May 2003 ECN-RX--03-014

‘GREEN’ DIESEL PRODUCTION WITH FISCHER-TROPSCH SYNTHESIS

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Presented at the Business Meeting Bio-Energy, Platform Bio-Energie
13 September 2002

Revisions			
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B			
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‘Green’ Diesel Production with Fischer-Tropsch Synthesis

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ECN Biomass

Content

- Definitions
- Why renewable transportation fuels
- Fischer-Tropsch synthesis
- From biomass to ‘green’ diesel
- Challenges
- Perspectives
- Conclusions

Definitions

for renewable fuels

Bio-diesel	liquid product from esterfication of vegetable oils (*e.g*. rapeseed oil) = RME
versus	
Green diesel	high-quality ultra-clean diesel-like product from Fischer-Tropsch synthesis
Biosyngas	gas rich in H_2 and CO obtained by gasification of biomass
Syngas	comparable to biosyngas, but from fossil origin
Bio-gas	from digestion of organic matter, consisting mainly of CH_4 and CO_2
Bio-ethanol	from fermentation of organic matter

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Renewable Fuels

motivation for ECN

- Biomass-based fuels
  - renewable energy
  - reduction of CO_2 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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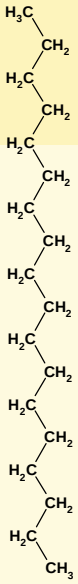
Fischer-Tropsch Synthesis

chemistry



- Established in 1923 by German researchers Franz Fischer and Hans Tropsch
- Synthesis of long-chain hydrocarbons from CO en H_2
- Catalysts: iron (Fe) en cobalt (Co)

Co: $CO + 2\,H_2 \rightarrow -CH_2- + H_2O$

WGS: $CO + H_2O \rightarrow CO_2 + H_2$

Fe: $2\,CO + H_2 \rightarrow -CH_2- + CO_2$

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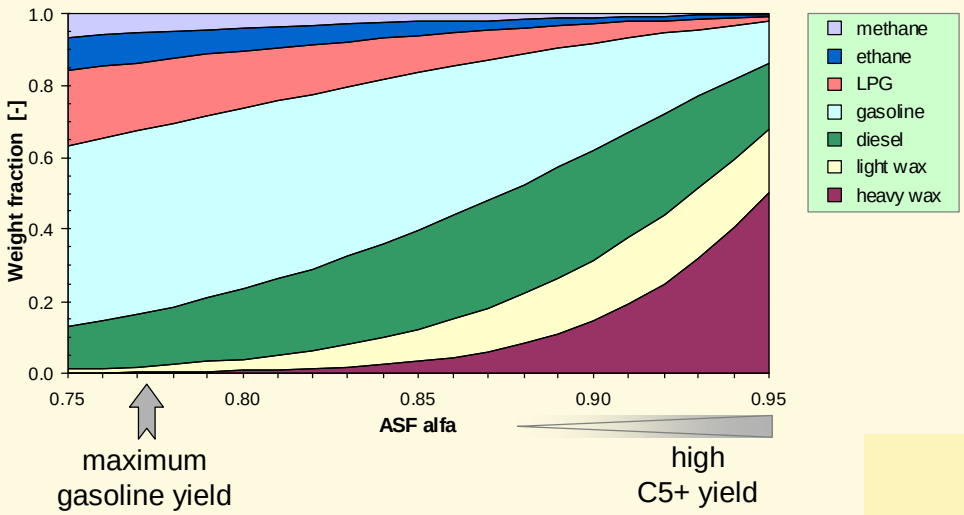
Products from FT synthesis

