

## ‘GREEN’ DIESEL PRODUCTION WITH FISCHER-TROPSCH SYNTHESIS

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Revisions		
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# 'Green' Diesel Production with Fischer-Tropsch Synthesis

*Business Meeting Bio-Energy*, Platform Bio-Energie  
13 September 2002

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ECN Biomass

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## Content

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- Why renewable transportation fuels
- Fischer-Tropsch synthesis
- From biomass to 'green' diesel
- Challenges
- Perspectives
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# Definitions

## for renewable fuels

<b>Bio-diesel</b>	liquid product from esterification of vegetable oils (e.g. rapeseed oil) = RME
<i>versus</i>	
<b>Green diesel</b>	high-quality ultra-clean diesel-like product from Fischer-Tropsch synthesis
<b>Biosyngas</b>	gas rich in H <sub>2</sub> and CO obtained by gasification of biomass
<b>Syngas</b>	comparable to biosyngas, but from fossil origin
<b>Bio-gas</b>	from digestion of organic matter, consisting mainly of CH <sub>4</sub> and CO <sub>2</sub>
<b>Bio-ethanol</b>	from fermentation of organic matter

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# Renewable Fuels

## motivation for ECN

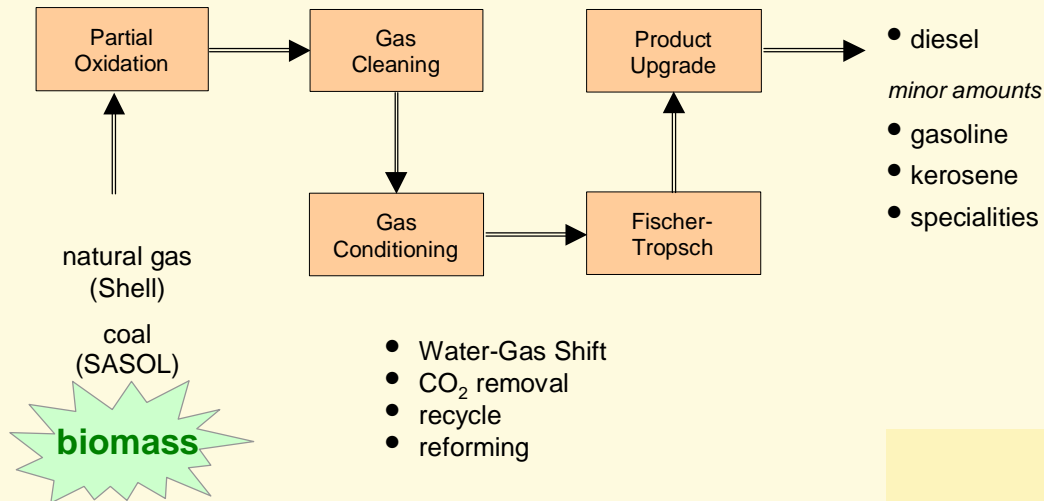
- Biomass-based fuels
  - renewable energy
  - reduction of CO<sub>2</sub> emissions
  - reserves of fossil fuels are not endless
- Directives from European Commission
  - 2% share in 2005 (for bio-fuels)
  - 6% in 2010
  - 8% in 2020

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# Diesel with Fischer-Tropsch

from feed to diesel



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# Fischer-Tropsch Diesel

a high quality product

- Contains no sulphur: no SO<sub>x</sub> emissions
  - to fulfil stronger European regulations
- Contains no aromatics: cleaner combustion
  - lower particulate emissions (-40%)
  - lower NO<sub>x</sub> emissions (-20%)
  - application in niche markets (city buses, canal boats)
- Added value compared to fossil diesel
  - blending to product (South-East Asia)

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# Challenges

For FT diesel from Biomass

Demonstrate integrated system of:

