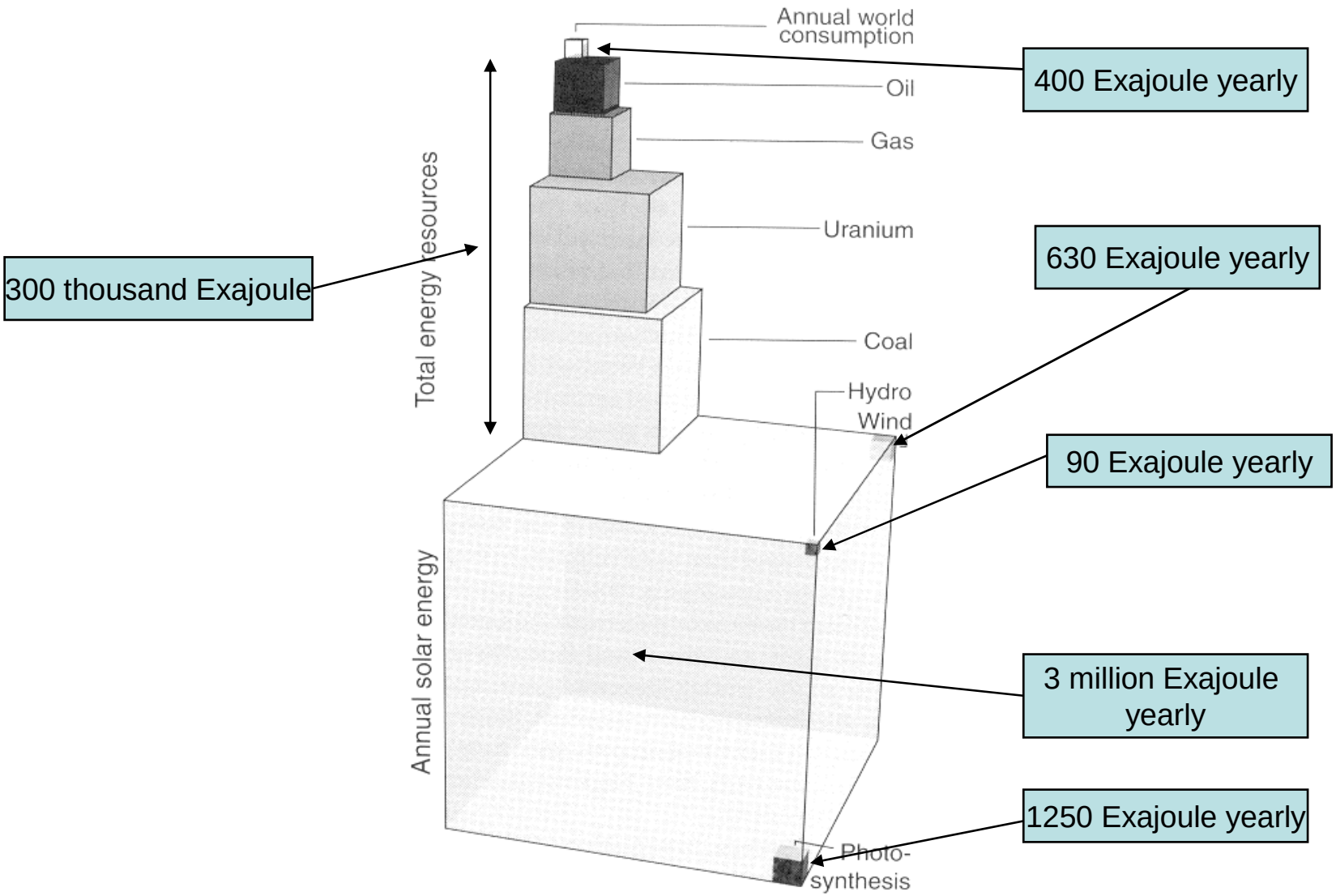
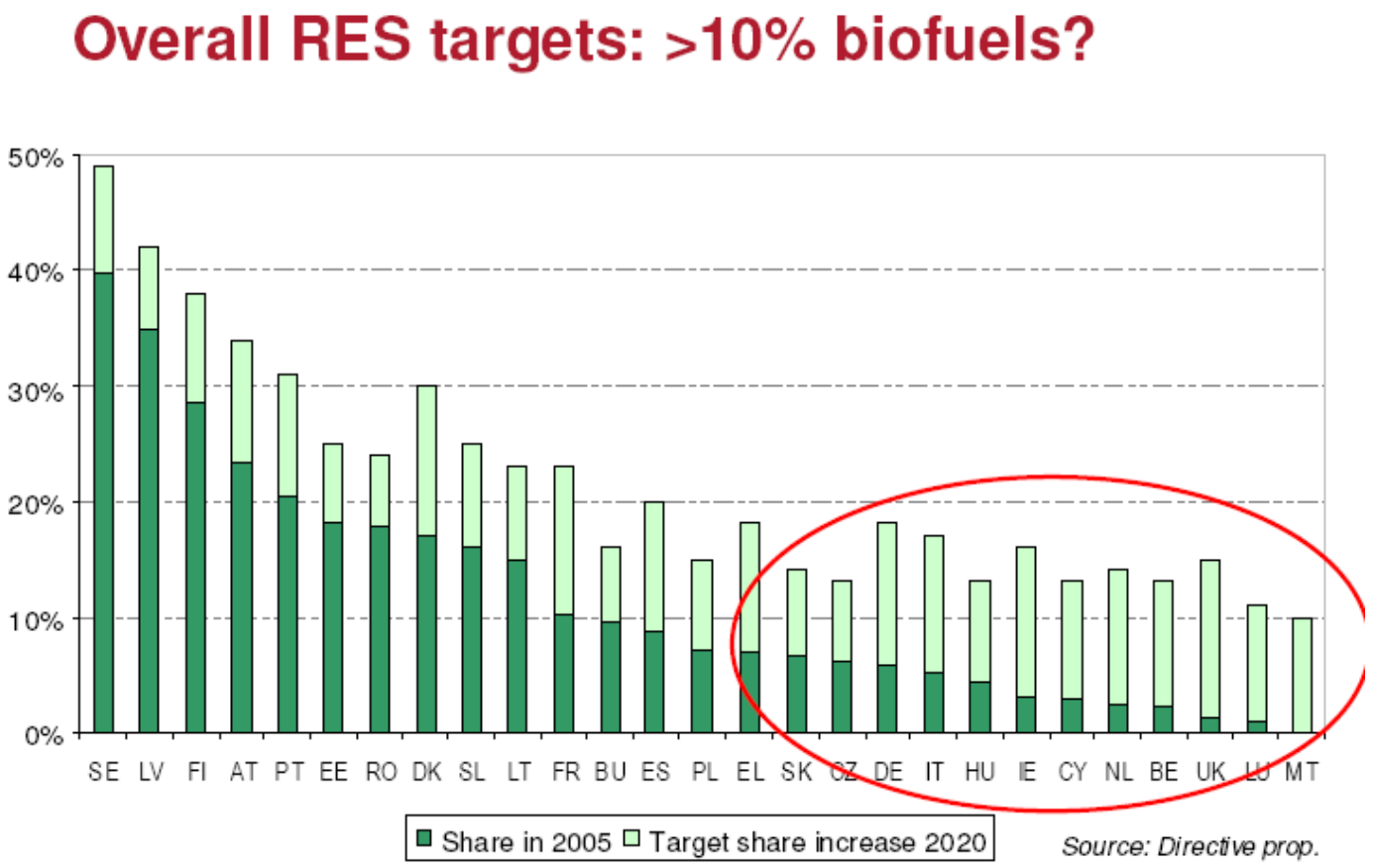
De wereld energie situatie



