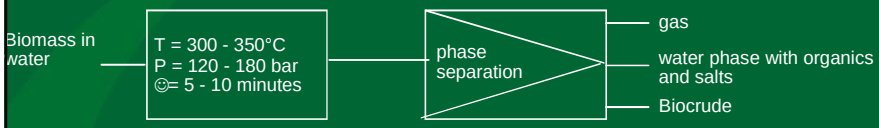
importance of condensed bio-fuels

> energy density (important for transport and storage)

fuel type	cal. value	bulk	energy
chips	12 GJ/t_{30}	0,2 t_{30}/m	2,4 GJ/m^3
pellets	16 GJ/t_{10}	0,6 t_{10}/m^3	9,6 GJ/m^3
charcoal	30 GJ/t	0,3 t/m^3	9,0 GJ/m^3
bio-oil	16 GJ/t	1,2 t/m^3	19,2 GJ/m^3

> scenario studies show an increasing importance of imported bio-fuels causing strong competition versus european energy crops.

Biomass liquifaction



Reactions: oxygen removed as CO_2
formation of hydrophobic oil (10 - 20% O_2), 30 MJ/kg

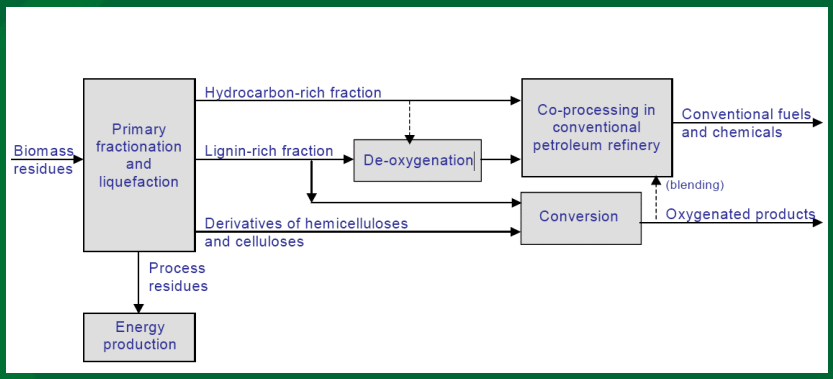
Biocrude to be refined to high value hydrocarbon (blending) stock

Process still in development in the Netherlands (Biofuel and TNO)

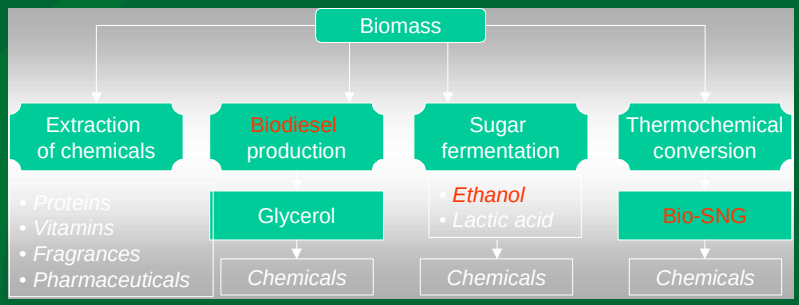
Developments in USA and Japan mothballed

Overall biorefinery concept - a new chemical industry sector

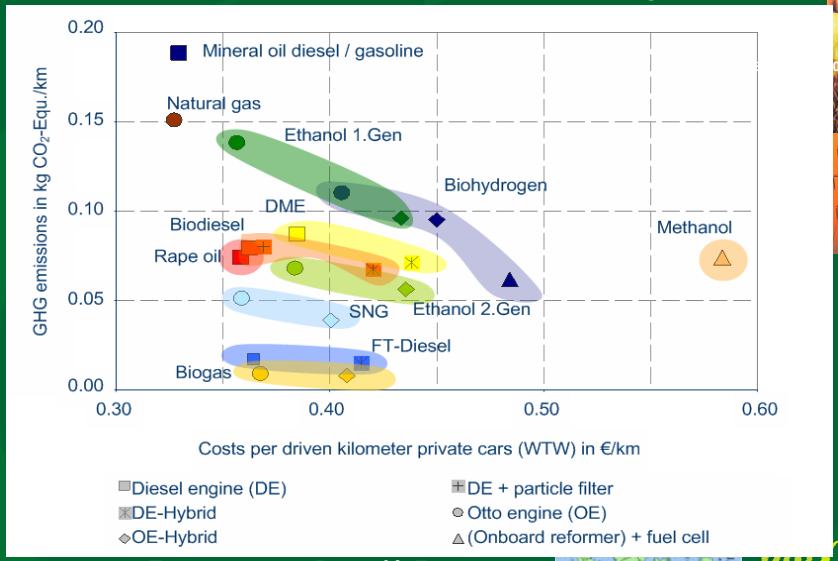
- equivalent to the petrochemistry concept



Biomass to high added value chemicals, an emerging chemistry



Comparison of technologies Economic versus environmental aspects



Concluding remarks - 1

- The new directive on bio-transport fuels has a strong impact on the demand of these fuels and on the development of new technologies.
- Bio-transport fuels will - at first - be produced on basis of available, proven conventional biological conversion technologies (bio-diesel, bio-methanol).
- These technologies are, however, limited due to their limited overall efficiency and high production costs
- Great efforts will be put into the development of second generation bio-transport fuels, based on thermal chemical conversion routes.

Concluding remarks - 2

- Small scale applications of thermo chemical biomass conversion remain remarkably competitive vs large scale applications. This is due to better possibilities for optimised CHP application and more attractive prices, through subsidies.
- Co-digestion of energy crops with manure also remains an attractive financial option for RE generation. However, overall impact on total RE share remains small due to limited size of individual systems.
- Because of new technologies for the production of condensed bio-fuels, the importance of large scale import of bio-fuels is increasing.


THANKS FOR YOUR ATTENTION
TERIMAH KASIH