# Internationale ontwikkelingen in Biosyngas en Waterstofproductie

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## Company profile BTG

> Spin-off company of University of Twente ('87)

> Independent, private firm, specialised in conversion of biomass into fuels and energy

> Track record: >1,500 projects in > 80 countries, > 40 systems and factories installed

> Unique selling points: market oriented, integrated R&D and consulting, global network



## Key services

> Consulting
- studies & technology assessment
- business development
- developing countries

> Research & Development
- contract research
- technology development

> Project Development / Implementation



## Implementation projects

> Anaerobic digestion plants (Moldovia, Costa Rica, NL, …

> Carbonization plants (Ghana, NL, Estonia, China…)

> Combustion (Bolivia, Bulgaria, Czech Republic, Brazil, …)

> Briquetting of sawdust (Netherlands)

> Pellet factories (Slovakia)

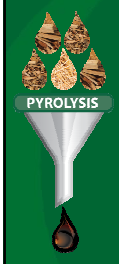
> Household energy (Africa)

> Agglomeration charcoal fines (Africa)



## Core business Pyrolysis: Why?

*Decoupling in biomass resource, location, time and scale*




› Tradable liquid products as main product from biomass (≤70%)

› Minerals remain in char / ash

› High fuel flexibility

› Increase in energy density with a factor of 4 - 5 (wood) to 10 - 20 (fibrous, wet EFB)

› Linking agriculture to (petro)-chemical industry

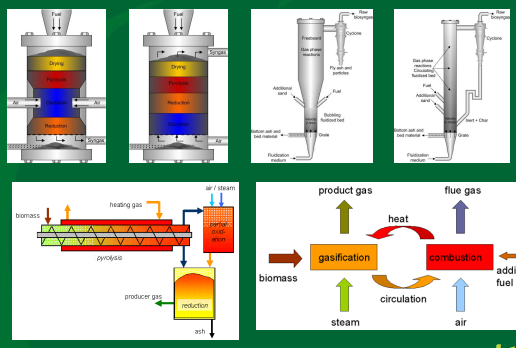
## Demonstration Plant Empyro at AKZO, Hengelo

## Core business gasification: Why?

- Synthesegas is als intermediair voor productie van 2e generatie biobrandstoffen de meest effectieve route; biologische routes verlopen traag en zijn minder efficiënt
- Uit synthesegas kunnen allerlei nuttige producten worden gevormd en is een bouwsteen voor de organische (bulk)chemie
- $CO_2$ afvang is mogelijk voor de secundaire conversie van gas in warmte, elektriciteit of een ander product
- Omzetting van een homogeen gas in energie is veel efficiënter en milieuvriendelijk dan energiewinning uit een inhomogene vaste brandstof
- De te reinigen hoeveelheid producer gas is vele malen kleiner dan de hoeveelheid rookgas

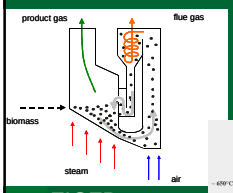


## Klassieke en nieuwe concepten

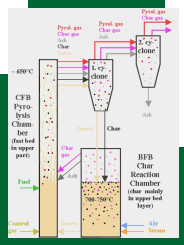




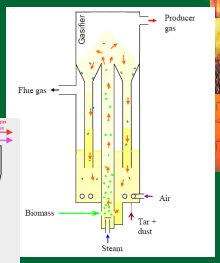

## Allotherme vergassingsprocessen




FICFB



LT-CFB




Milena

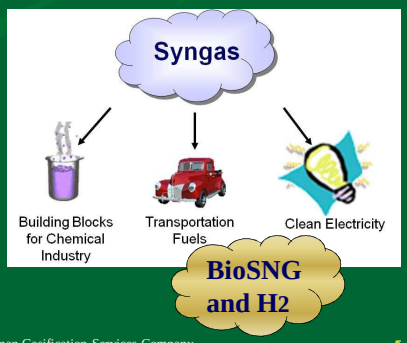


## Large scale gasification technologies

- Gasification/ co-gasification in entrained flow, slagging gasifiers
- Gasification / co-gasification of bio-liquids in residue gasifiers
- Catalytic gasification/co-gasification in ACR-systems (autothermal catalytic reforming)
- Gasification Technologies Council database at www.gasification.org (> 150 facilities, > 500 gasifiers)