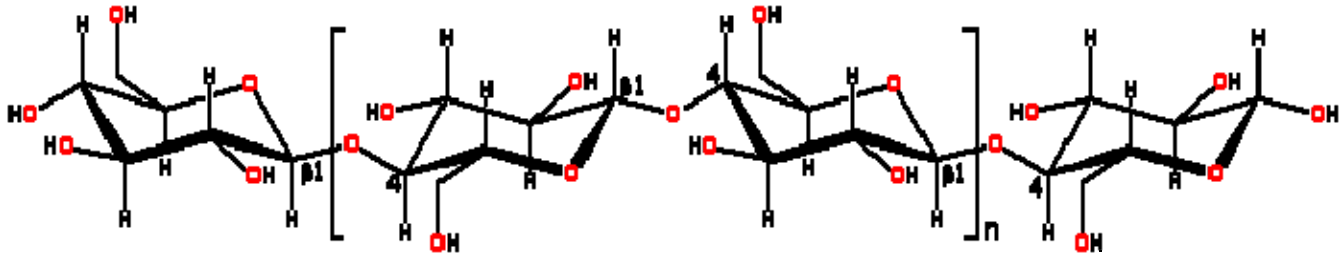
De koolstof kringloop

Doelstellingen

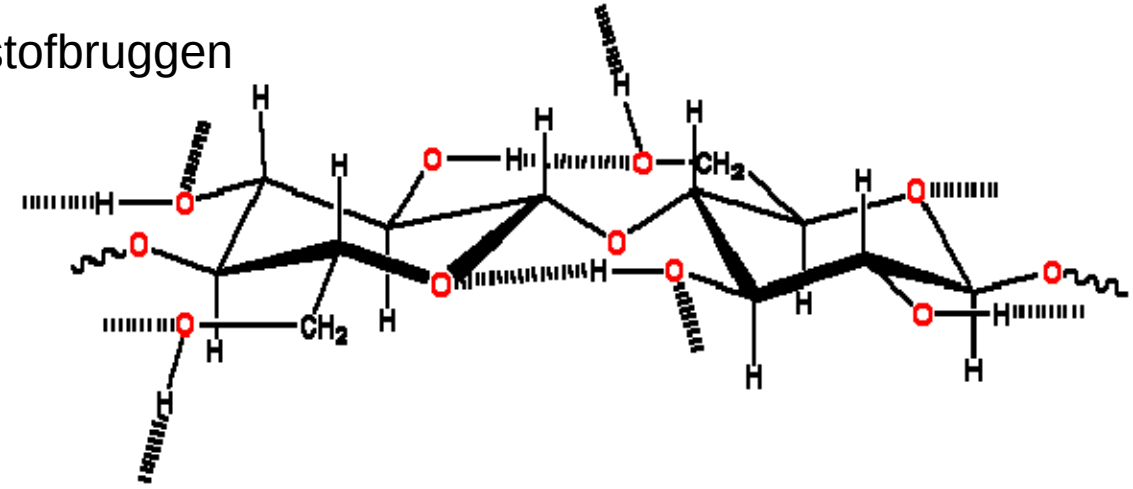


Biomassa structuur 1

Cellulose



Waterstofbruggen

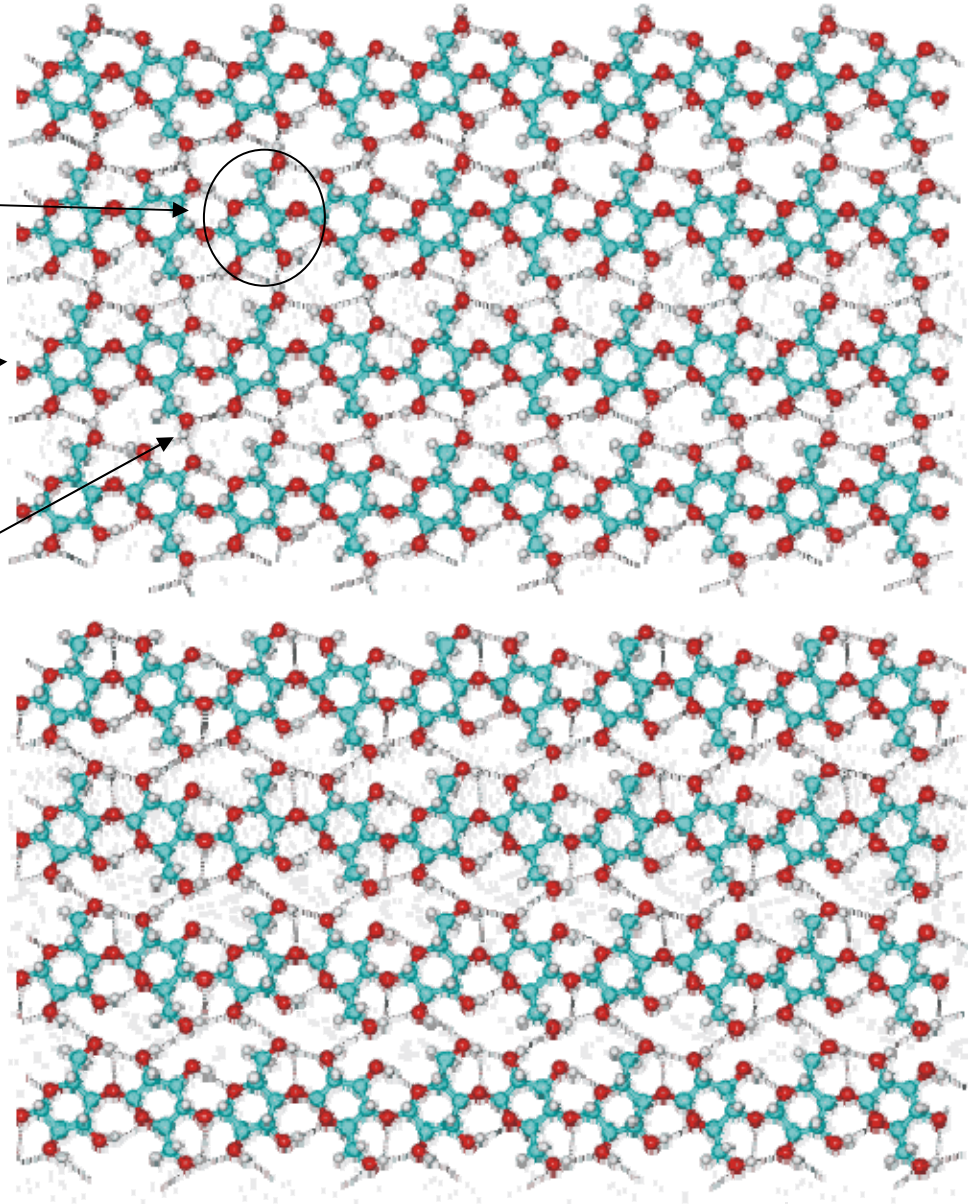


Biomassa structuur 2

Eenheidscel

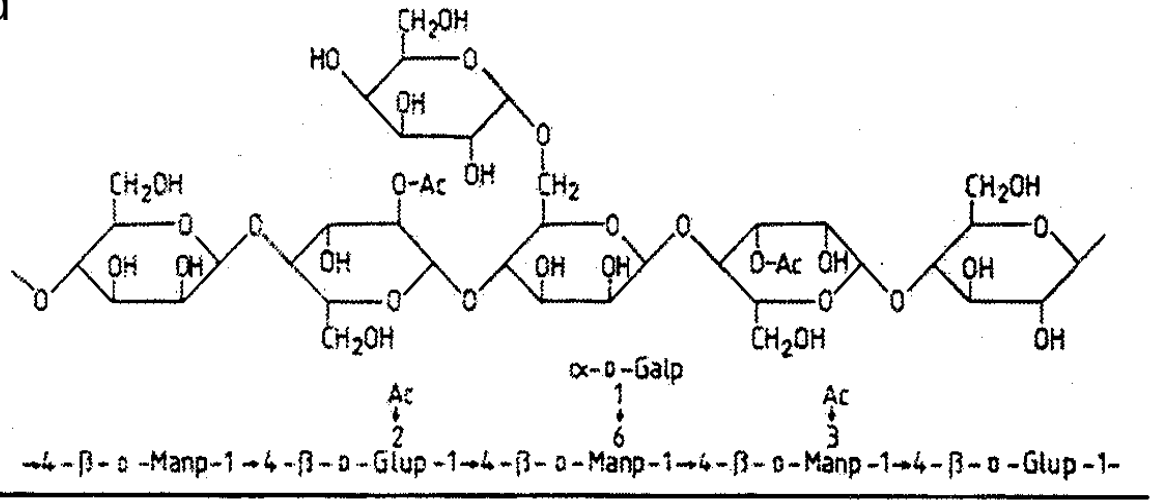
Vezelstructuur van cellulose

Waterstof brug

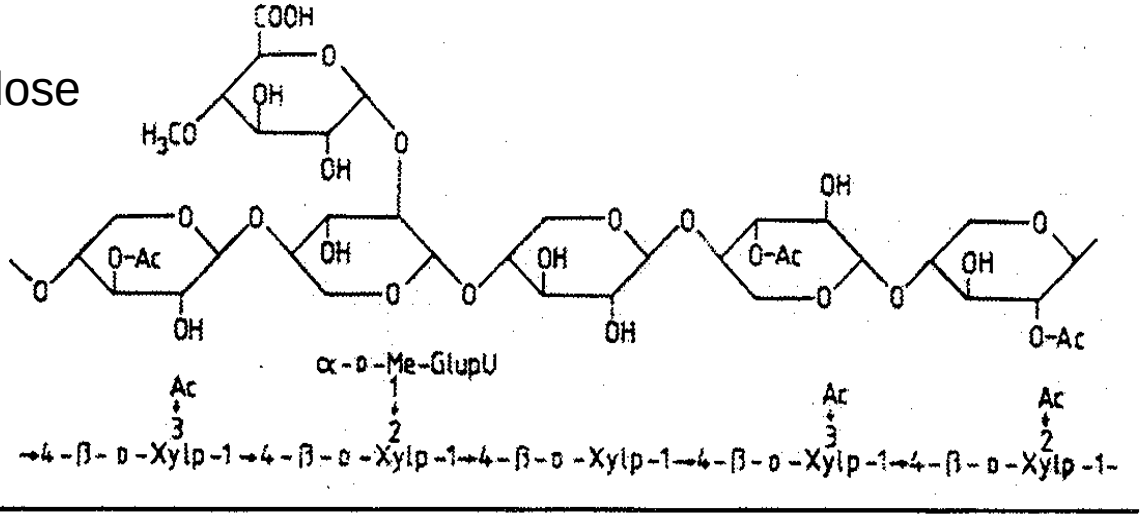


Biomassa structuur 3

Branched cellulose

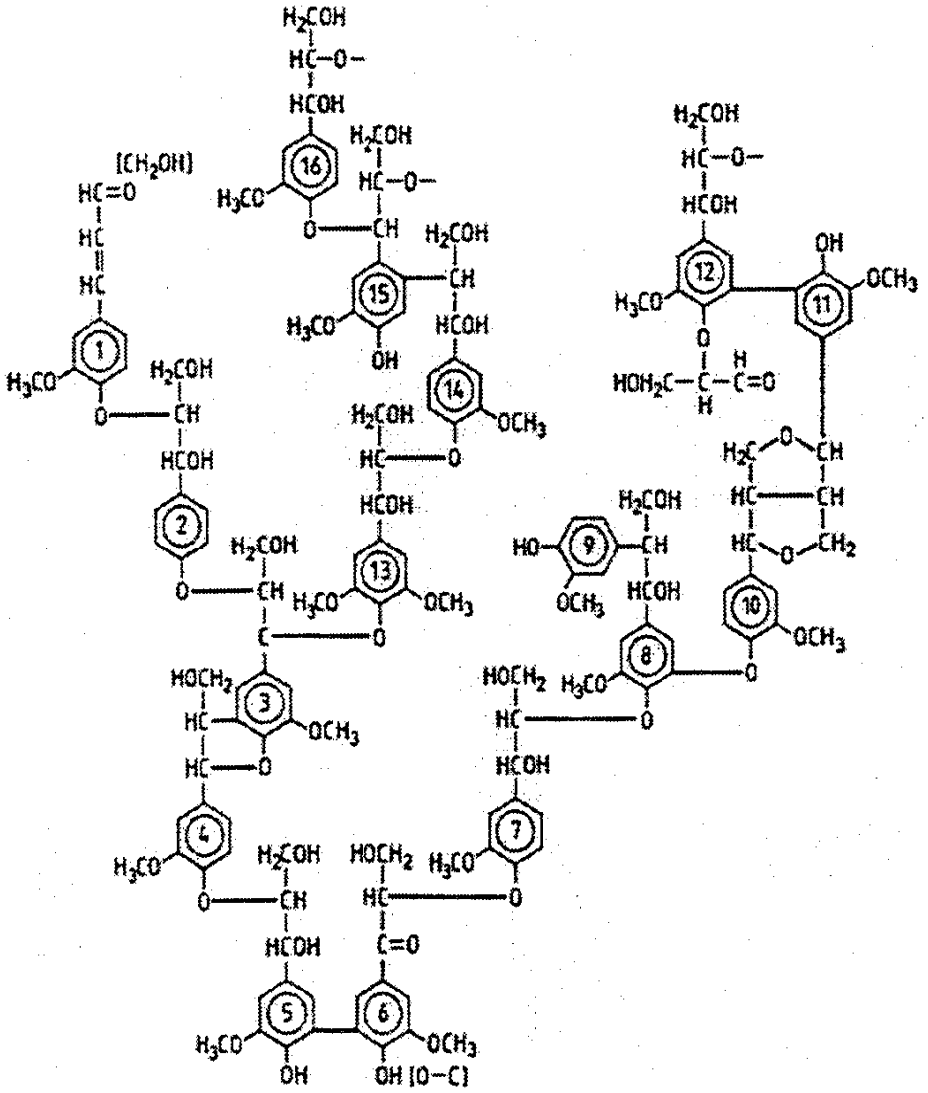


hemicellulose



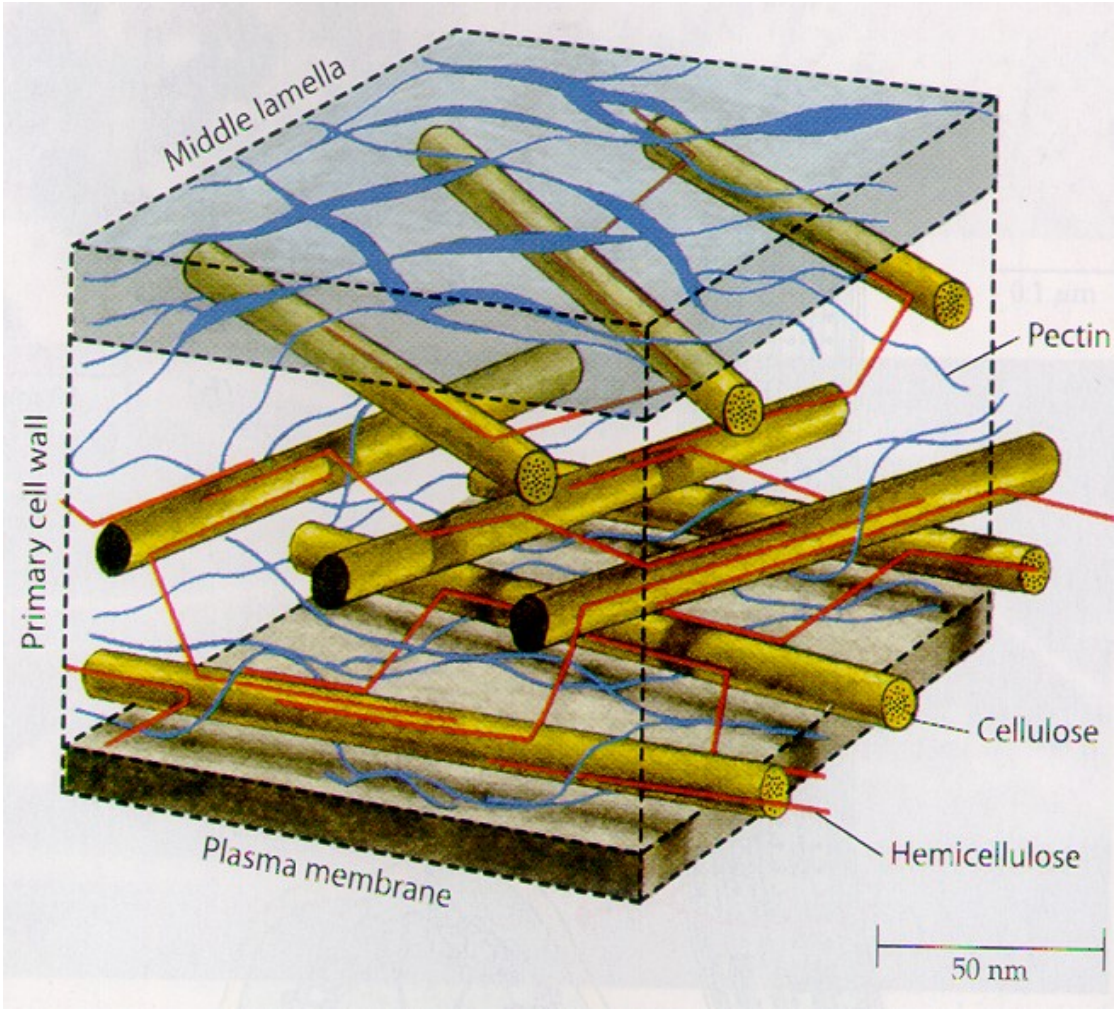
Biomassa structuur 4

Lignine



Biomassa structuur 5

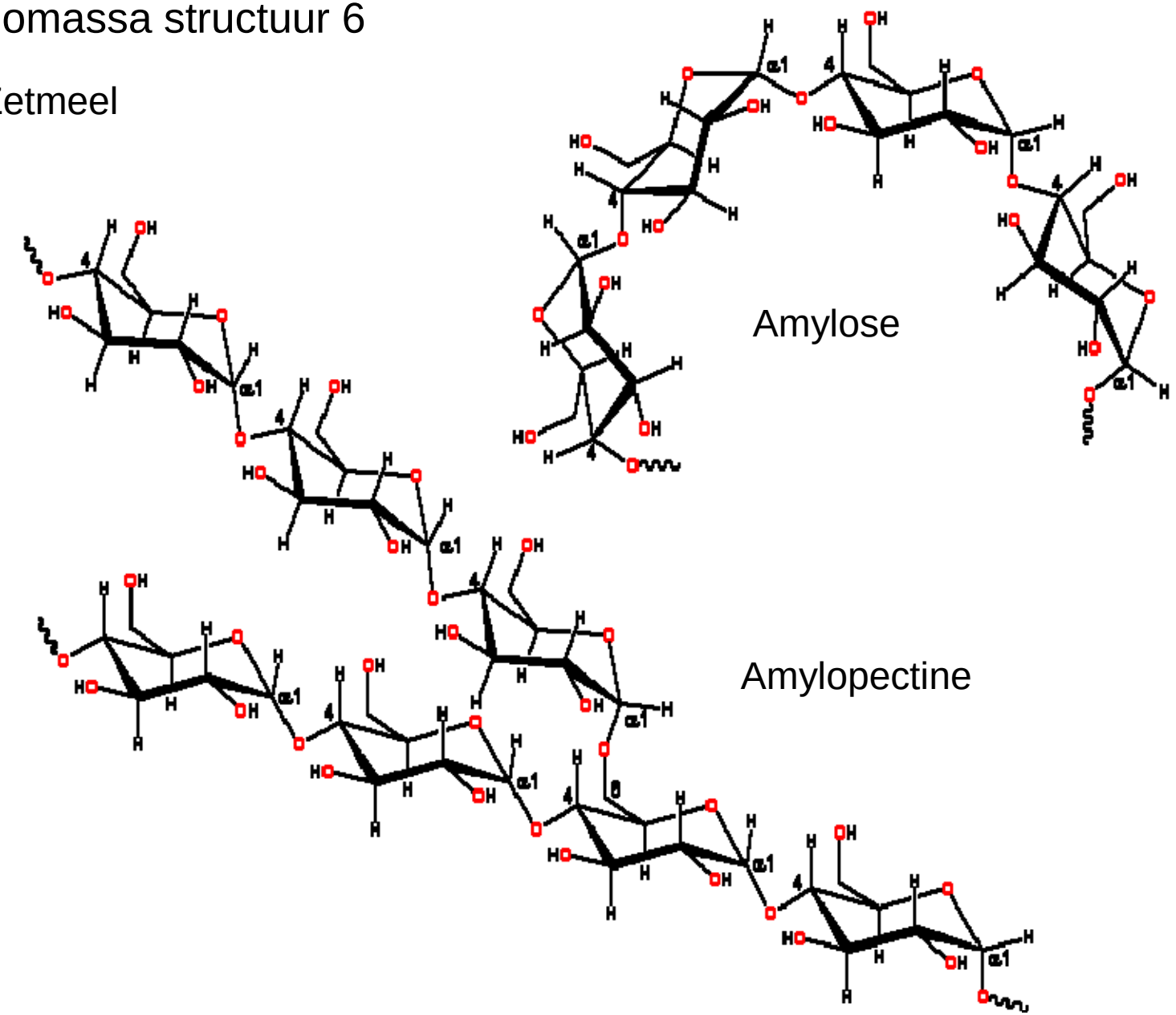
Structure of wood



Lignin-random co-polymer

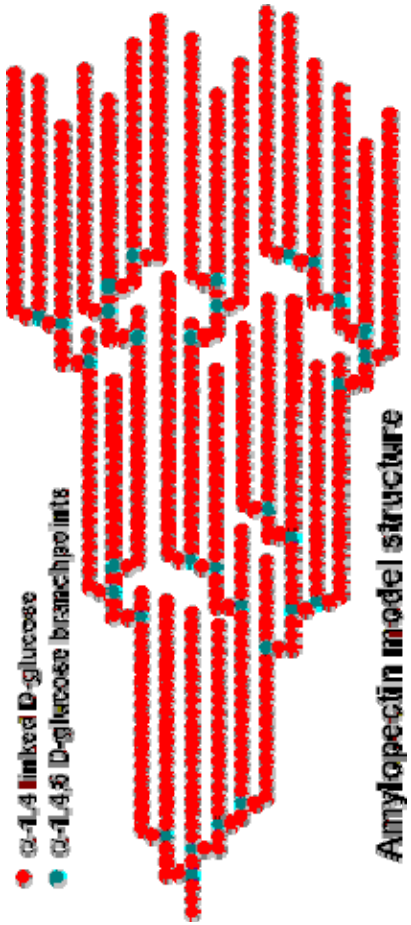
Biomassa structuur 6

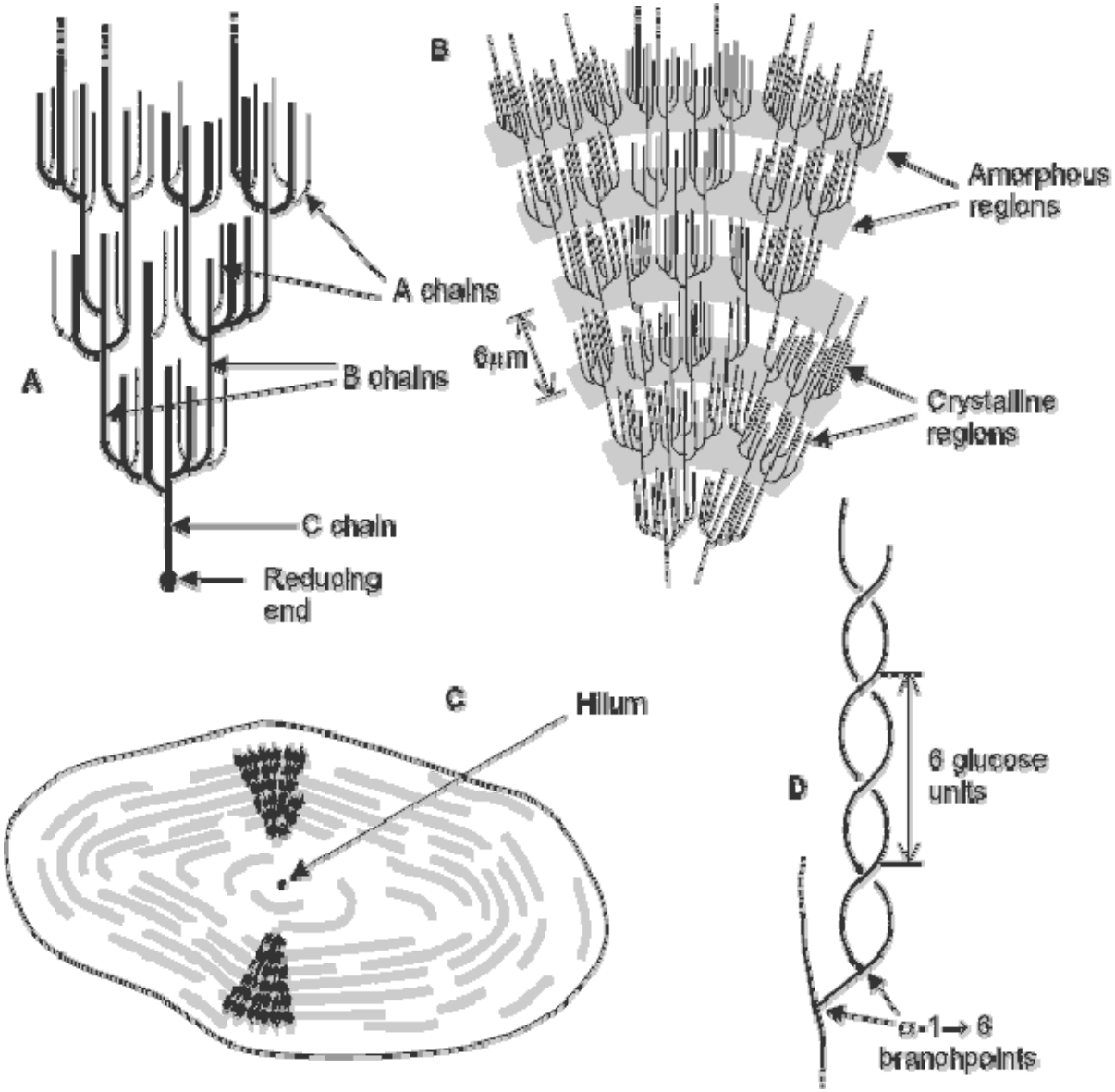
Zetmeel