Anderson-Schulz-Flory (ASF) relation



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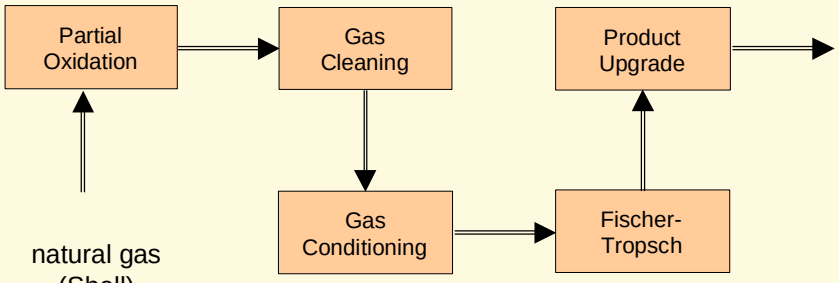
Diesel with Fischer-Tropsch

from feed to diesel



- diesel

minor amounts

- gasoline
- kerosene
- specialities

natural gas (Shell)

coal (SASOL)

biomass

- Water-Gas Shift
- CO_2 removal
- recycle
- reforming

Fischer-Tropsch Diesel

a high quality product

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

Challenges

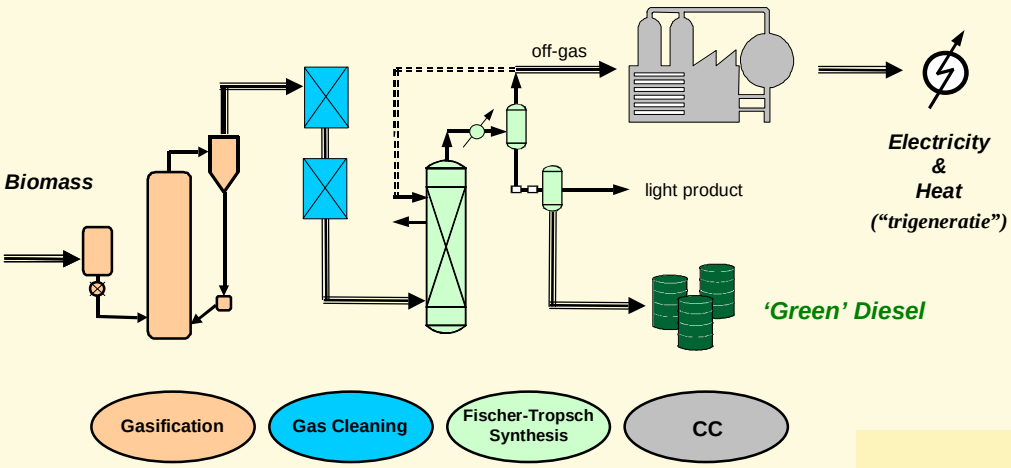
For FT diesel from Biomass

Demonstrate integrated system of:

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

Integrated System

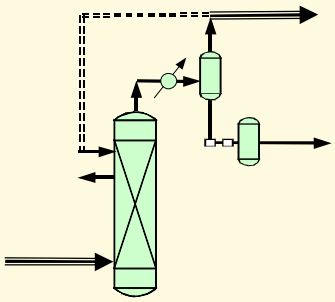
BG-FT-CC



Fischer-Tropsch synthesis

specifications feed gas

Impurity	Removal level
$H_2S + COS + CS_2$	< 1 ppmV
$NH_3 + HCN$	< 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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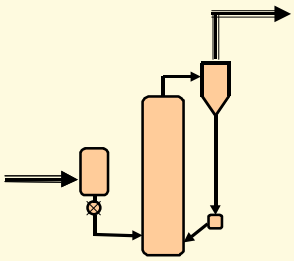
Biomass gasification

raw biosyngas

Main Constituents	*[vol%, dry]*	*[LHV%]*
CO	18	27.8
H_2	16	21.1
CO_2	16	-
N_2	42	-
CH_4	5.5	24.1
C_2H_4 (ethene)	1.7	12.4
C_2H_6 (ethane)	0.1	0.8
BTX	0.53	10.5
sum of tars	0.12	2.8
TOTAL	*100*	*100*

Impurities	*[mg/m_n^3]*
NH_3	2200
HCl	130
H_2S	150
all COS, CS_2, HCN, HBr	< 25
dust, soot, ash	2000