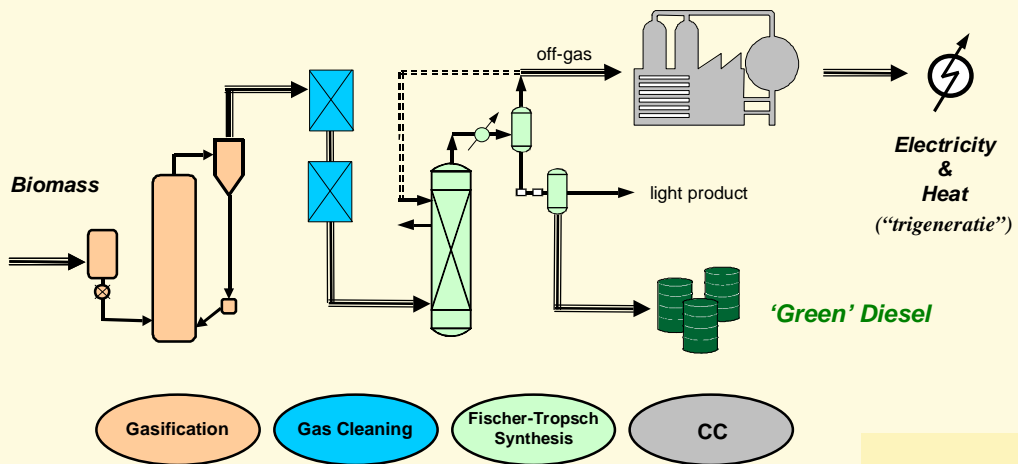
- biomass gasification,
- gas cleaning, and
- Fischer-Tropsch synthesis



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# Integrated System

BG-FT-CC

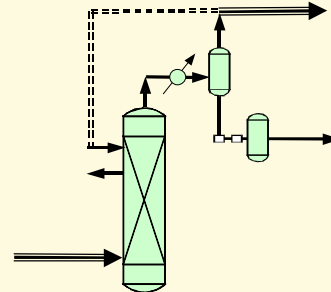


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# Fischer-Tropsch synthesis

specifications feed gas

Impurity	Removal level
H <sub>2</sub> S + COS + CS <sub>2</sub>	< 1 ppmV
NH <sub>3</sub> + HCN	< 1 ppmV
HCl + HBr + HF	< 1 ppmV
solids (soot, dust, ash)	quantitative
organic compounds (tars)	below dew point
- class 2 (hetero atoms)	< 1 ppmV



- class 2 tars: phenol, pyridine, thiophene
- organic compounds include also BTX

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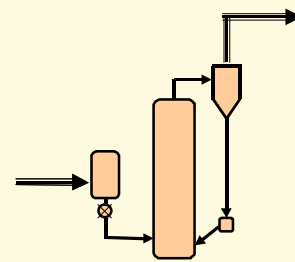
# Biomass gasification

raw biosyngas

Main Constituents	[vol%, dry]	[LHV%]
CO	18	27.8
H <sub>2</sub>	16	21.1
CO <sub>2</sub>	16	-
N <sub>2</sub>	42	-
CH <sub>4</sub>	5.5	24.1
C <sub>2</sub> H <sub>4</sub> (ethene)	1.7	12.4
C <sub>2</sub> H <sub>6</sub> (ethane)	0.1	0.8
BTX	0.53	10.5
sum of tars	0.12	2.8
<b>TOTAL</b>	<b>100</b>	<b>100</b>

Impurities	[mg/m <sup>3</sup> ]
NH <sub>3</sub>	2200
HCl	130
H <sub>2</sub> S	150
all COS, CS <sub>2</sub> , HCN, HBr	< 25
dust, soot, ash	2000



CFB gasifier  
air-blown, atmospheric

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# Design Gas Cleaning

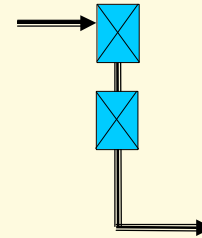
for large-scale systems

Gas		Raw biosyngas	Cracked biosyngas	FT feed gas
CH <sub>4</sub>	[vol%]	6.42	0.01	0.01
C <sub>2</sub> H <sub>4</sub>	[ppmV]	5936	< 5	< 5
C <sub>2</sub> H <sub>6</sub>	[ppmV]	7359	< 5	< 5
BTX	[ppmV]	1266	< 5	< 5
Tars	[ppmV]	+/- 50%	< 10	< 10
NH <sub>3</sub>	[ppmV]	~	516	0.02
H <sub>2</sub> S	[ppbV]	~	23789	< 10
COS	[ppbV]	~	47578	278
CS <sub>2</sub>	[ppbV]	~	207	< 10
TOTAL	[vol%]	100.0	100.0	100.0