Biomassa structuur 7

Organisatie zetmeel

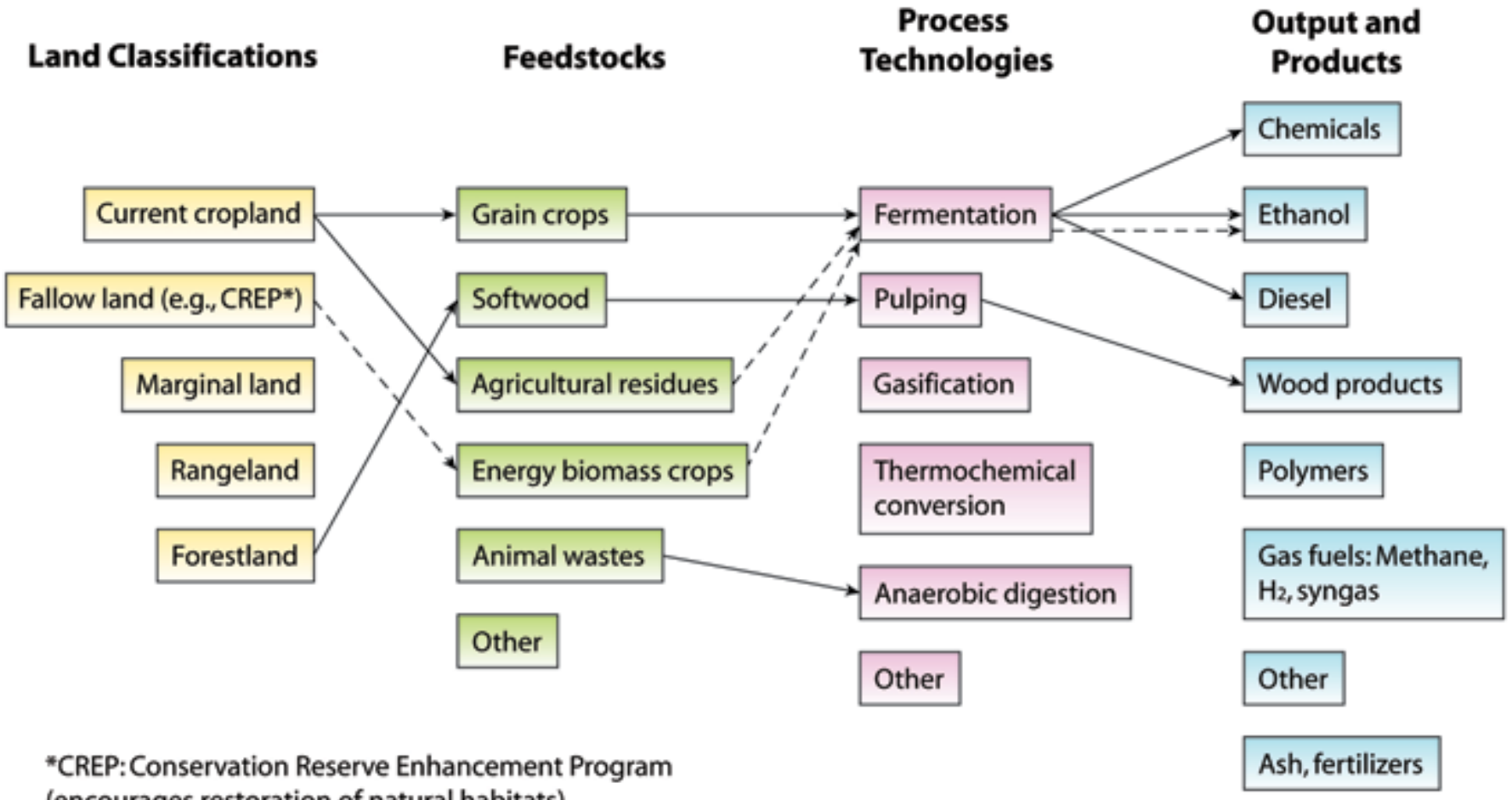




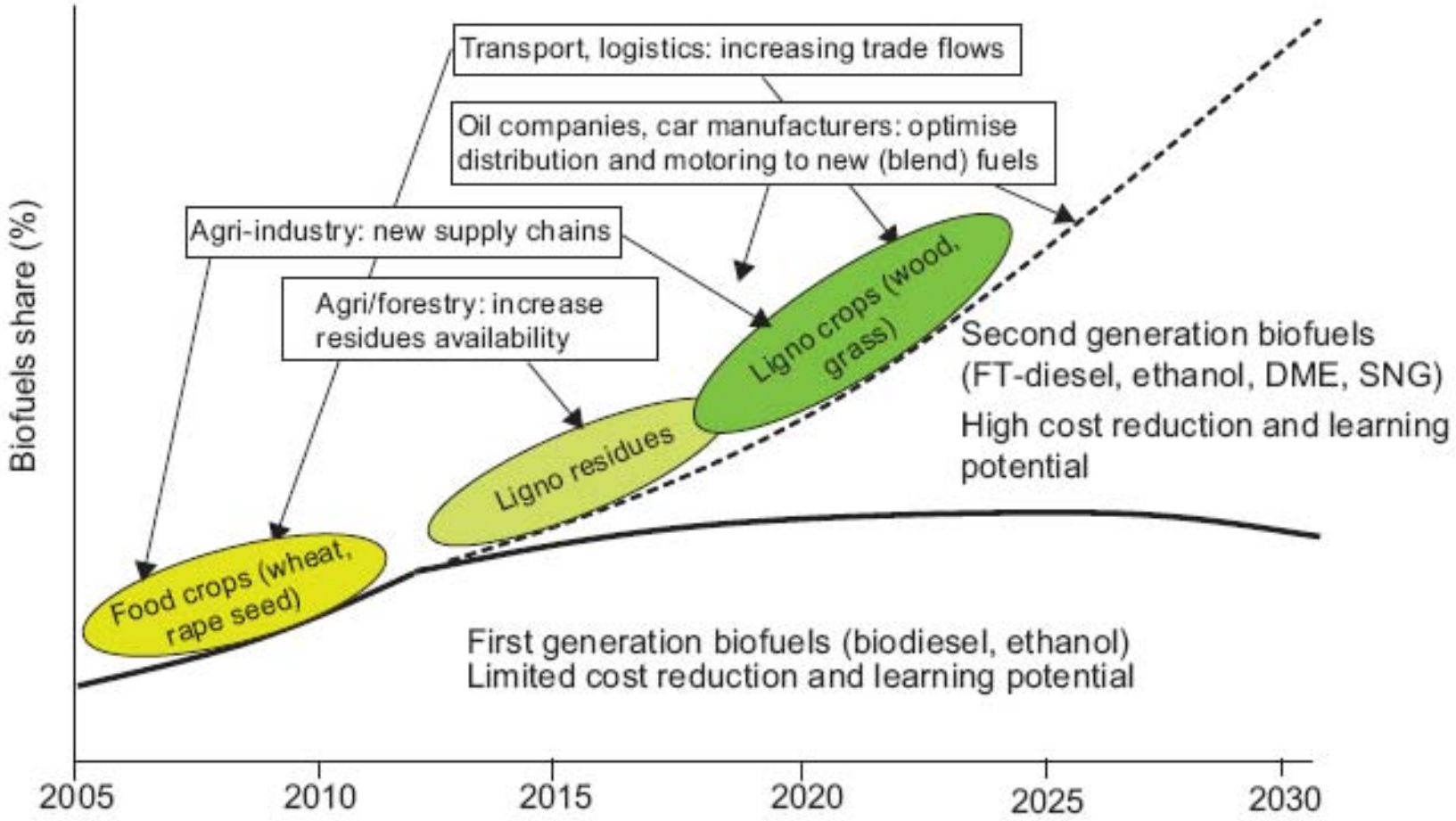
1st Generation Biofuels

2nd Generation Biofuels

Bronnen en producten



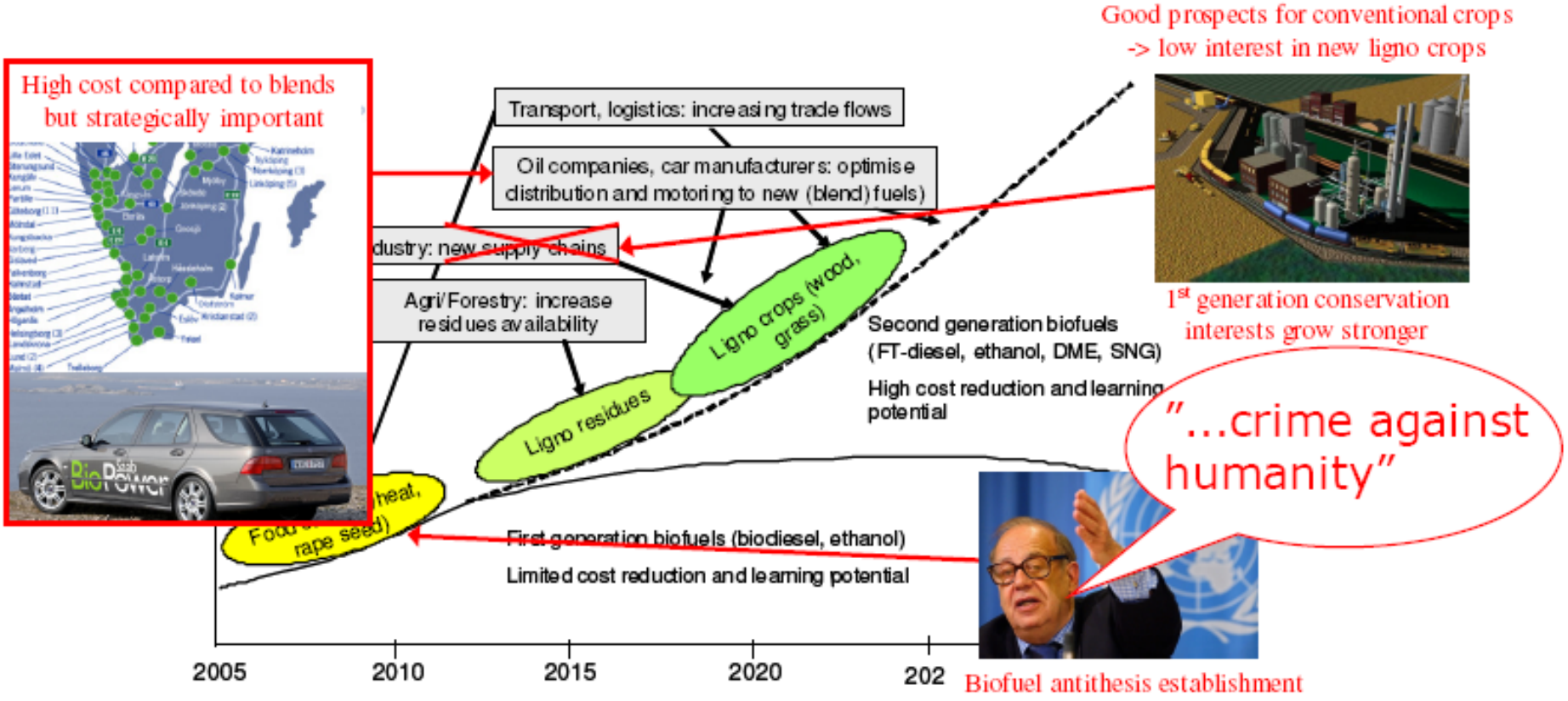
Ontwikkelingstraject



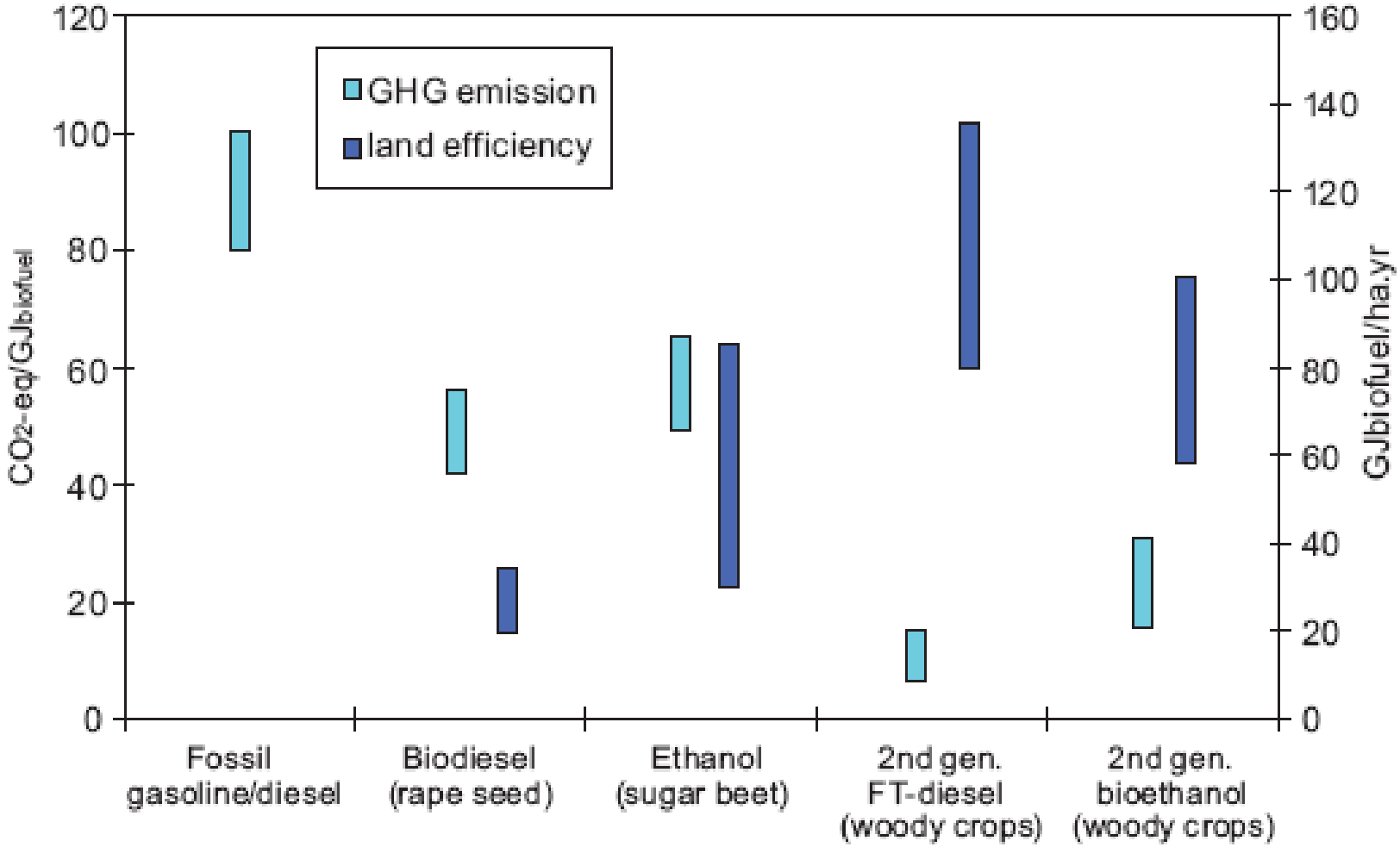
Consensus

Policy strategies: paving the way?

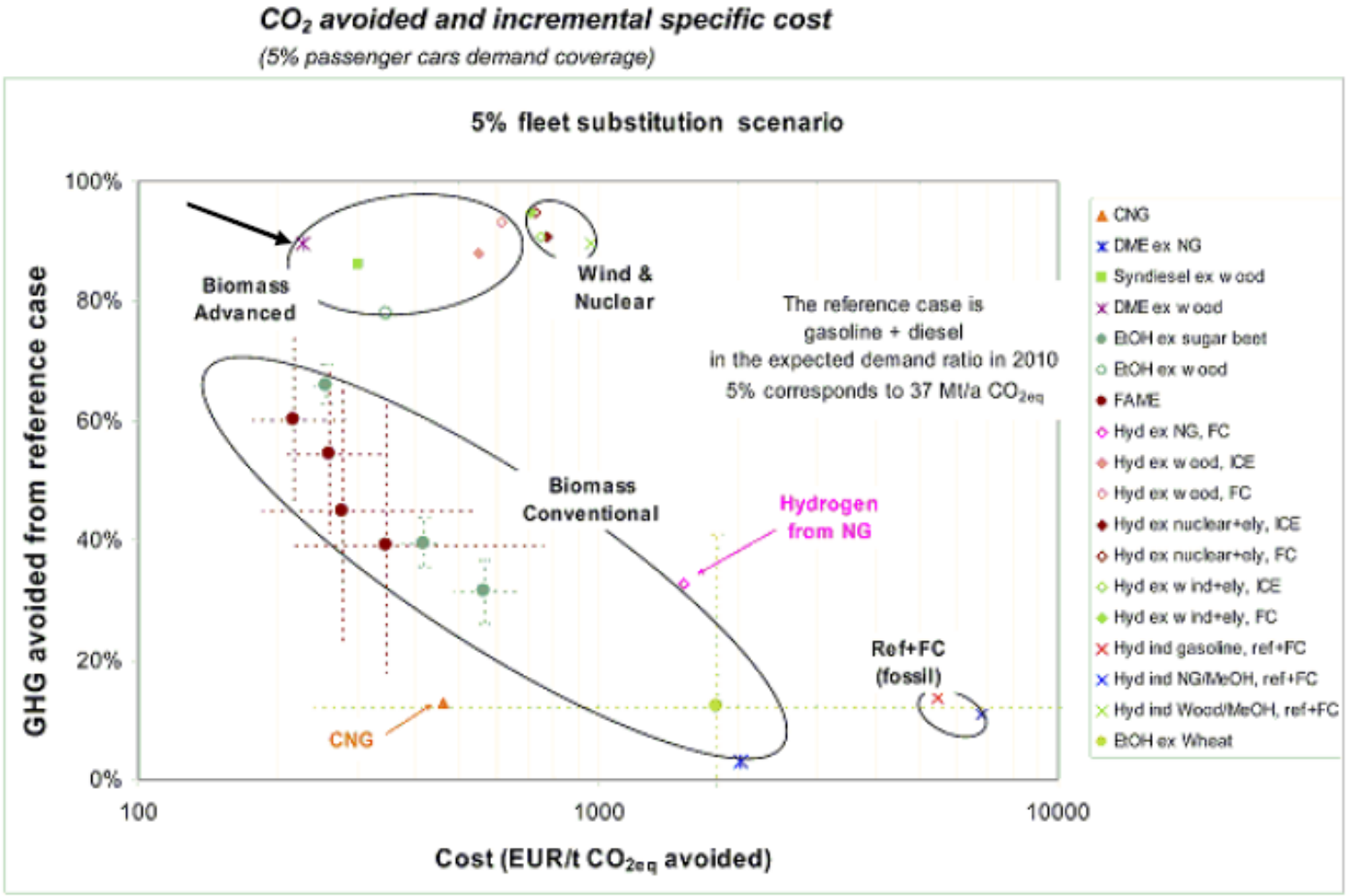
refuel



Van eerste naar tweede generatie 1



Van eerste naar tweede generatie 2

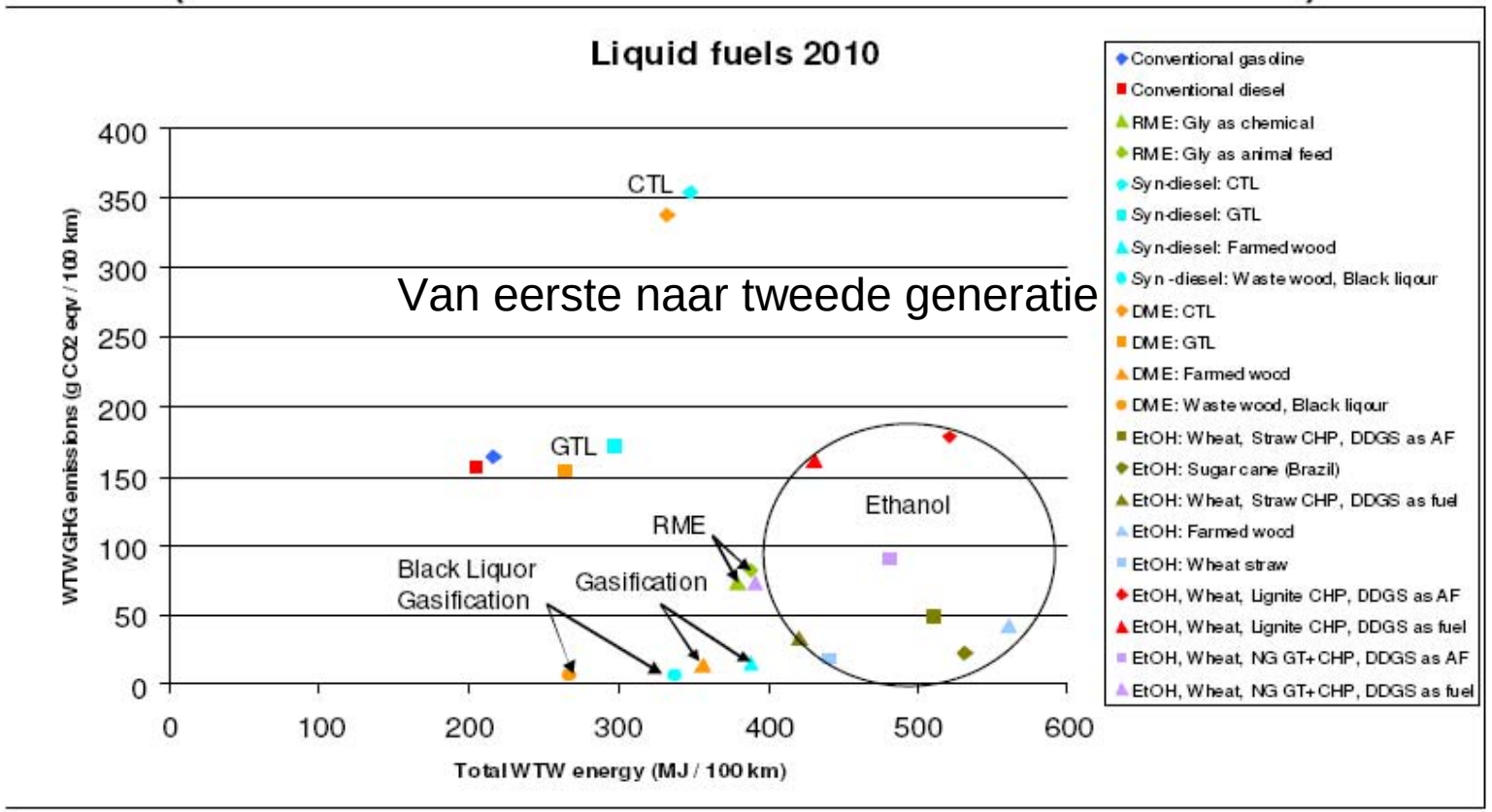


Dotted lines are error bars due to N_2O emissions uncertainty

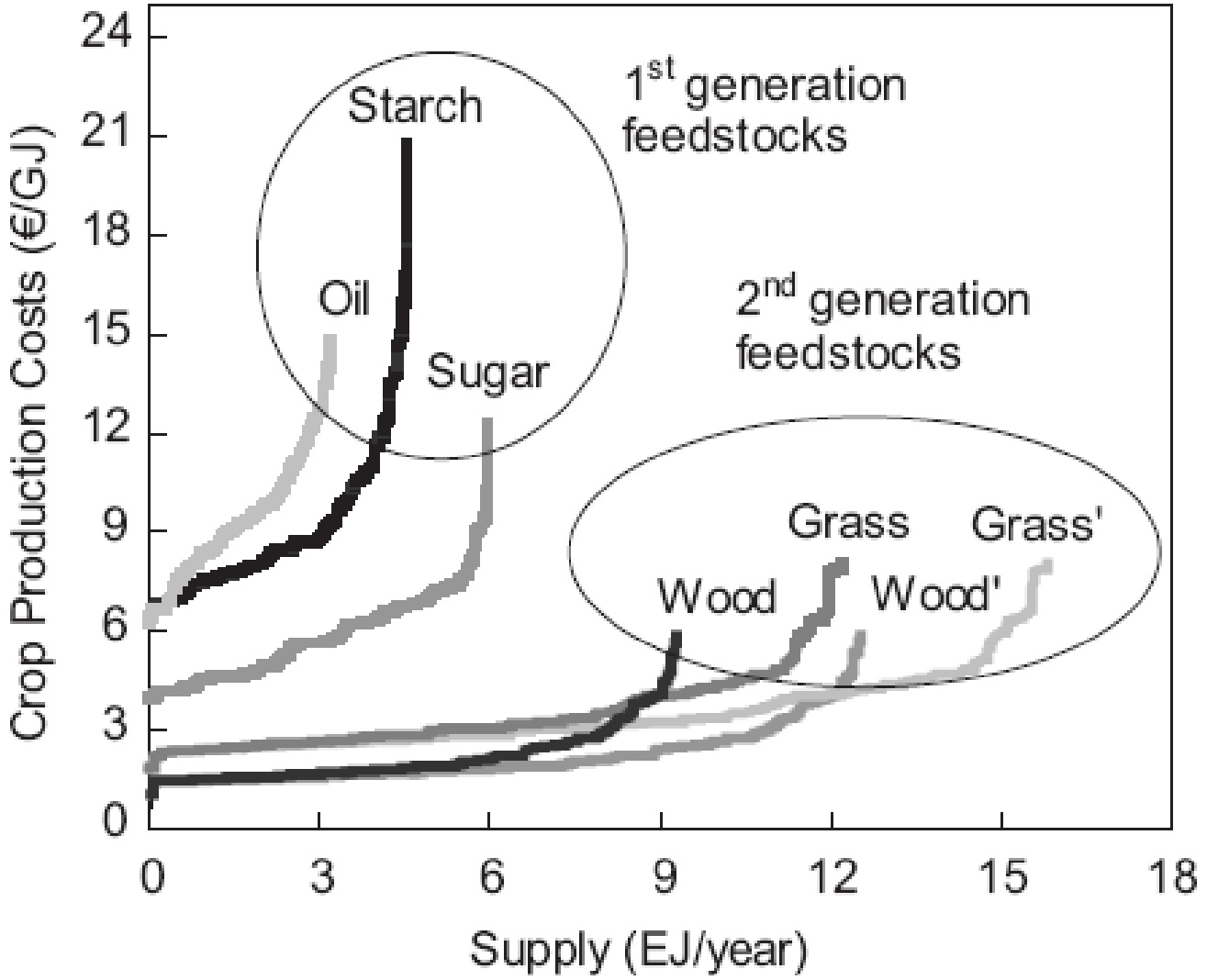
Source: EUCAR-CONCAWE-JRC

Van eerste naar tweede generatie 3

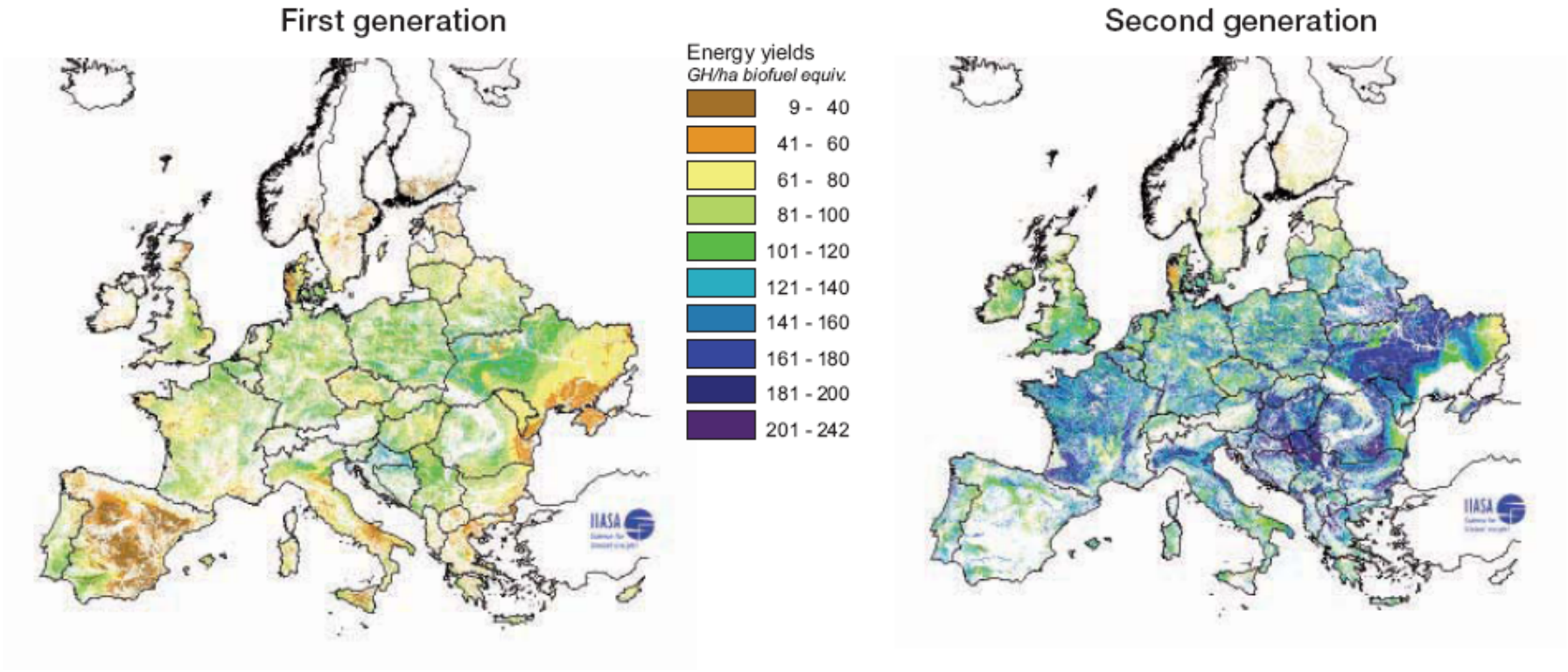
WtW GHG versus total energy use (ref: Eucar/Concawe/JRC 2005)