CFB gasifier
air-blown, atmospheric

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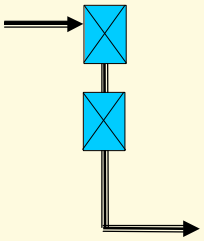
Design Gas Cleaning

for large-scale systems

Gas		Raw biosyngas	Cracked biosyngas	FT feed gas
CH_4	[vol%]	6.42	0.01	0.01
C_2H_4	[ppmV]	5936	< 5	< 5
C_2H_6	[ppmV]	7359	< 5	< 5
BTX	[ppmV]	1266	< 5	< 5
Tars	[ppmV]	+/- 50%	< 10	< 10
NH_3	[ppmV]	~	516	0.02
H_2S	[ppbV]	~	23789	< 10
COS	[ppbV]	~	47578	278
CS_2	[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

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

“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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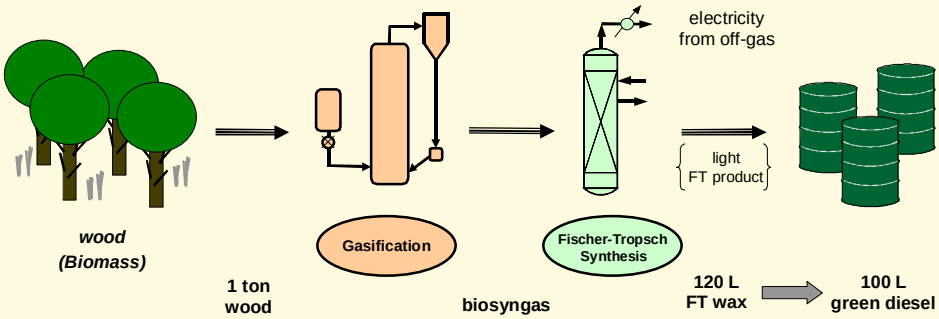
From Tree to Barrel