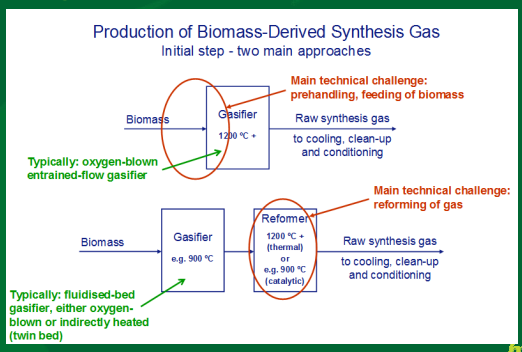
## Wat kunnen we doen met CO + $H_2$?



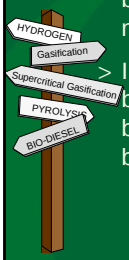

Source: Eastman Gasification Services Company



## Key issues



## BTG's involvement on large scale BG




> Suprabio: Review on the gasification of bioliquids and slurries in slagging and non-slagging entrained flow gasifiers

> IEA Task 27: Hydrogen market facilitation based on distributed processing of biomass to tradable intermediates – bioenergy carriers



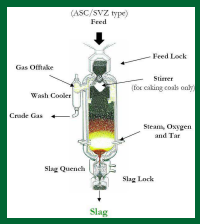
## Moving bed gasifiers

> Either slagging or non-slagging depending on temperature and ash fusion temperature

> Lower temperature; volatile components difficult to decompose

> Coal is fed as dry, lump
  – (5 to 50 mm)

> Britisch Gas Lurgi (BGL)






## Fluidized bed gasifiers

> Feedstock introduced into upward stream of oxygen

> Carbon conversion limited due to loss of feedstock in ash stream

> Size of feed – 0.5 to 5 mm

> Low rank coals or biomass

> Non-slagging to avoid maintenance issues

> Produces very dirty syngas with high tar content due to lower temperatures

> High Temperature Winkler (HTW)



## Entrained flow gasifiers

> Slagging - for ash containing feedstock

> Non-slagging - for essentially ash-free feedstock

> Particles must be less than 500 µm

> Short residence times (1-10 seconds)

> Highest operating temperatures

> Tar-free syngas

> 99% carbon conversion



## Examples entrained flow gasifiers

> Koppers-Totzek (Hamburg)

> Shell (Buggenum)

> Prenflo (Puertollano, Spain)

> Siemens (formerly Future Energy, Noell)

> General Electric (formerly Texaco)

> Conoco Philips E-gas (Destec, Dow)

> Lurgi's Multi Purpose

> Mitsubitsi Heavy Industries

> Choren Industries



## Methanization of syngas

$CO + H_2O \Rightarrow H_2 + CO_2$ (water-gas shift)

> $H_2$/CO ratio of different biomass gasifier: 0,3 .... 1,6

> $H_2$/CO ratio preferred for SNG production: 3,0

> Low temperature favours methane production, but

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

$CO_2 + 4H_2 \Rightarrow \mathbf{CH_4} + H_2O$

are highly exothermic:
  – more heat produced than $CH_4$

> Nickel, 350 oC, 5 bar, fluid bed

> Upgrading: $CO_2$ removal

PSI test rig

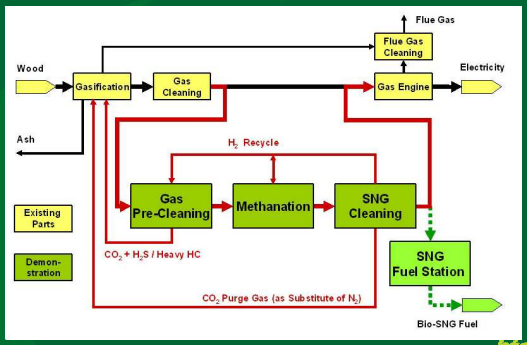
## SNG van bruinkool, Dakota

*14 x FBDB Units, 22 years in Operation: 1985 – 2007*
*Coal: Low Rank, Lignite*
*Products: Substitute Natural Gas (SNG), Ammonium Sulphate, Phenols, $CO_2$ for Oil Exploration*