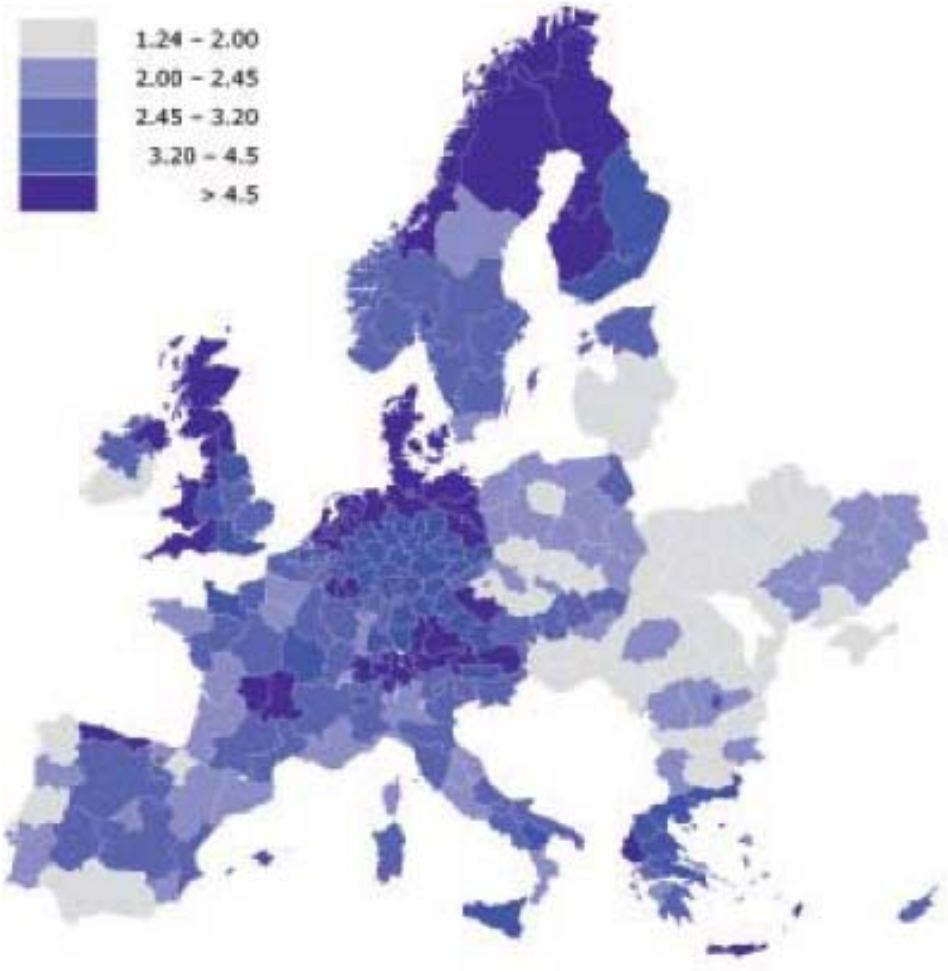
Van eerste naar tweede generatie 4: beschikbaarheid



Van eerste naar tweede generatie 5: opbrengsten



Van eerste naar tweede generatie 6: kosten Euro per Gigajoule

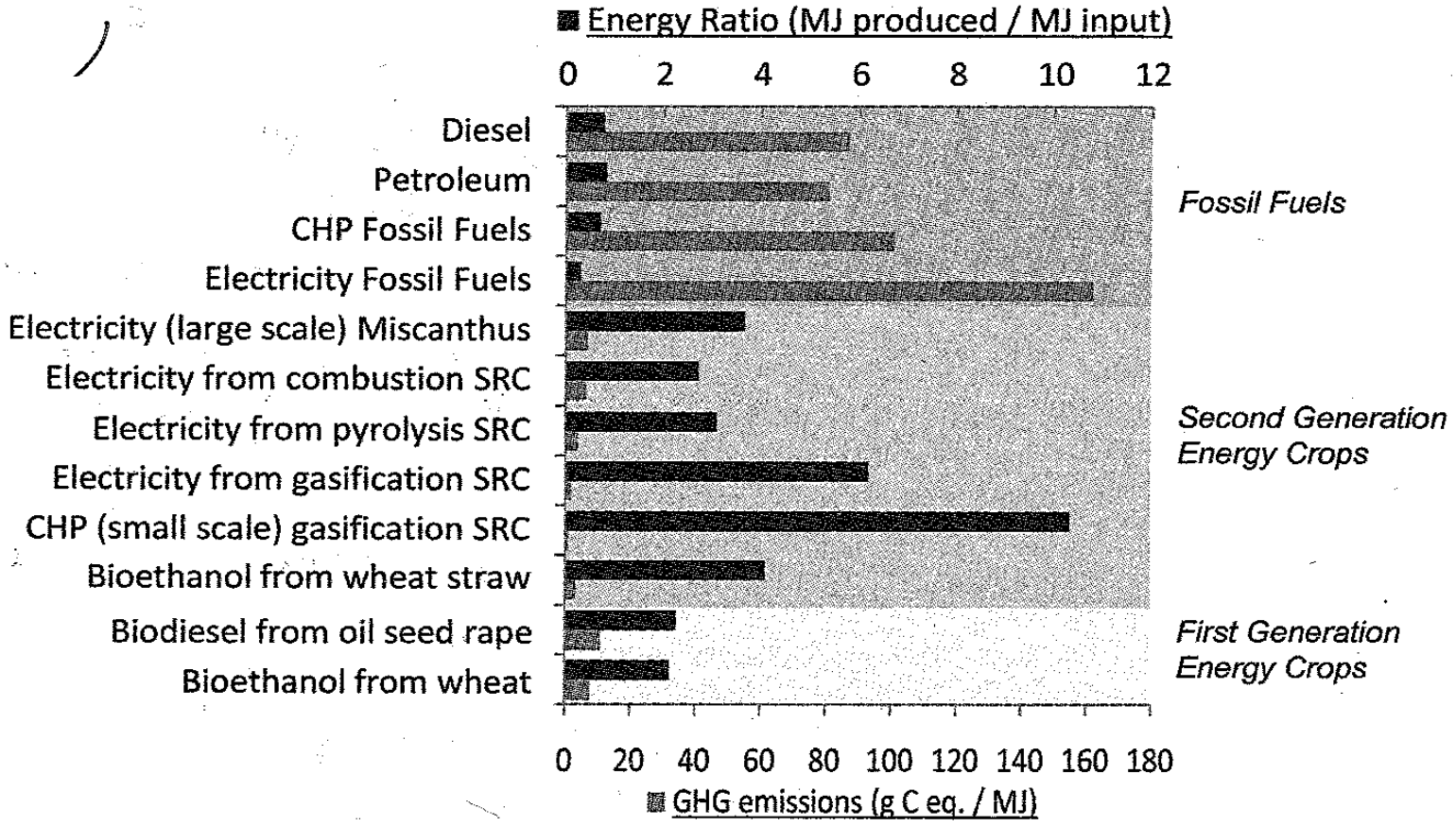


Van eerste naar tweede generatie 7: toepassingen

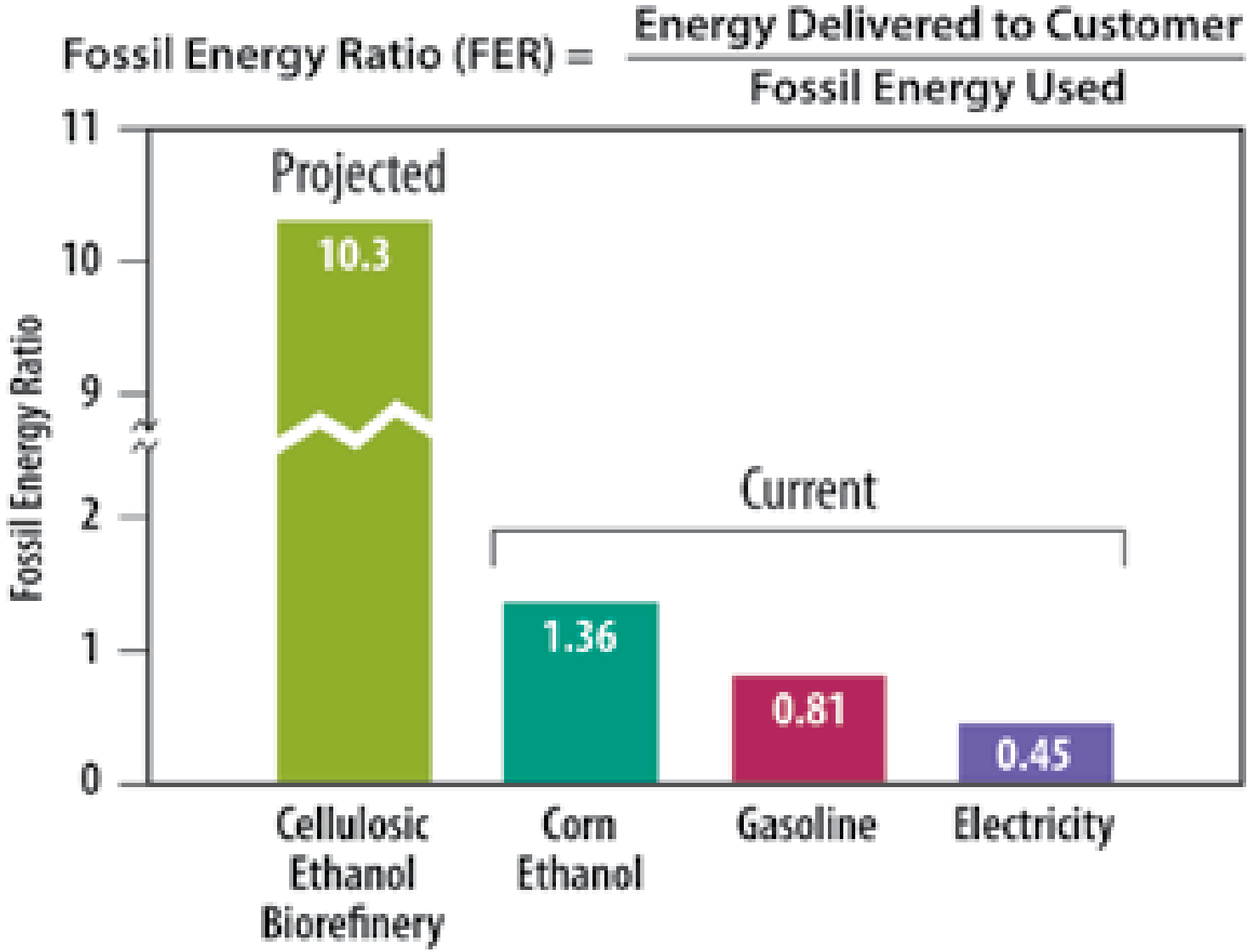
Feedstock			Classi-fication	Biofuel				
				Biodiesel	Bioethanol	FT-Diesel	Bio-DME	Bio-SNG
Energy crops	Lignocellulosic crops	Woody plants 1)	2nd		X	X	X	X
		Herbaceous plants 2)	2nd		X	X	X	X
	Oil crops	Rapeseed	1st	X				
		Sunflower	1st	X				
	Sugar crops	Sugar beet	1st		X			
		Sugar cane	1st		X			
	Starch crops	Wheat	1st		X			
		Maize	1st		X			
		Triticale	1st		X			
		Sweet sorghum	1st		X			
Residues	from agriculture	Digestible	1st		X			X
		Non-digestible (straw)	2nd		X	X	X	X
	from forestry		2nd		X	X	X	X
	from wood industry		2nd		X	X	X	X
Waste	Organic waste	Used oils/fats/fatty acids	1st	X				

1) Short rotation forestry: poplar, willow, eucalypt
2) Perennials: miscanthus, switch grass, reed canary grass
1st First generation of biofuels
2nd Second generation of biofuels

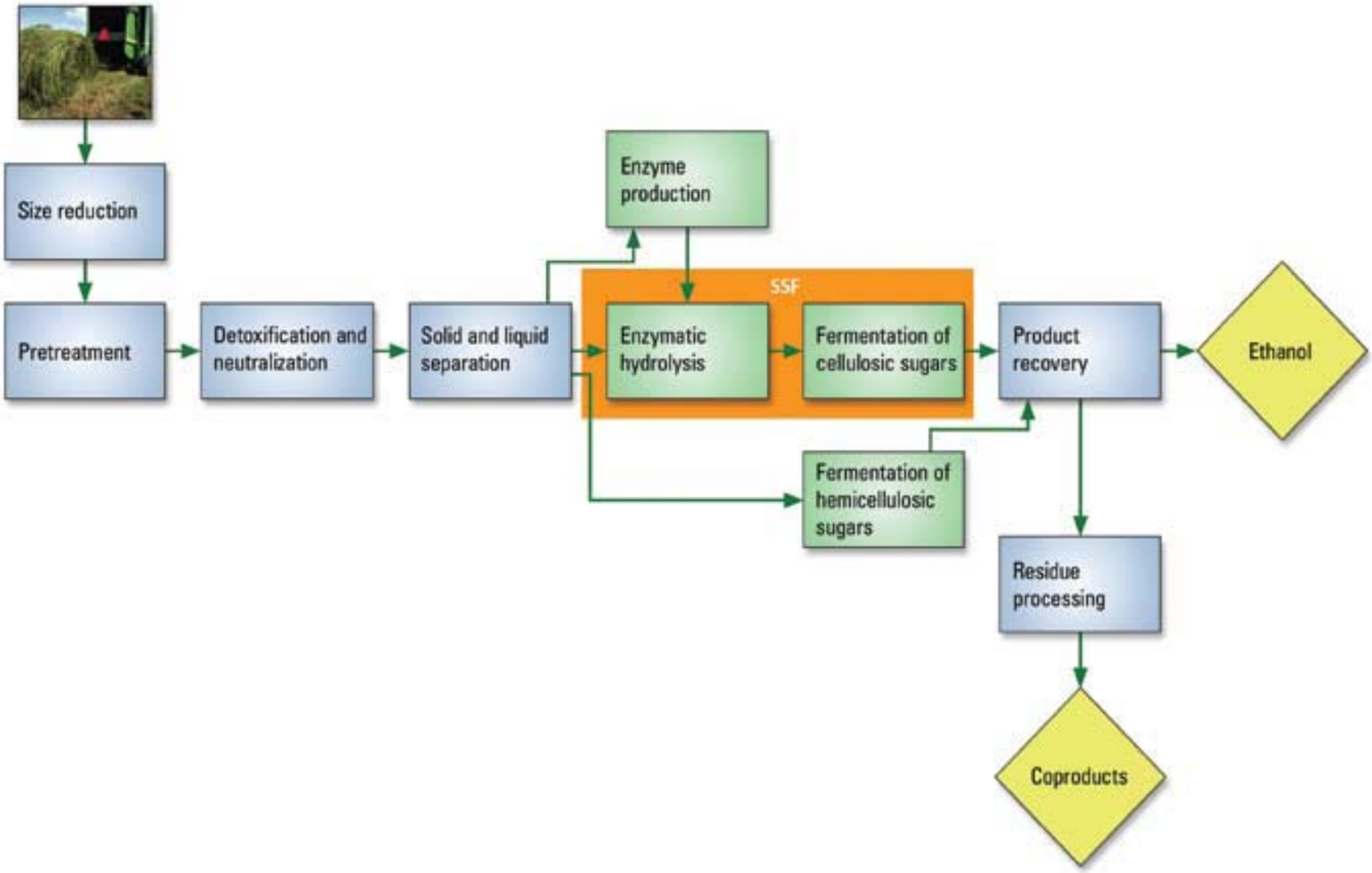
Van eerste naar tweede generatie 8: rendementen



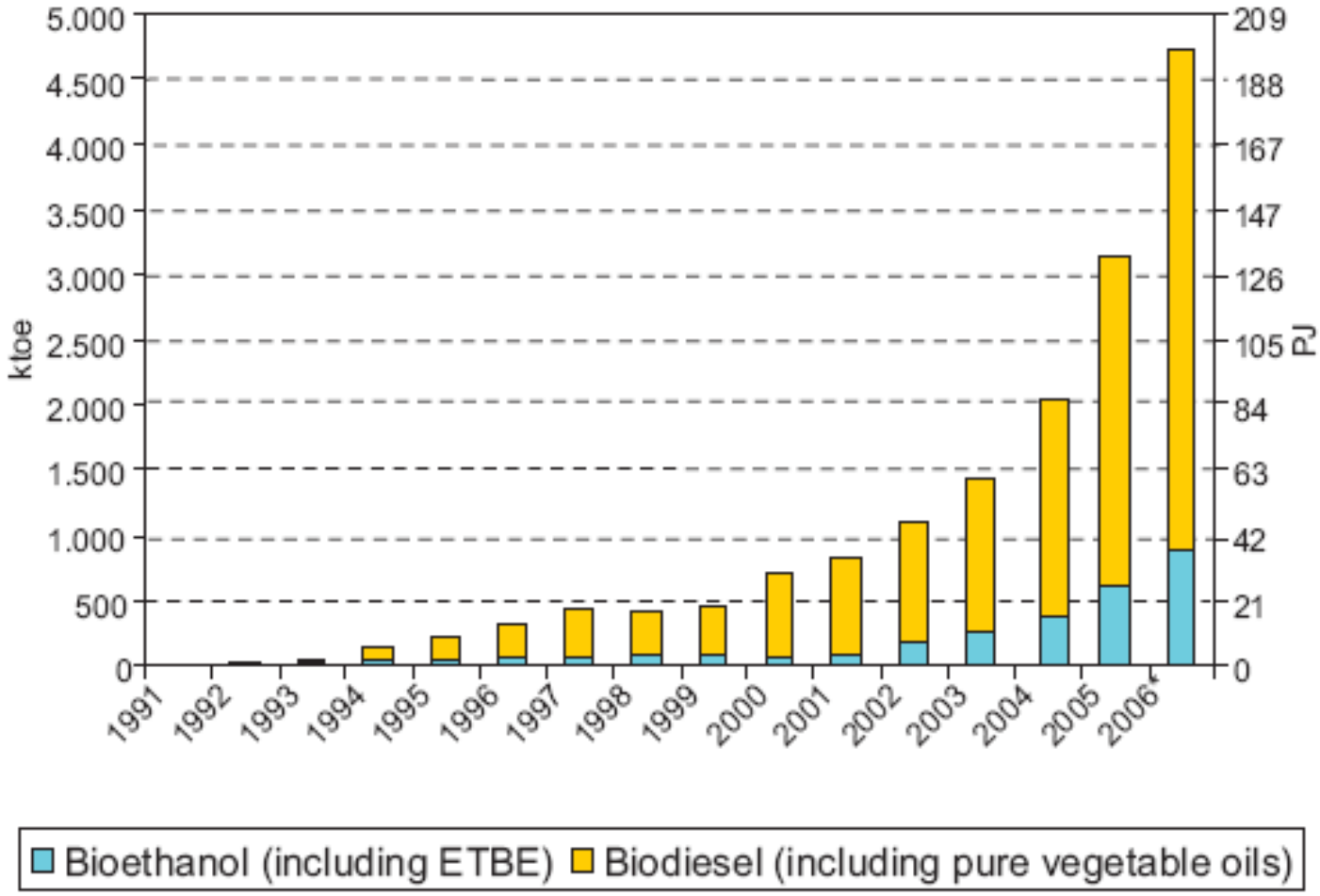
Van eerste naar tweede generatie 9: rendementen