(Experimental data)

1. high-temperature tar cracker
2. wet scrubbers
3. active carbon en ZnO guard beds

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# Technical Feasibility

demonstration of integrated system

Two tests for 150 h and 500 h:

1. *gasification of willow*
2. *cleaning of biosyngas to FT specifications*
3. *operating a small FT unit on the cleaned gas*

## Successful:

- No loss of catalyst activity
- Constant gas consumption and off-gas composition
- FT products similar to fossil equivalents

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## “Product in Bottle”



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## Perspectives

Large-scale production of green diesel is required, for:

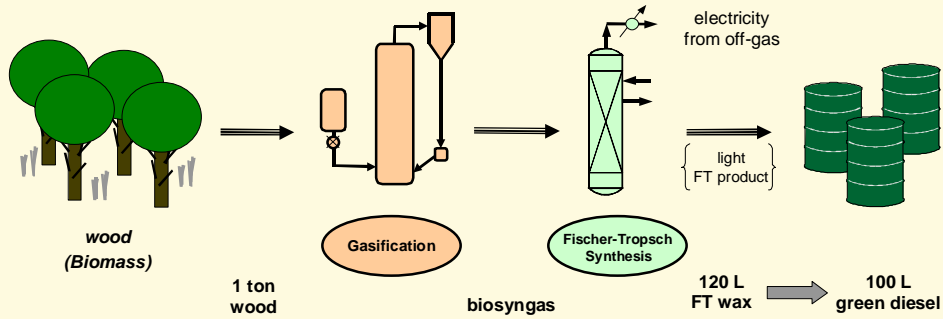
- replacement of significant part of fossil diesel
- reduction of production costs

*Further technology optimisation is required !!*

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# From Tree to Barrel

yield of green diesel from wood



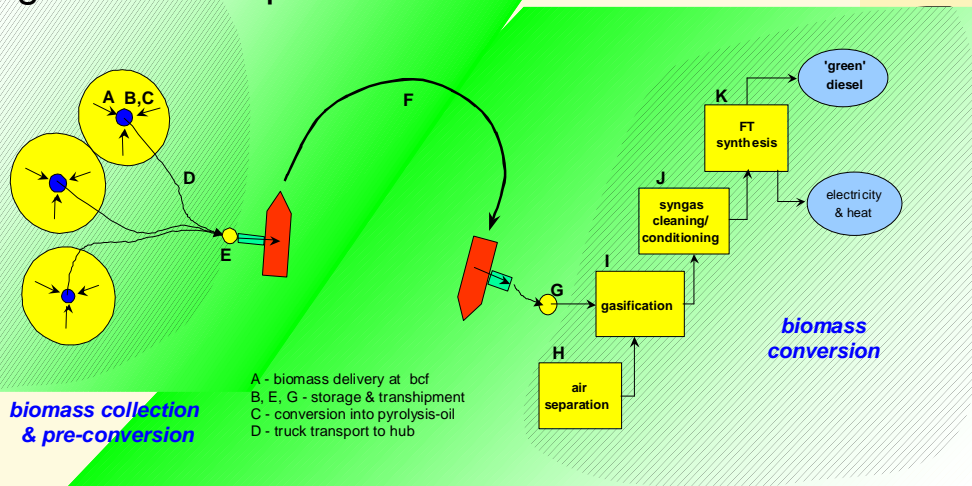
10% moisture, no tar cracker, once-through FT, 90% conversion, 80% C5+ yield

Future technology improvements allow increase of yield to:  
over 210 L green diesel per ton wood