*Dakota Gasification Company – Beulah, North Dakota USA*



## EU-BioSNG project Güssing






## Other bio-SNG initiatives

> Goteborg Energi, Gobigas project
  – Based on the Güssing concept

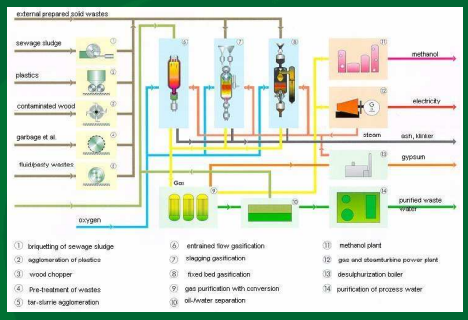
> Oberwart, Austria
  – Based on the Güssing concept

> HVC / ECN
  – Based on the Milena concept

> Investering: 1 miljard € voor 1000 MW input
  – Bron: Ingenia



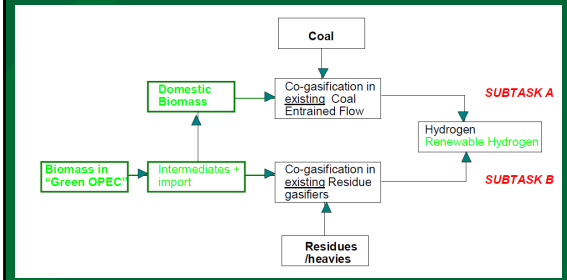
## Gasification of oil and slurries




Schwarze Pumpe and Vresová, CZ



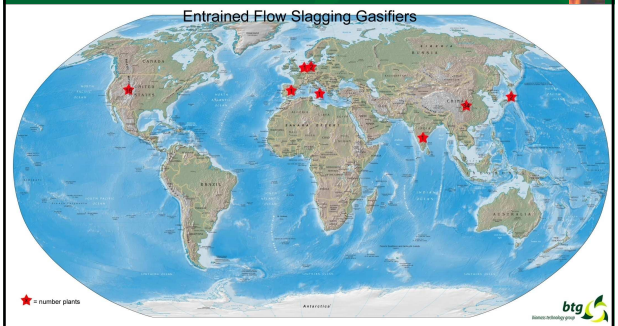
## Near term hydrogen from biomass IEA Task 27-B






## EF slagging or residue gasifiers for bio-slurries (60)

Entrained Flow Slagging Gasifiers

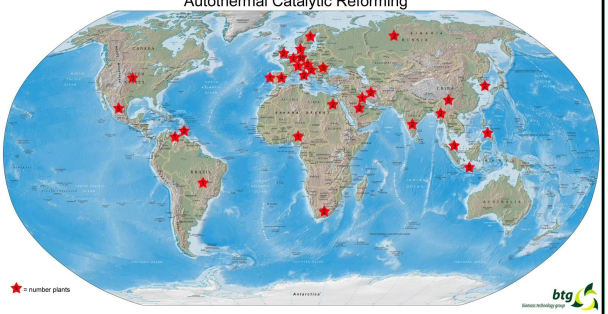


## EF non-slagging gasifiers for bio-liquids (80)

Entrained Flow Non-Slagging Gasifiers

## EF ACR gasification for reforming of bio-liquids (90)

Autothermal Catalytic Reforming





## Hydrogen Production from bio-liquids:

(Co-) Gasification of bio-liquids

- Application of existing 'residue' gasifiers
- Non-catalytic, non slagging
- Commercially applied for production of syngas, hydrogen and other chemicals from (heavy) oil residues