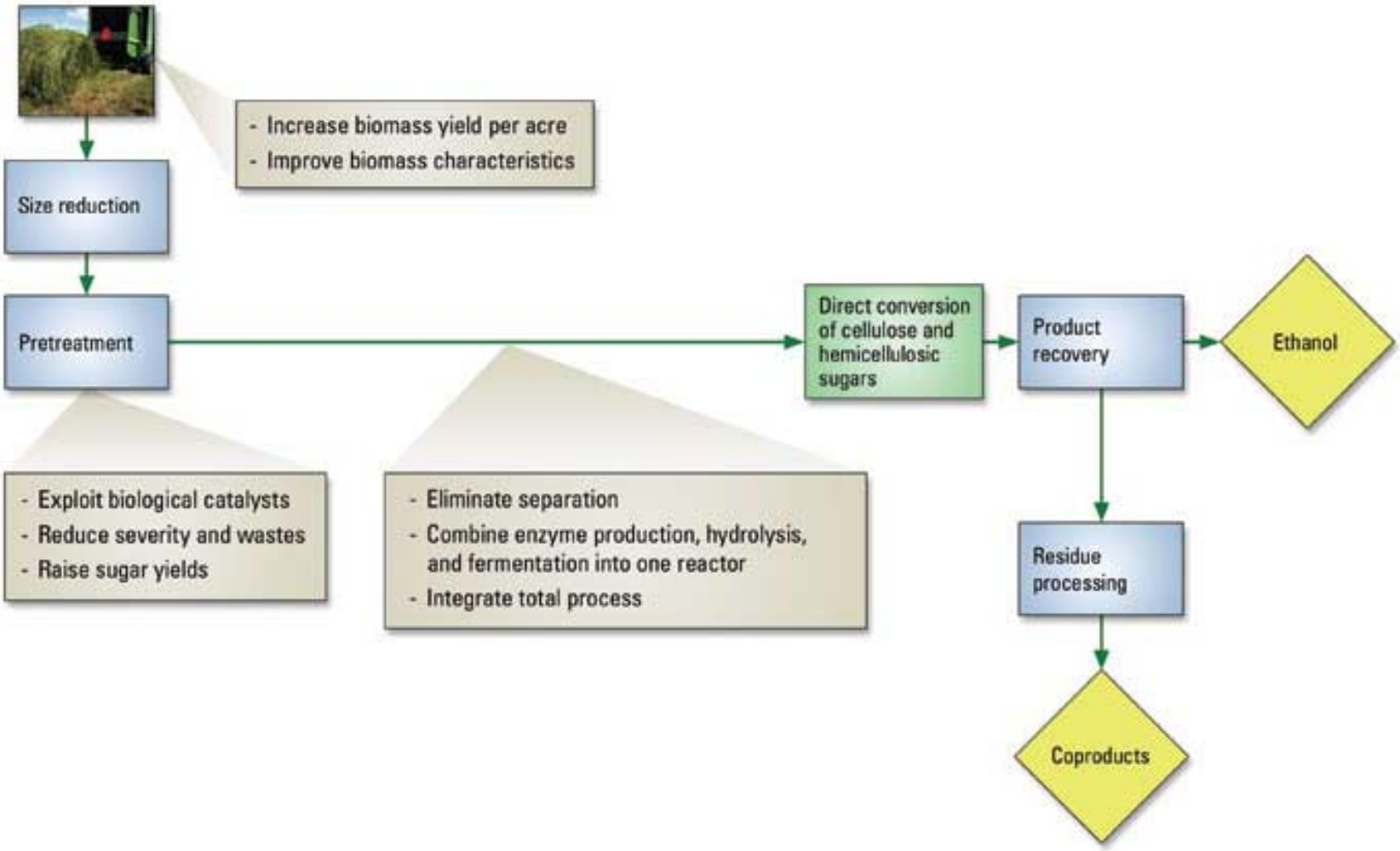
Van eerste naar tweede generatie 10: Ethanol productie conventioneel en nieuw



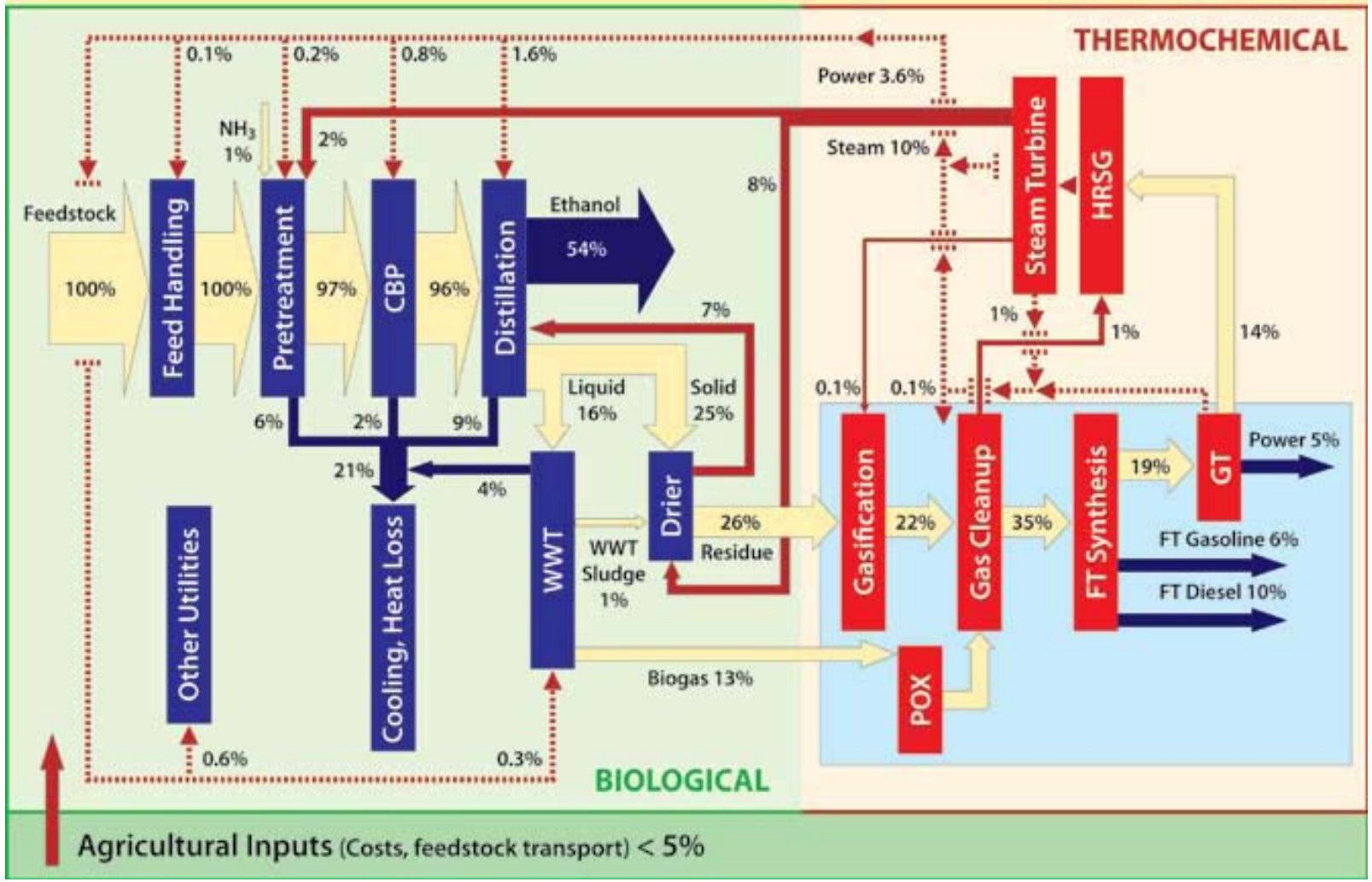
Eerste generatie



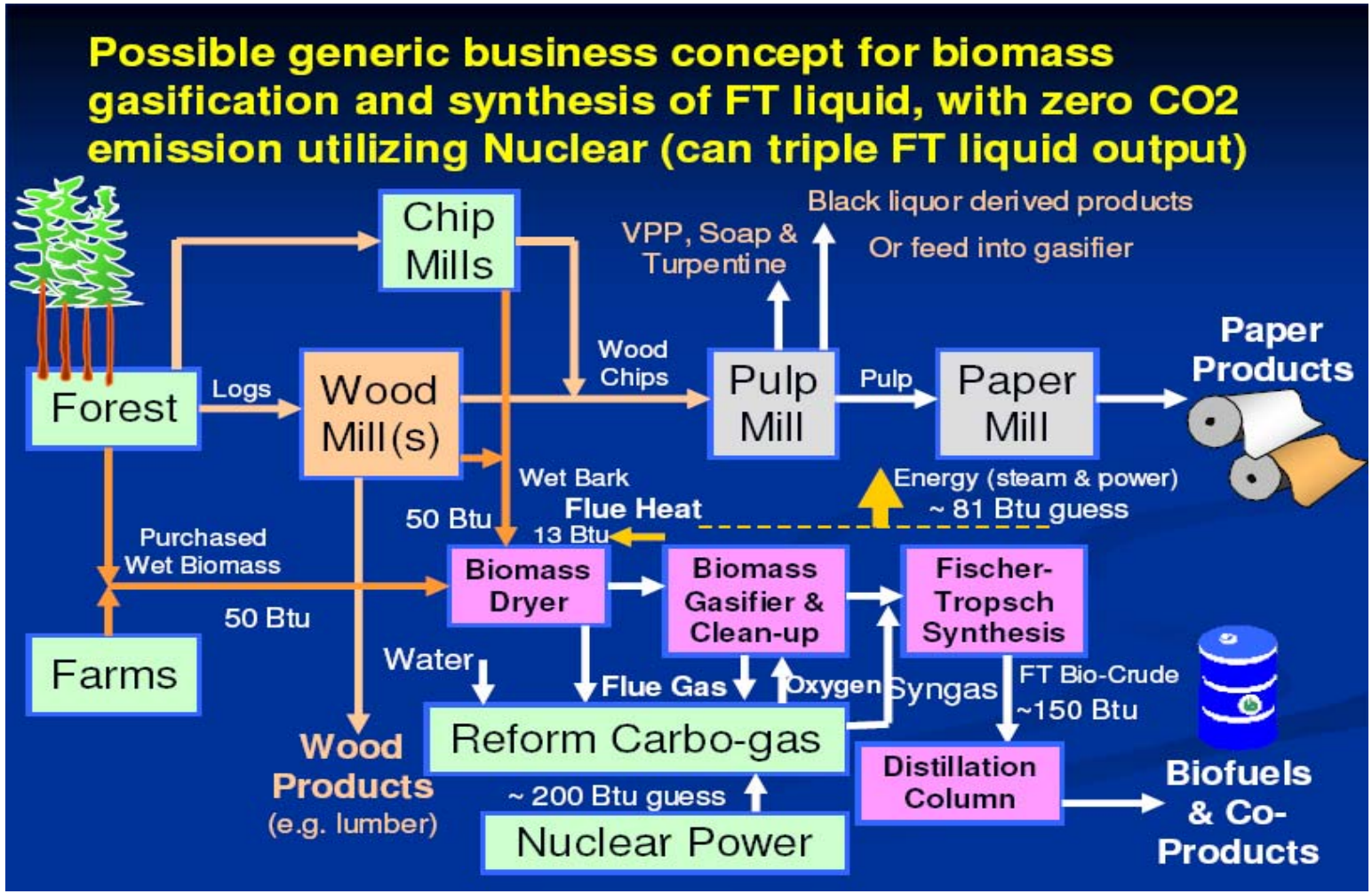
Tweede generatie 1: biorefinery



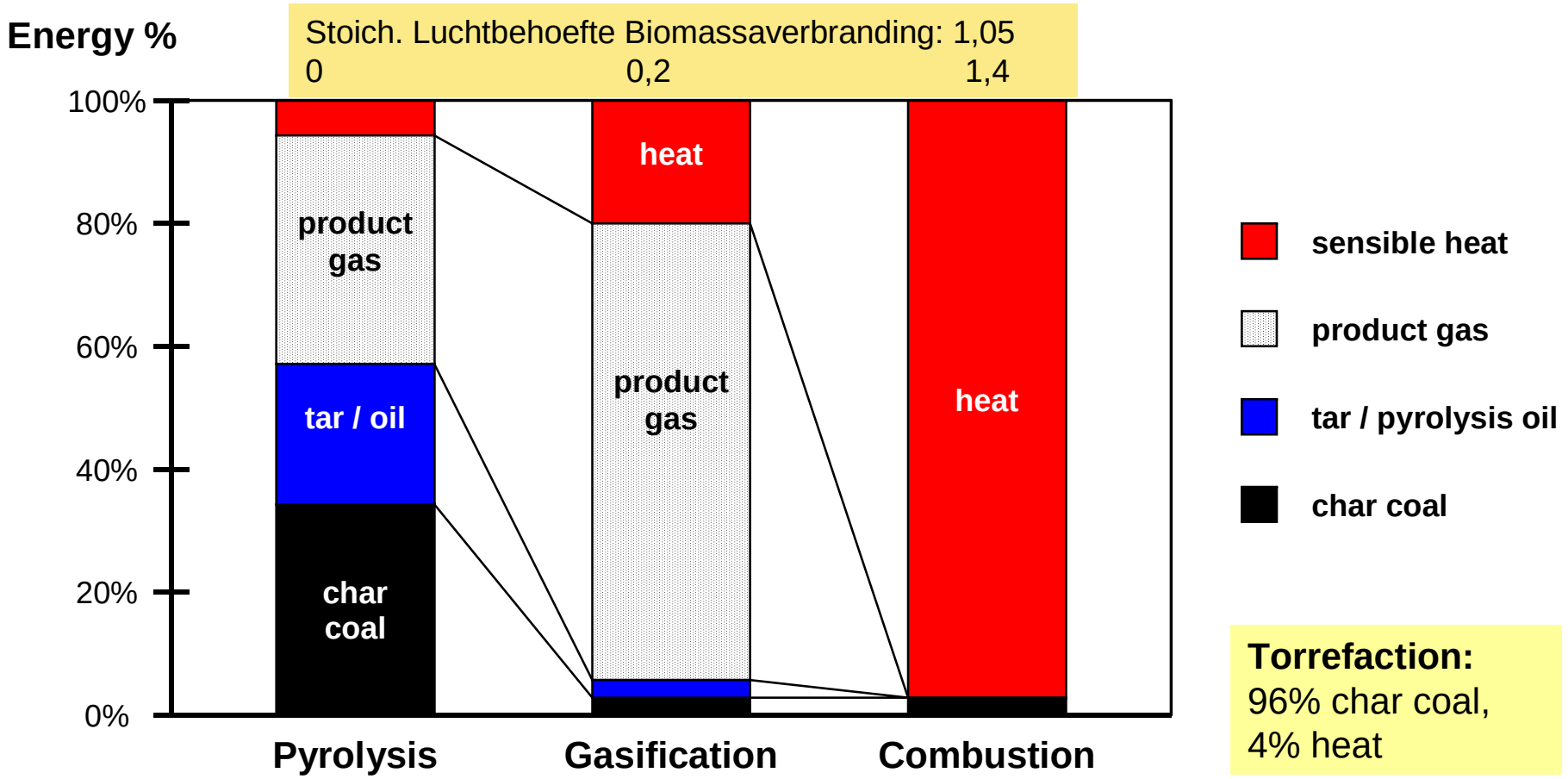
Tweede generatie 2: biorefinery, processstromen