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# Large-Scale Import

general line-up

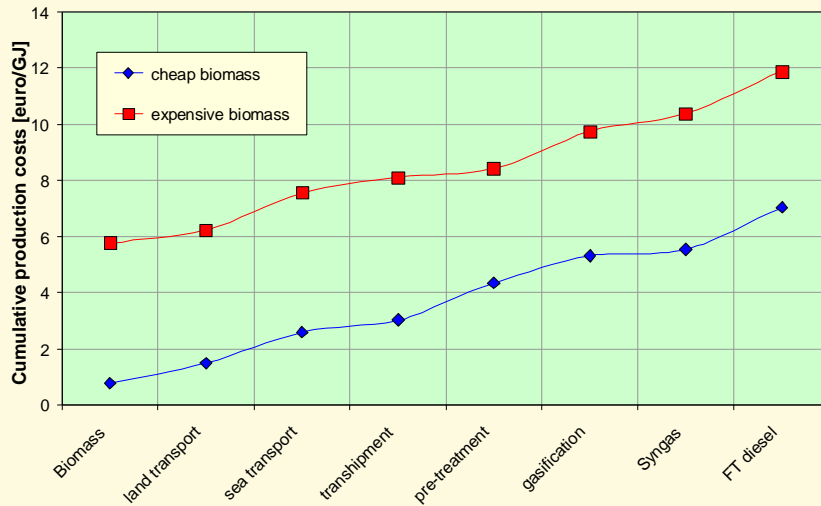


Projected situation after 2010 ...

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# Large-Scale Import

cumulative cost break-down 'green' diesel



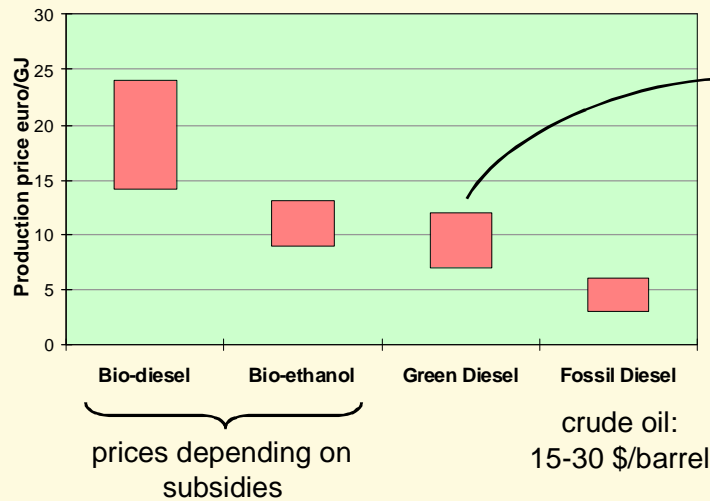
Efficiency = crucial !

(from 2010)

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# Perspectives of Green Diesel

comparison with green alternatives

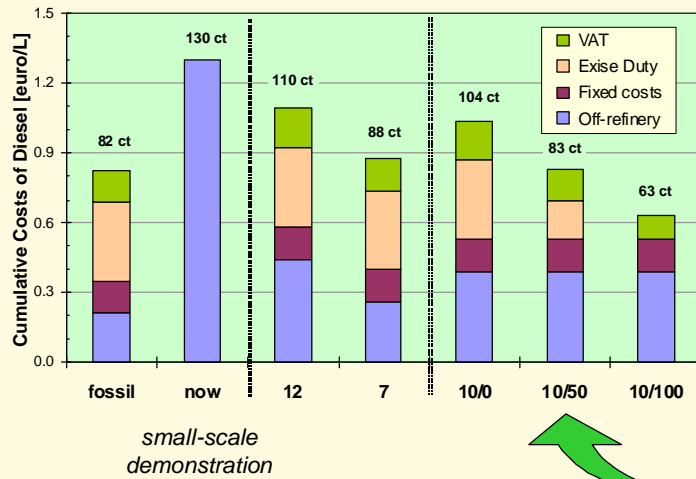


Green diesel: projected production costs for large scale (from 2010)

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# Perspectives of Green Diesel

cost break-down price-at-pump



FT diesel costs  
range 12 to 7 €/GJ

Expected price:  
10 €/GJ

Exise Duty  
exemption level

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## Conclusions

for Green (FT) Diesel

- High quality fuel (sulphur and aromatics free)
- Production from biomass is technical feasible
- Technology optimisation required for cost reduction
- Competitive with other renewable fuels
- With tax incentives also competitive with fossil diesel

*(assuming large-scale production and technology optimisation)*

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