yield of green diesel from wood

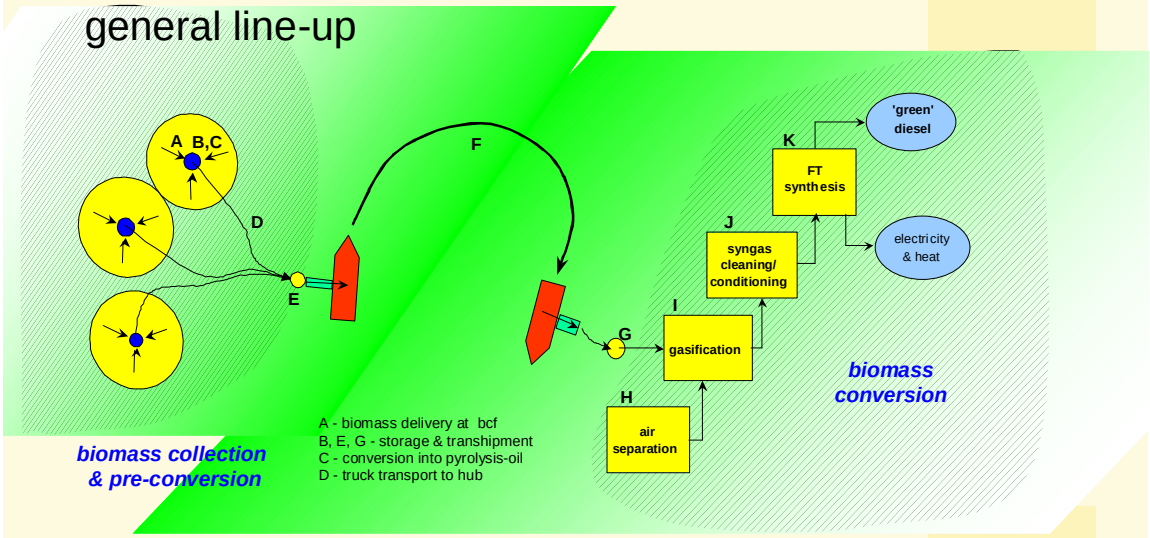


10% moisture, no tar cracker, once -through FT, 90% conversion, 80% C5+ yield

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

Large-Scale Import

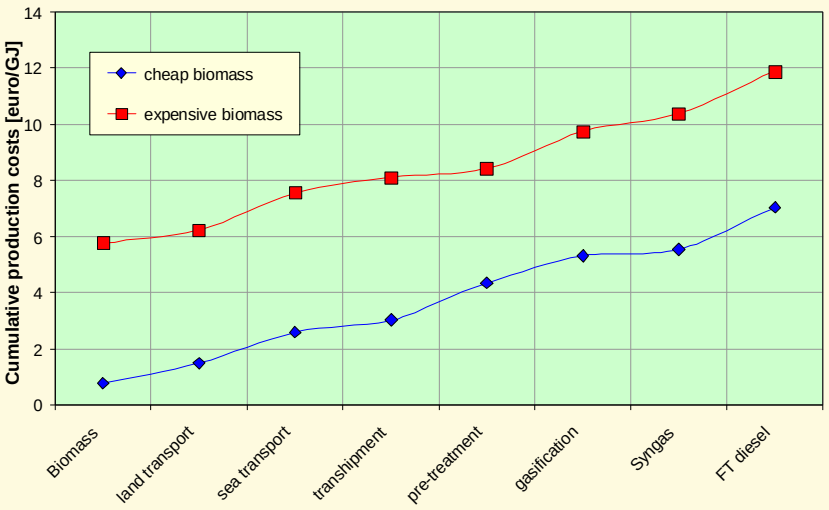
general line-up



Projected situation after 2010 ...

Large-Scale Import

cumulative cost break-down ‘green’ diesel



Efficiency
=
crucial !

(from 2010)

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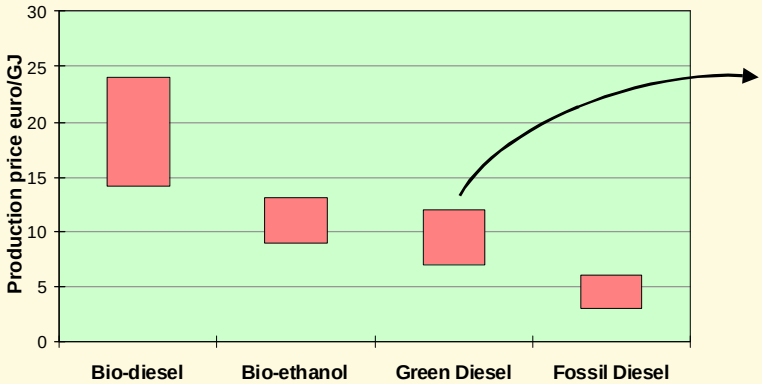
Perspectives of Green Diesel

comparison with green alternatives



Green diesel:

projected production costs for large scale

(from 2010)

prices depending on subsidies

crude oil:
15-30 $/barrel

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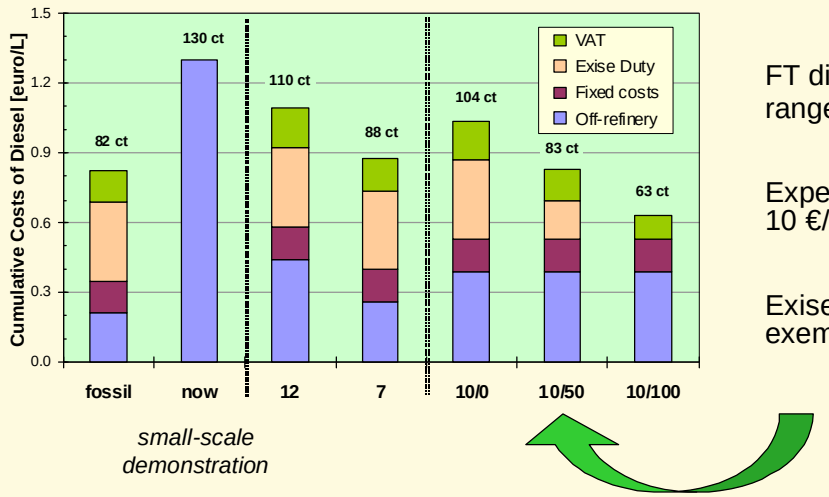
Perspectives of Green Diesel

cost break-down price-at-pump



FT diesel costs range 12 to 7 €/GJ

Expected price: 10 €/GJ

Exise Duty exemption level

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)