Tweede generatie 3: biorefinery en integratie met ander activiteiten

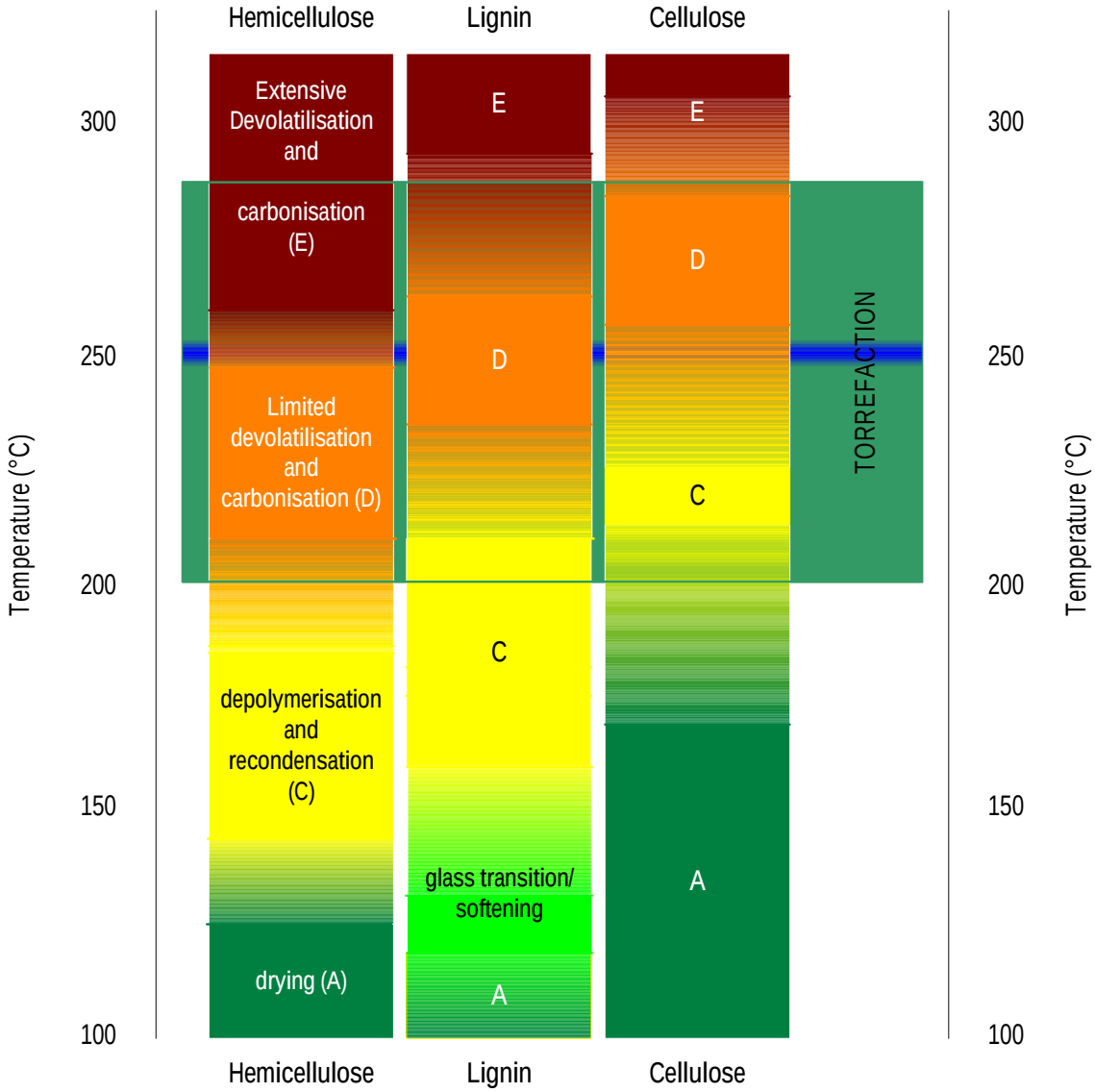


Thermochemische conversie 1; Verbranding, vergassing en pyrolyse

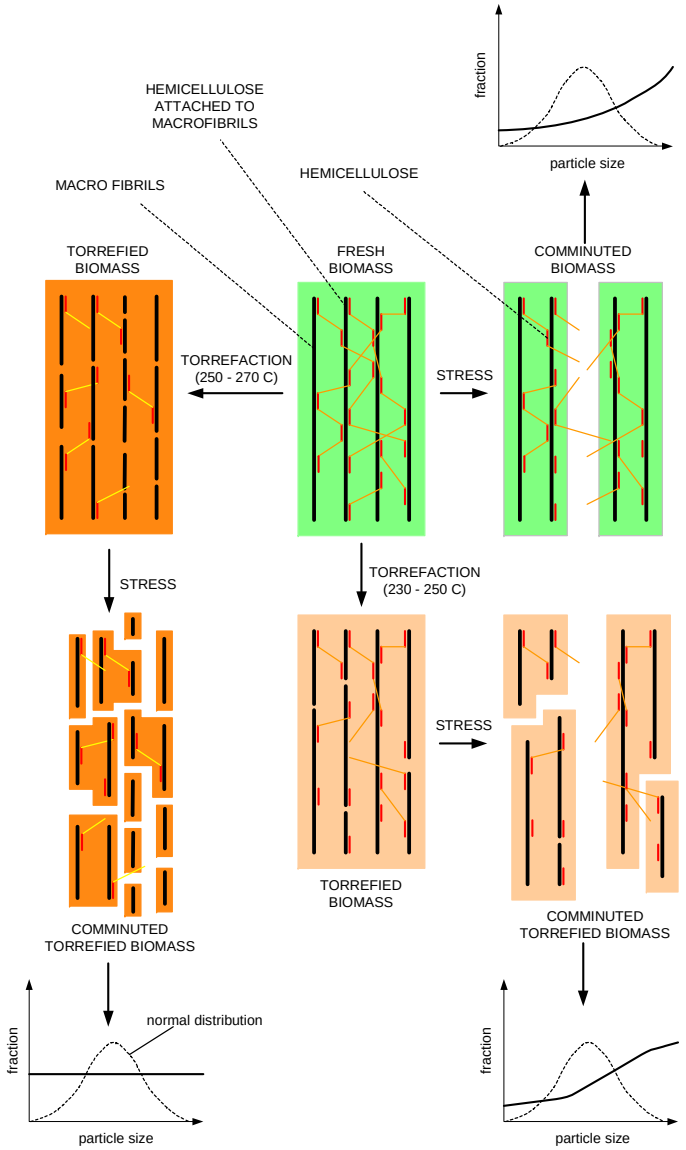


Bron: HB, ECN, JOVD European meeting, Petten, 5 April 2005

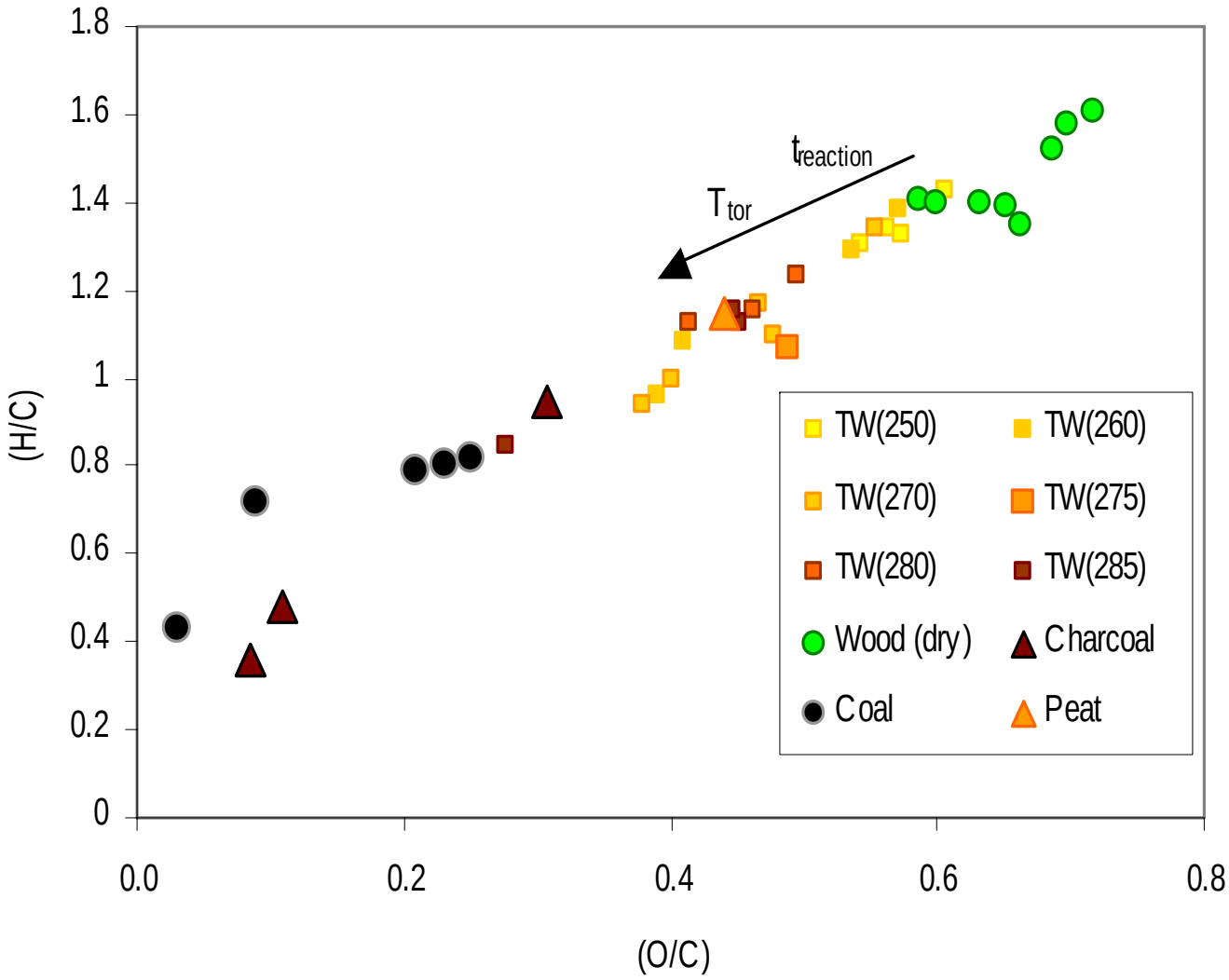
Thermochemische conversie 2: torrefactie



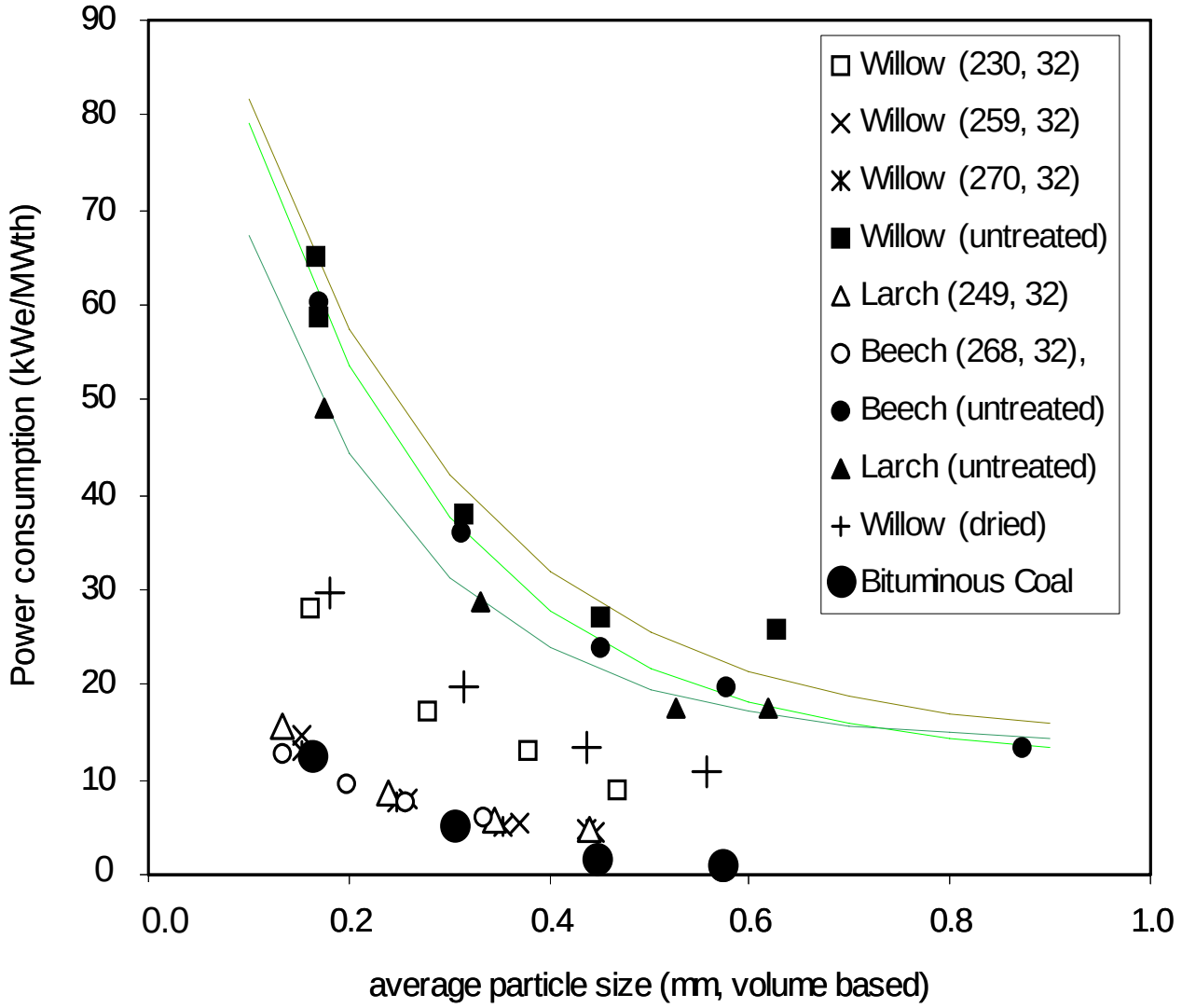
Thermochemische conversie 3: torrefactie



Thermochemische conversie 3: torrefactie, van Krevelen diagram

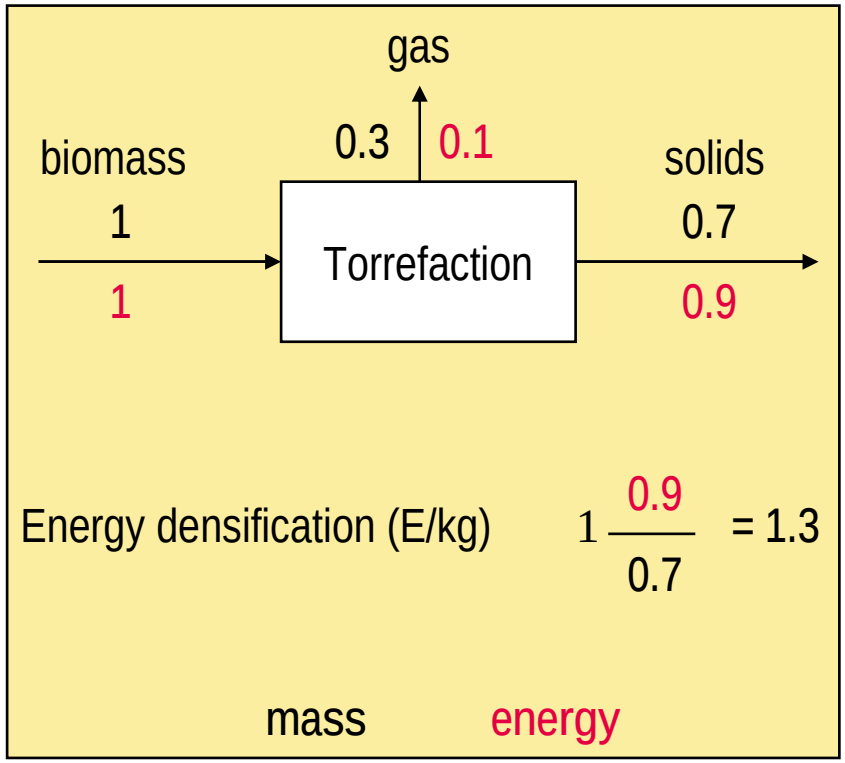


Thermochemische conversie 4: torrefactie, maalenergie



Torrefaction

Charcoal	Pyrolysis oil
mass yield: 0.2-0.3	mass yield: 0.6-0.7
energy yield: 0.4-0.6	energy yield: 0.6-0.7



- Temperature: 200-300 °C
- Pressure: near atmospheric
- Heating rate: <50 °C/min
- Absence of oxygen
- Product: solid phase
- Residence time 30 to 90 min
- Particle size < 4 cm thickness

Lignocellulose loses components with low energy content
and so keeps the energy in the product

Thermochemische conversie 5: Pyrolyse, proces

- Thermal cracking of organic material in absence of oxygen
- Main product: liquid bio-oil
- Process conditions

  T = 400 - 600 °C

  P = atmospheric

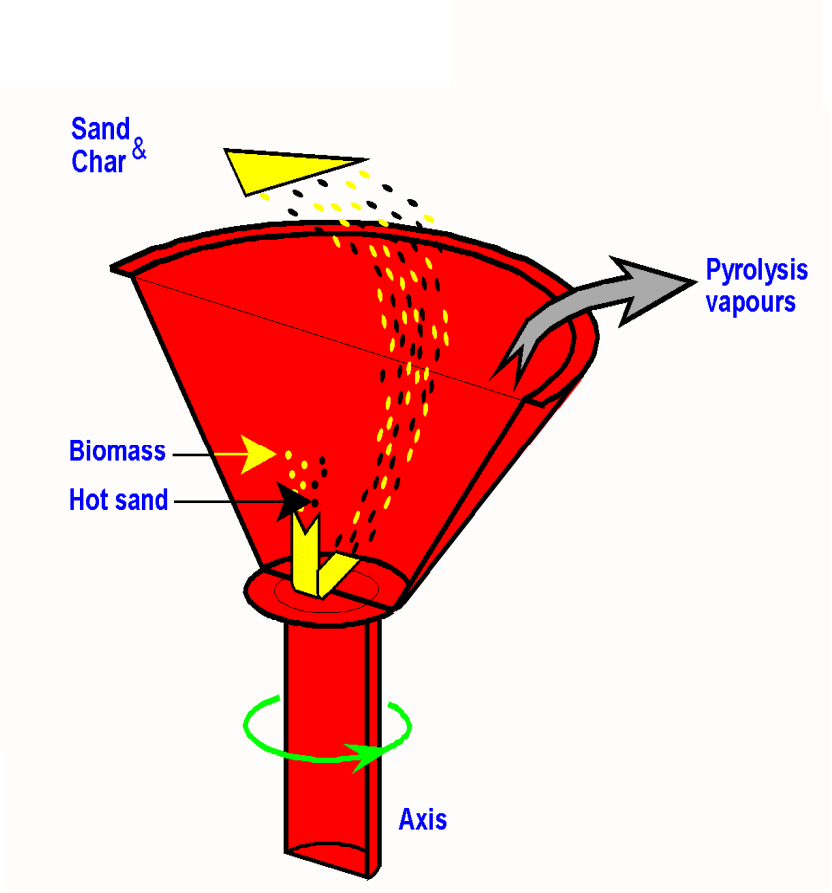
  τ_{gas} ~ 1 s
- Dry feed
- Excess char

Thermochemische conversie 6: Pyrolyse, producten

- Products:
  - gas: 15 wt% (internal electricity)
  - bio-oil: 70 wt% (tradable product)
  - char: 15 wt% (internal heat)
- Minerals remain in char; bio-oil is virtually mineral free
- High fuel flexibility
- Increase in energy density with a factor of 4 - 5

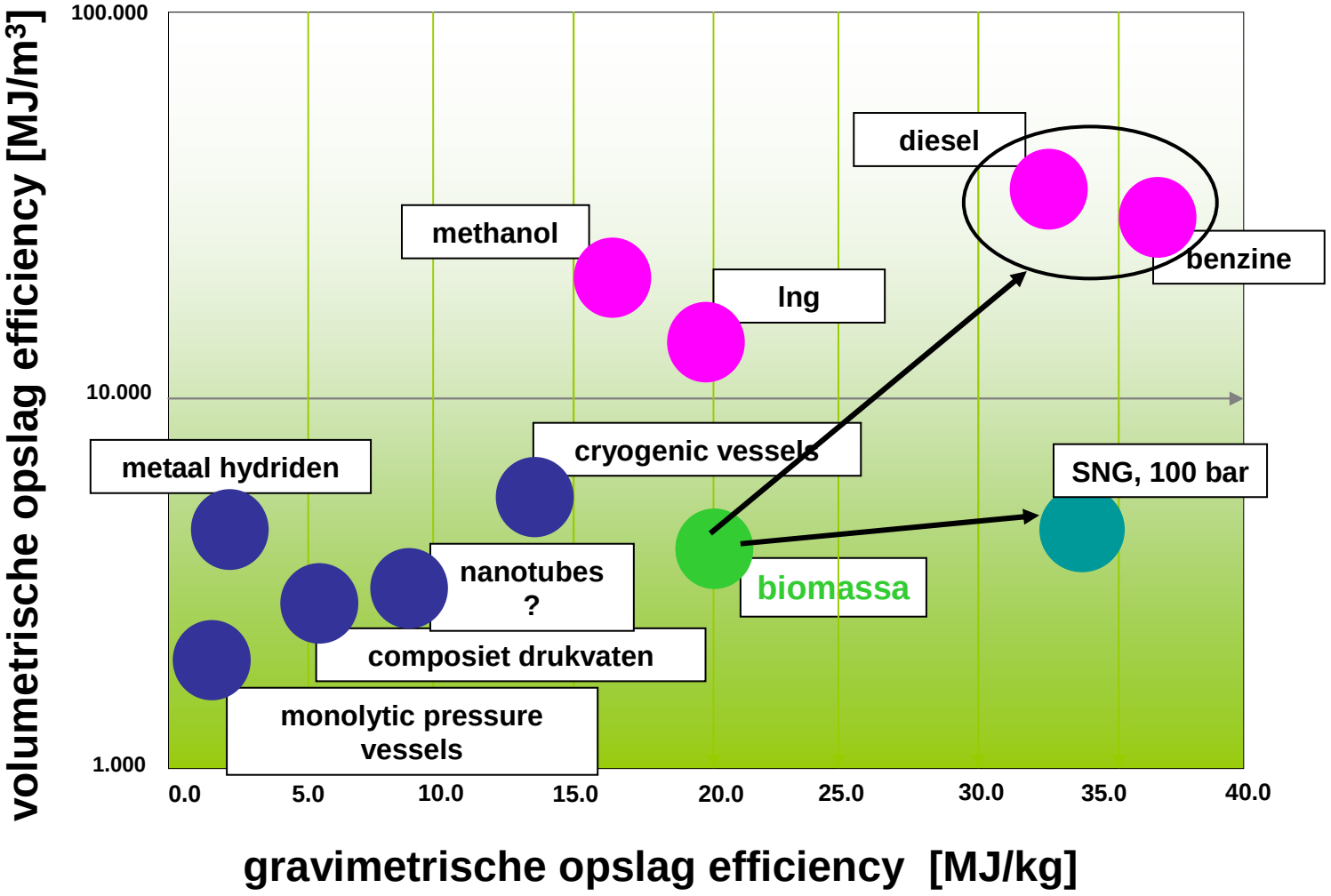
1 MJ Feedstock **1 MJ Product**

Principle rotating cone reactor

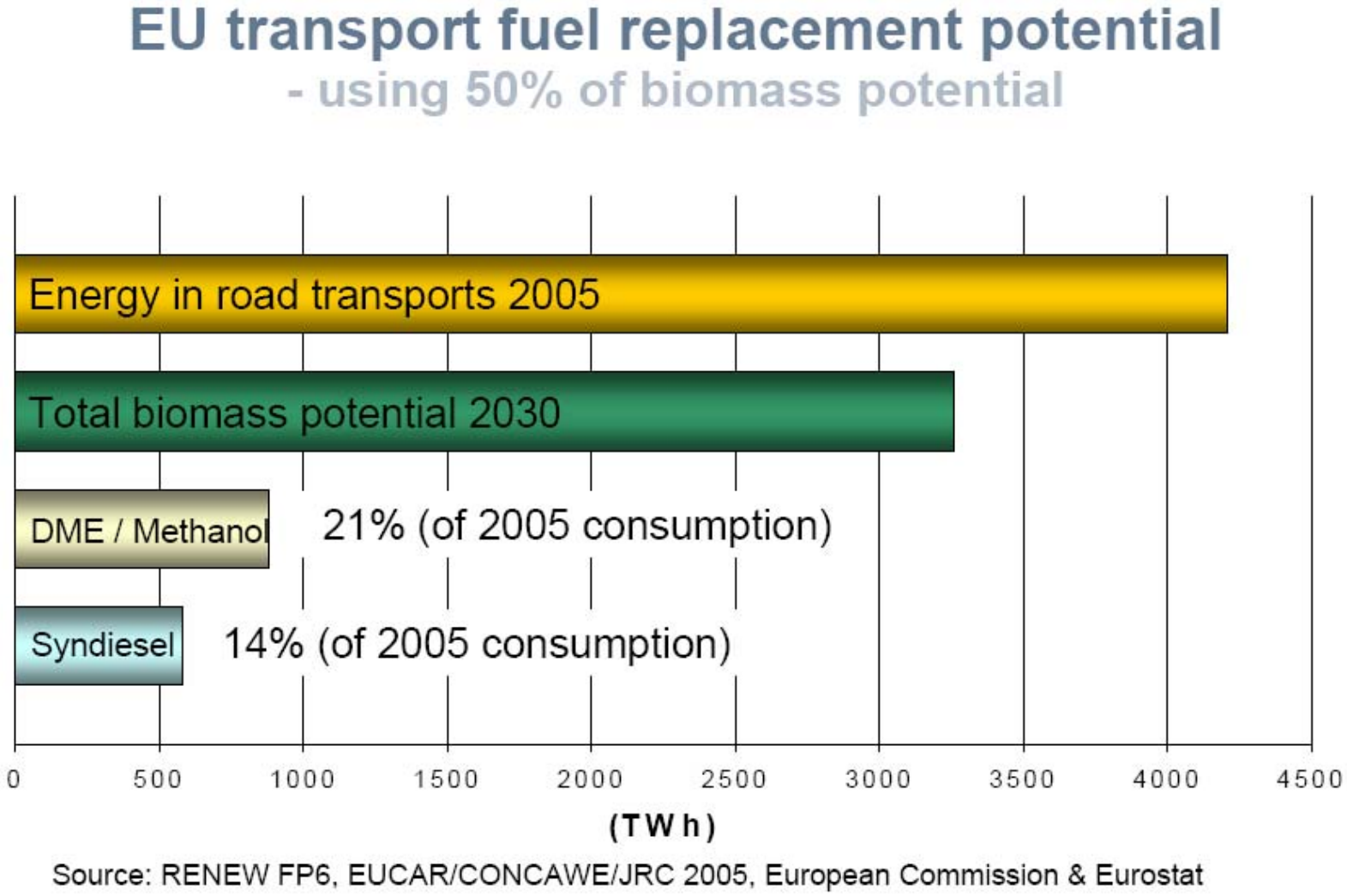


10 kg/hr test unit at the University of Twente

Brandstoffen 1: opslag capaciteit



Brandstoffen 2: potentieel



Source: RENEW FP6, EUCAR/CONCAWE/JRC 2005, European Commission & Eurostat

Brandstoffen 3: processtappen

BTL processing steps pose a challenge for implementation

Pulp & Paper Industry is joining forces with Fuel Refining Companies in search for synergistic, efficient and economic production processes for biofuels, and in particular using the thermochemical processing route.