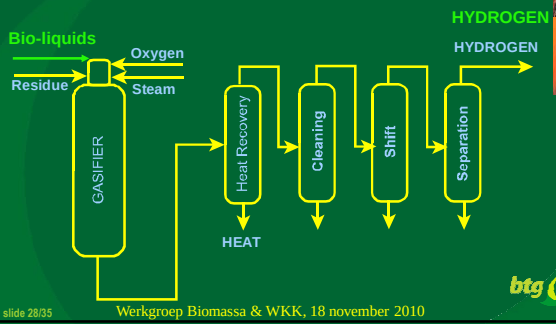
- *Example:*

  Residue gasifier of Shell Pernis, the Netherlands
  - Gasification (non-catalytic partial oxidation) of residues with oxygen
  - Temperature ~ 1350 C; Pressure 65 bar
  - Co-production of hydrogen, steam and electricity
  - Daily hydrogen production ~ 285 tonnes
  - (but location not suitable for experiments)



## Hydrogen Production from Bio-liquids

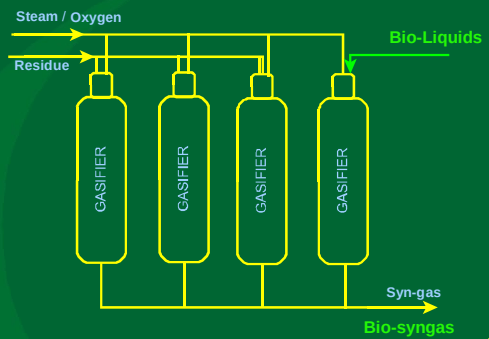
(Co-) Gasification of bio-liquids / torrified material (1)






## Hydrogen Production from Bio-liquids

(Co-) Gasification of bio-liquids / torrified material (2)






## Hydrogen Production from bio-liquids:

Catalytic co-reforming of bio-liquids

- Lower process temperatures
- R&D stage (?not near term)
- Combination with ACR systems

*Example:*

- Catalytic reforming of complete pyrolysis oil at Twente University
- Catalytic reforming of aqueous phase of pyrolysis oil at NREL
- Reforming of bio-ethanol (UK)
- ……

CATALYTIC REFORMING OF PYROLYSIS OIL

## Current hydrogen production

| Plant name | Country | Technology | production |
|---|---|---|---|
| Brisbane H2 | Australia | Ref. gas | 0,8 |
| Singapore Syngas | Singapore | petroleum | 0,7 |
| Paradip gasification | India | petcoke | 4,5 |
| Kaohsuing syngas | Taiwan | petroleum | 3,8 |
| LaPorte synga | USA | gas | 1,4 |
| Convert H2 | USA | petroleum | 1,8 |
| Texas City Praxair | USA | natural gas | 1,1 |
| Ludwigsafen H2 | Germany | petroleum | 1 |
| Gela Ragusa H2 | Italy | natural gas | 0,5 |
| | | **million Nm3/day** | 15,6 |

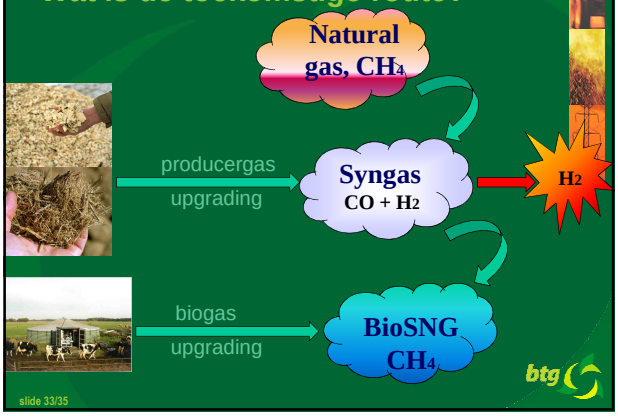


## Concluding remarks

> Challenge: use of intermediates in existing EF
  – torrified material, bioslurries or bioliquids
  – transport of intermediates
> Non-technical issue: 'willingness' to co-gasify bioliquids in existing EF gasifiers
> Near term: co-gasification of bioliquids
> Catalytic and non-catalytic processes
> Growth demand in China



## Wat is de toekomstige route?






## Challenges

> Storage technologies for hydrogen
  – in particular for use in vehicles
  – efficient energy storage (compression)
> Utilization technologies for hydrogen
  – distribution of hydrogen to disperse locations
  – infrastructure: hydrogen pipeline system
  – Safety
> Conventional route; produce syngas from $CH_4$
> New route: produce $CH_4$ from syngas