- Logistics
- Size reduction
- Storage
- Handling
- De-watering
- Drying

- Effect of type
- Pressurizing
- Syngas Quality

- Particulates
- Tar removal
- Impurities
- CO_2 removal
- H_2/CO adjustment

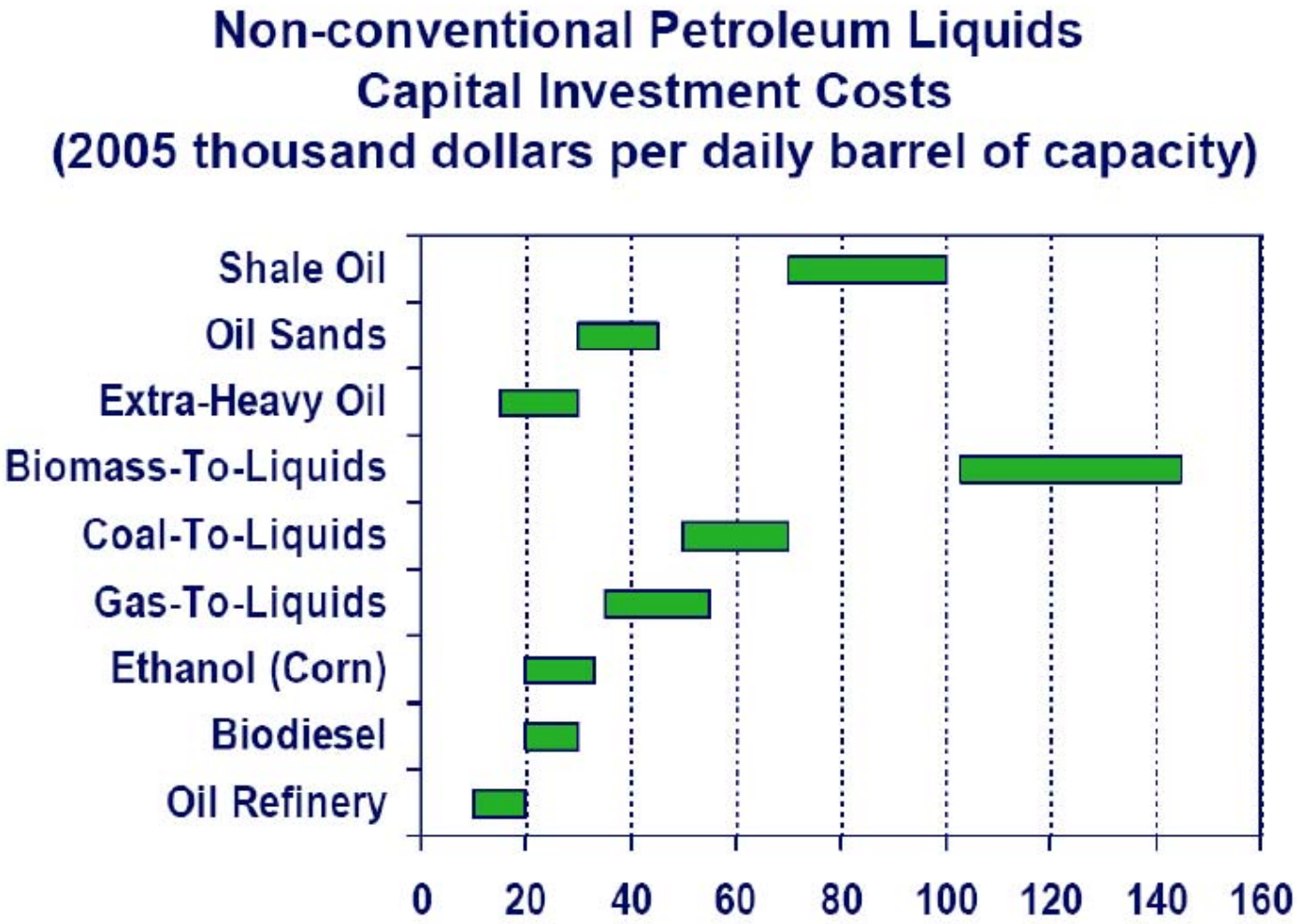
Synthesis
- FT
- Methanol, DME

Technology
- Licence
- Performance

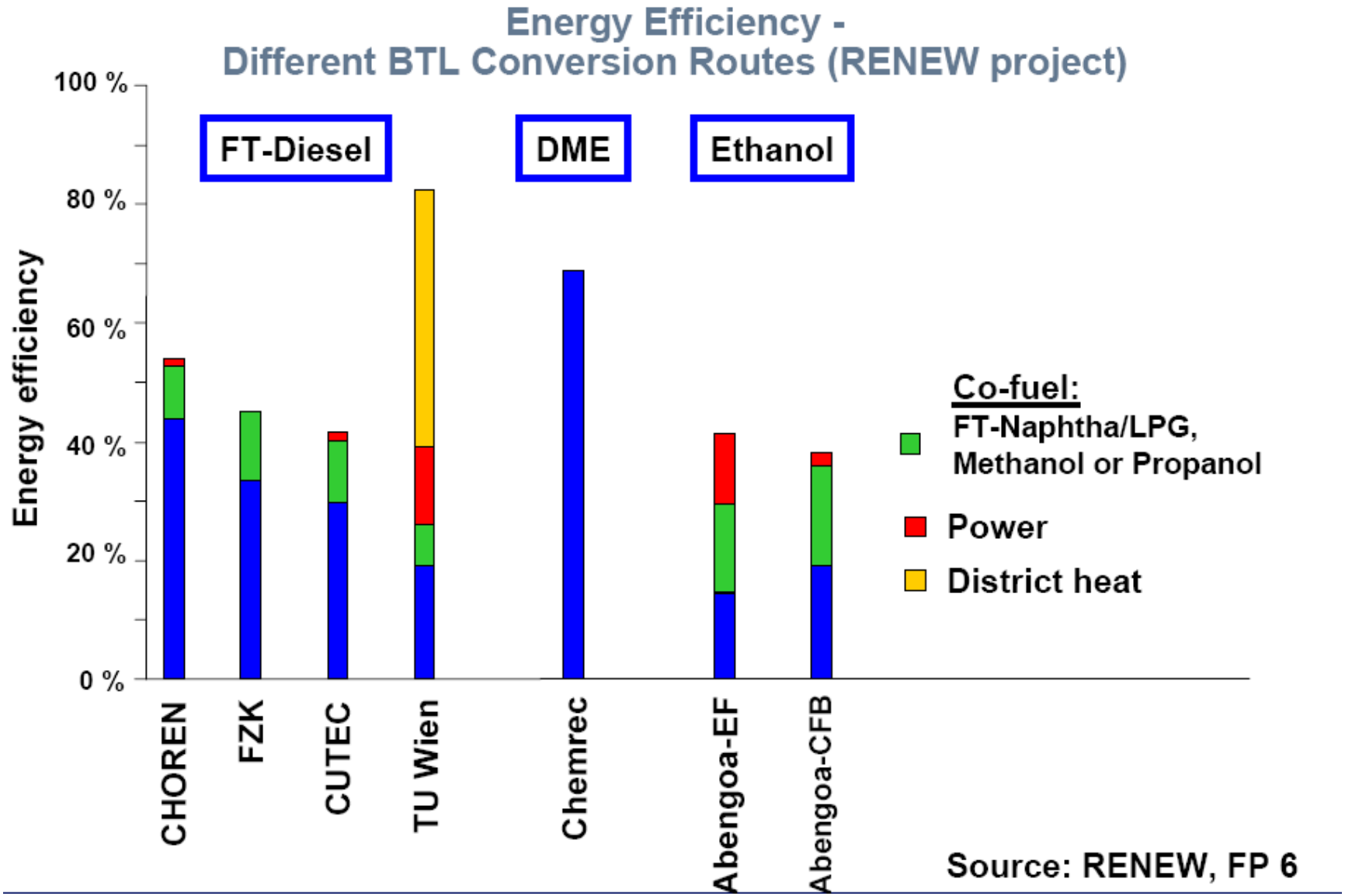
- Fuel components
- Byproducts
- Waste streams
- Heat

Technology
- Licence
- Performance

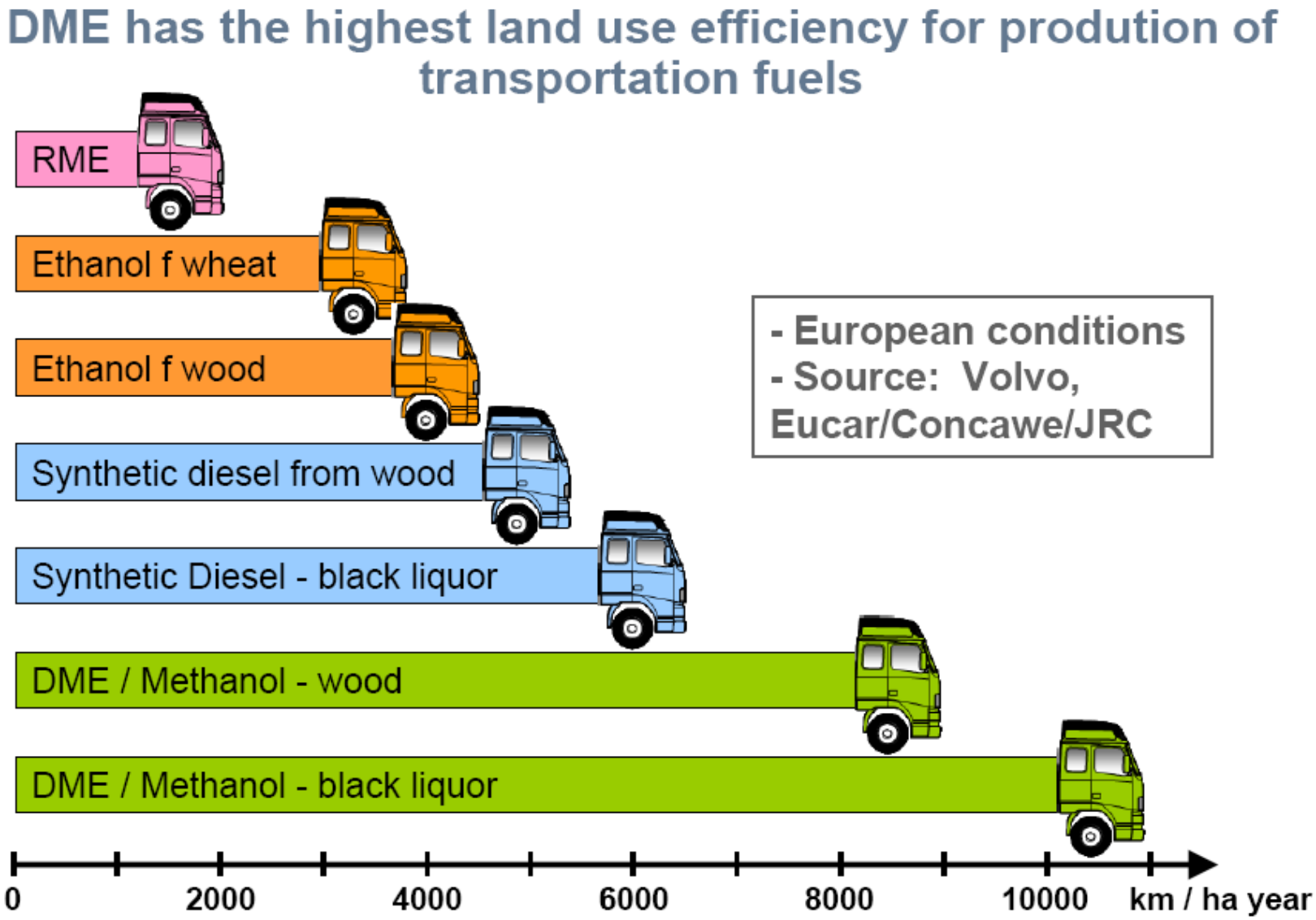
Brandstoffen 4: Economie



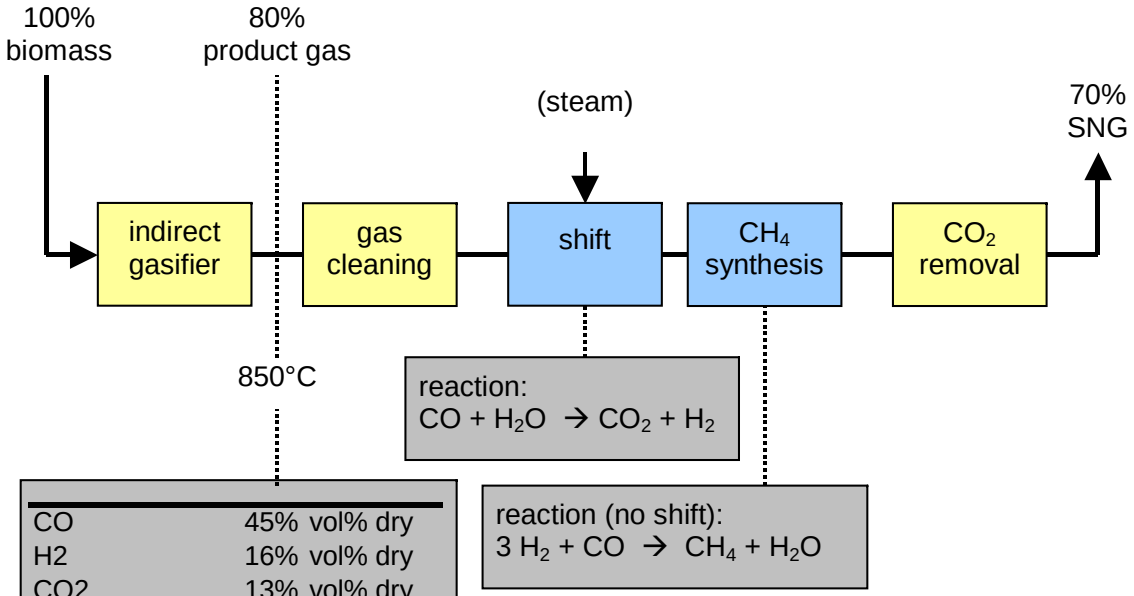
Brandstoffen 5: coproducten en rendement



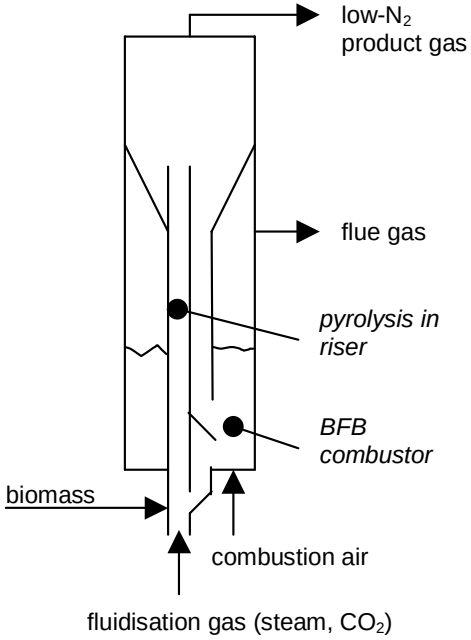
Brandstoffen 6: Di-Methiel-Ether



Brandstoffen 7: Substitute Naturel Gas, processchema



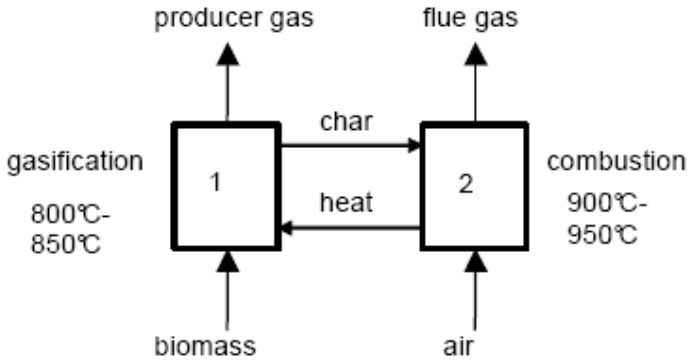
CO	45% vol% dry
H2	16% vol% dry
CO2	13% vol% dry
CH4	18% vol% dry
C2H2	1% vol% dry
C2H4	5% vol% dry
C2H6	1% vol% dry
C6H6	1% vol% dry
N2	1% vol% dry
tar	0.4% vol% dry
H2O	35% vol% wet

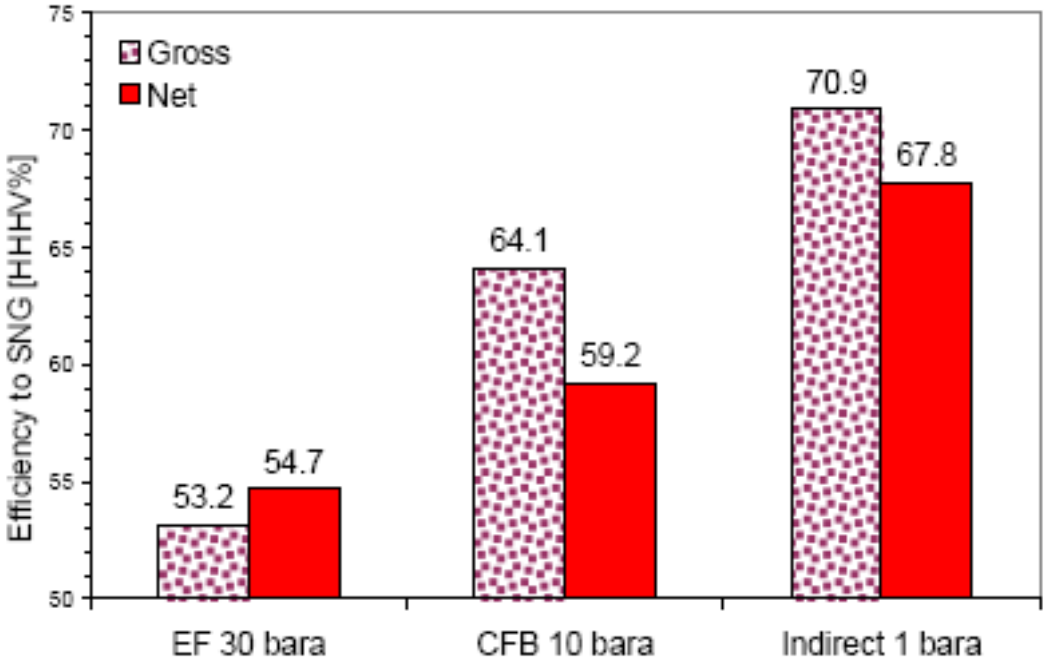


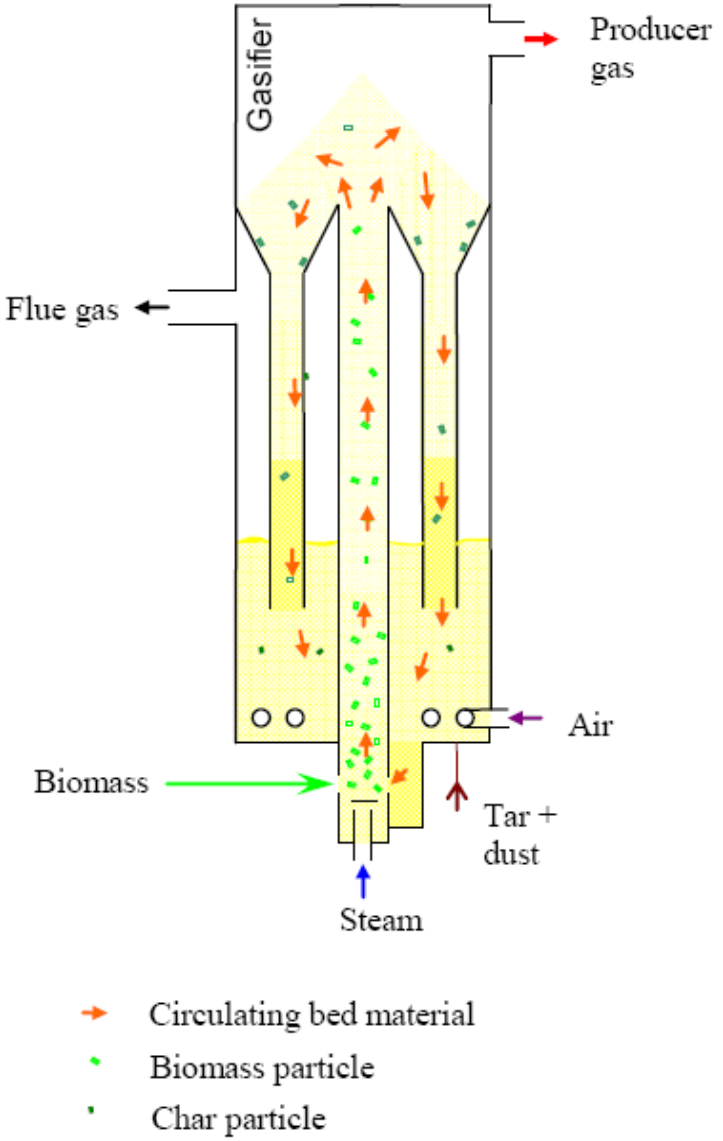
		O_2-blown gasifier	Indirect gasifier	Hydrogasifier
Thermal input				
biomass	MW	100	100	50
hydrogen	MW			47
Efficiency SNG production	%	67.0*	66.3*	79.1
Carbon conversion	%	100	93.3	80.1
Specific investment costs	€/kW_{th}	449	482	616
SNG production costs	€/GJ_{SNG}	7.8	8.5	5.6
Dutch market price “Green Gas”	€/GJ_{SNG}	8.7	8.7	5.2
	€/tonne	83	95	115

* When the separated tar from the product gas is recycled and converted within the gasifier, SNG production efficiencies up to 70% (on LHV basis) can be achieved.

Brandstoffen 8: Substitute Natural Gas, grootschalige productie







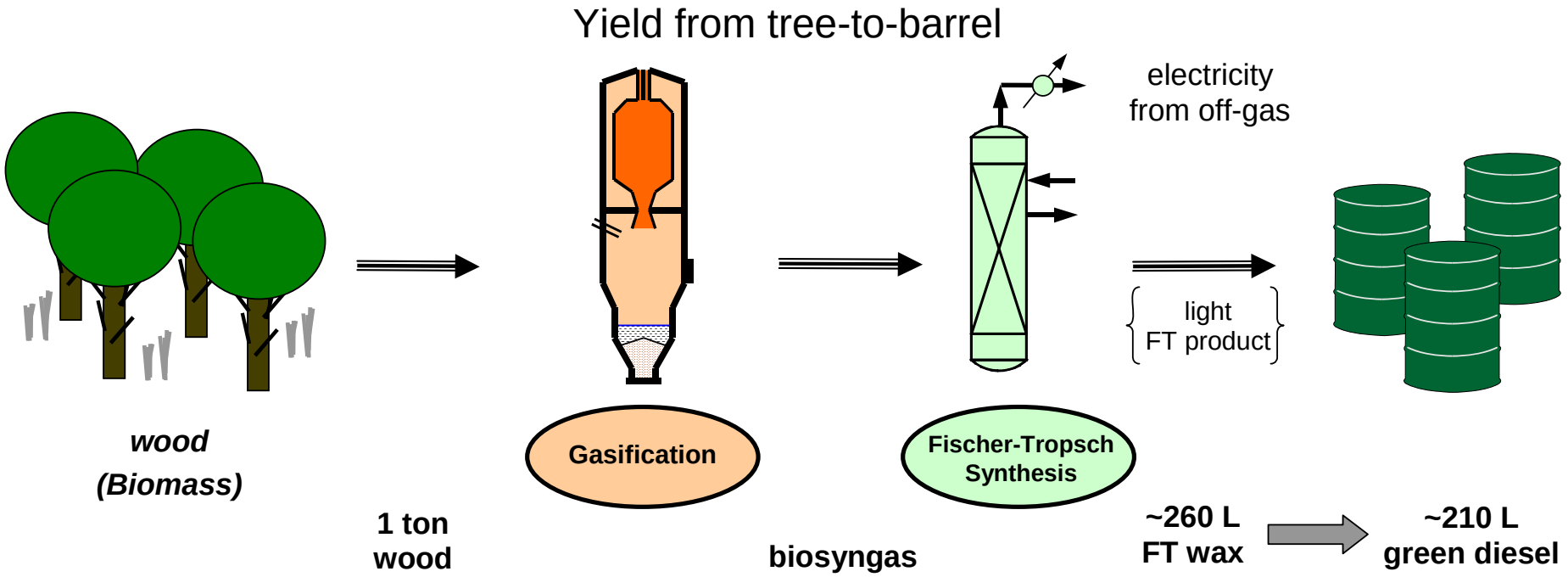
Brandstoffen 9: Substitute Natural Gas, eigenschappen

Property		NG	O_2-blown gasifier	Indirect gasifier	Hydrogasifier
Composition					
CH_4 (incl. C_{2+})	vol.%	84.75	87.67	87.62	82.97
H_2	vol.%	0.00	1.77	1.95	8.02
CO_2	vol.%	0.89	8.65	8.90	8.37
N_2	vol.%	14.35	1.84	1.441	0.53
Calorific value, LHV	MJ/kg	38.0	38.41	38.41	39.57
	MJ/Nm^3	31.7	31.26	31.26	30.67
Wobbe-index	MJ/Nm^3	43.46-44.41	43.74	43.74	44.03

		O_2-blown gasifier	Indirect gasifier	Hydrogasifier
Thermal input				
biomass	MW	100	100	50
hydrogen	MW			47
Efficiency SNG production	%	67.0*	66.3*	79.1
Carbon conversion	%	100	93.3	80.1
Specific investment costs	€/kW_{th}	449	482	616
SNG production costs	€/GJ_{SNG}	7.8	8.5	5.6
Dutch market price “Green Gas”	€/GJ_{SNG}	8.7	8.7	5.2
	€/tonne	83	95	115

* When the separated tar from the product gas is recycled and converted within the gasifier, SNG production efficiencies up to 70% (on LHV basis) can be achieved.

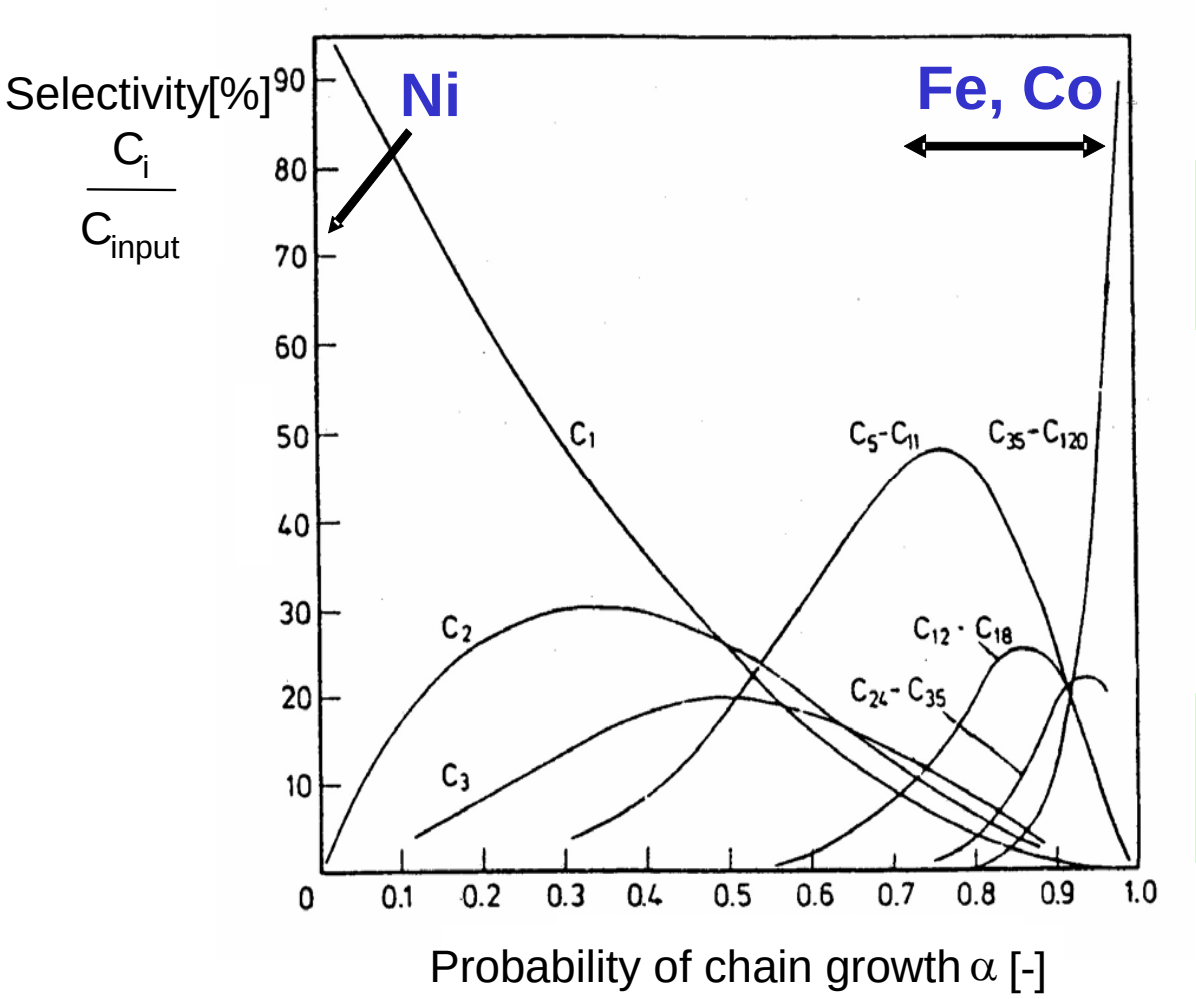
Brandstoffen 10: Fisher Tropsch diesel



Energy efficiency from wood to diesel = ~44%, light products: 11%, power: 14% -> total energetic efficiency: 69%

Optimised technology; 7% moisture; 78% CGE to syngas; 95% FT conversion; 92% C5+ yield; 80% wax-to-diesel yield; EE to light product 11%; EE to electricity 14% (55% CC, 25% heat); overall EE 69%

Brandstoffen 11: Fisher Tropsch diesel en SNG als coproduct



Catalyst for fuel synthesis

Bio-SNG

$CO + 3\,H_2 \Longleftrightarrow \mathbf{CH_4} + H_2O$

C_1: methane

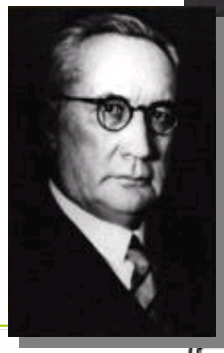
C_5-C_{11}: gasoline

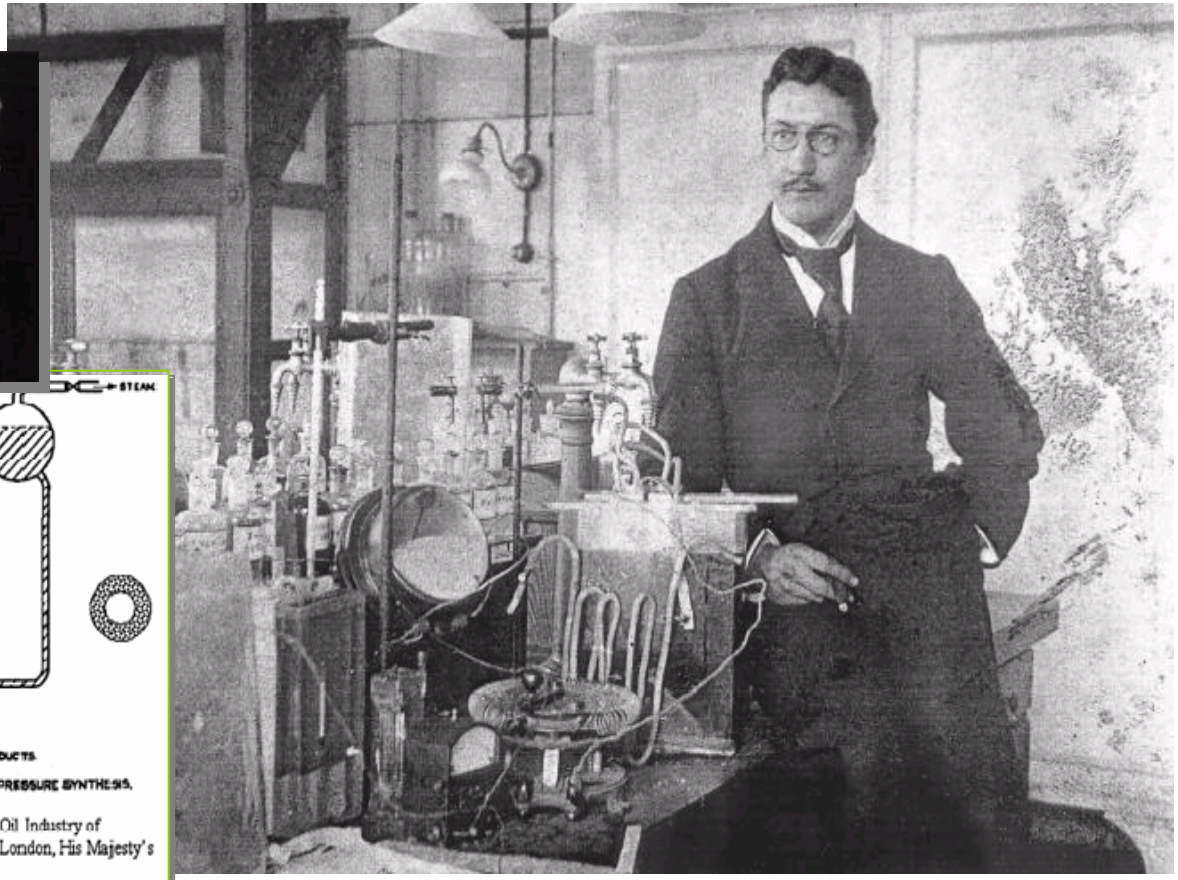
C_{12}-C_{18}: diesel

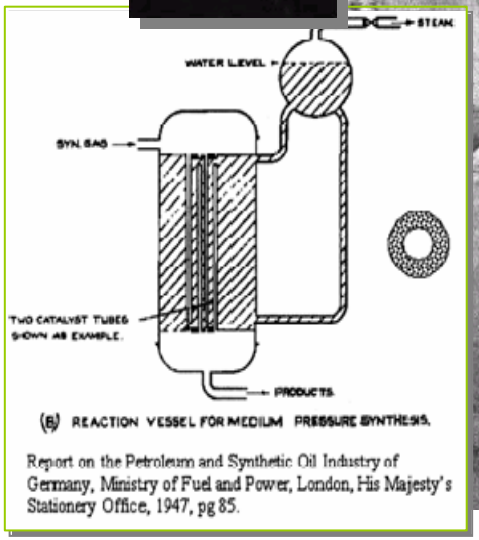
FT liquids

$8\,CO + 17\,H_2 \Longleftrightarrow \mathbf{C_8H_{18}} + 8\,H_2O$

Fischer-Tropsch



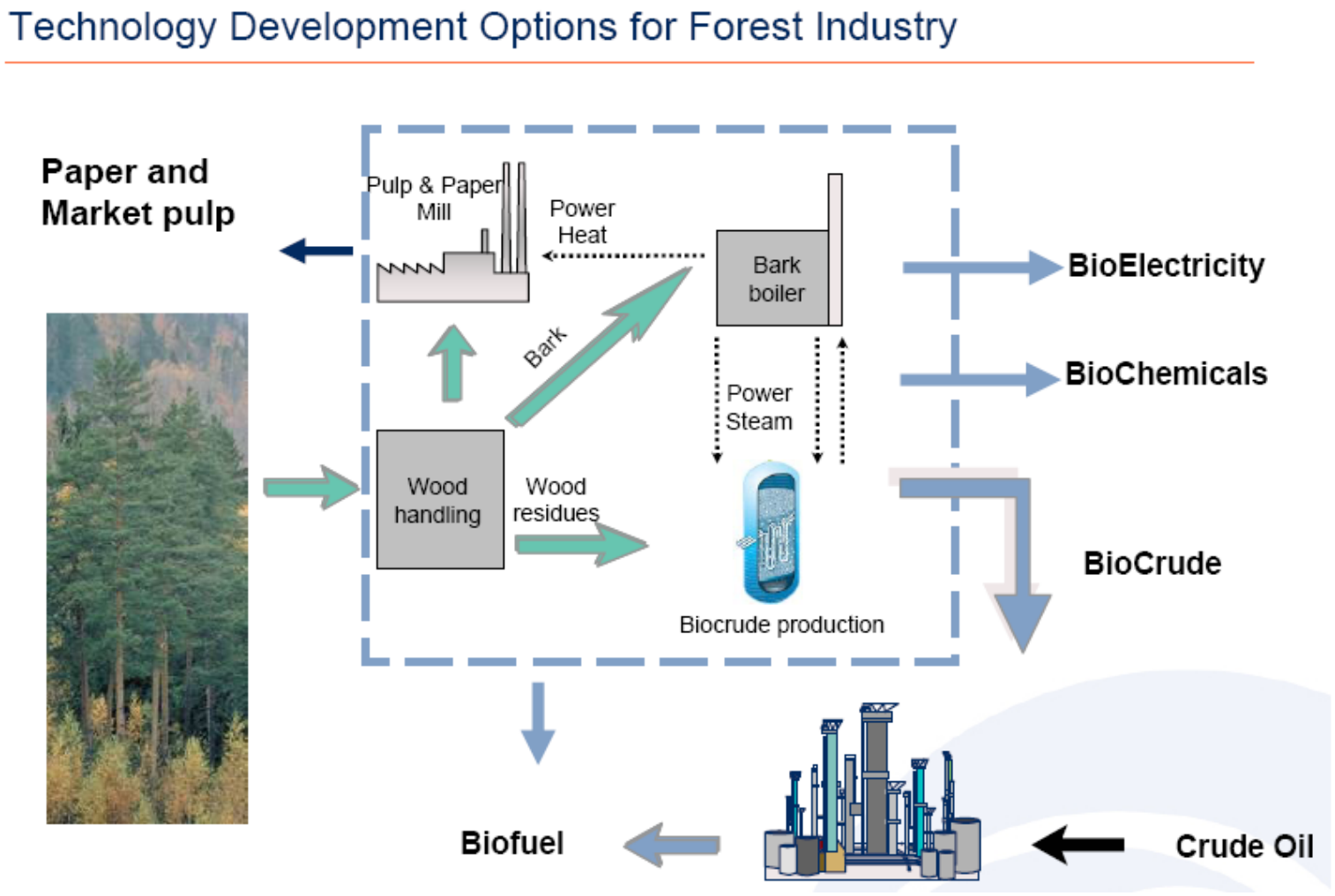




(B) REACTION VESSEL FOR MEDIUM PRESSURE SYNTHESIS.

Report on the Petroleum and Synthetic Oil Industry of Germany, Ministry of Fuel and Power, London, His Majesty's Stationery Office, 1947, pg 85.

Brandstoffen 12: Fisher Tropsch diesel productie en integratie met Pulp and Paper



Our 2G BTL Concept