WASTE GASIFICATION

CFB and SWR

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CONTENTS:

• introduction
• CFB
• SWR
• conclusions
ECN BIOMASS

gasification facilities

- 100 kg/h CFB gasifier
- 1 kg/h BFB gasifier
- 40 kg/h downdraft gasifier
- 5 kg/h screw gasifier
- 5 kg/h BFB or indirect gasifier

introduction
CFB
SWR
conclusions
ECN BIOMASS
gas cleaning facilities

- GASREIP: water-based gas cleaning
- OLGA: oil-based gas cleaning
- high-T filter
- thermal cracker
- wet ESP

introduction
CFB
SWR
conclusions
ECN BIOMASS

gas utilisation facilities

introduction
CFB
SWR
conclusions

flare

Fischer-Tropsch/SNG reactor

boiler

gas compression

gas engine

SOFC
WASTE GASIFICATION

CFB fuel:
- high calorific
- uniform

SWR fuel:
- high calorific
- high ash
- high metal

CFB: circulating fluidised bed
SWR: solid waste resourcer
CFB GASIFICATION

ECN
- test unit
- many fuels: demolition wood, railroad sleepers, plywood, chicken manure, grass, straw, ....
- fuel input: 0.5 MW_{th}
- various gas cleaning options

ESSENT
- co-firing in 600 MW_{e}
  PF-coal boiler (+ESP+deSO_{x})
- demolition wood
- fuel input: 85 MW_{th}
- electricity output: ca. 30 MW_{e}
- CFB-gasifier by Lurgi
(1) 500 kW$_{th}$ circulating fluidised bed (CFB) gasifier; (2) three-stage gas cooler to cool to ~300/350°C; (3) cyclone at 300°C; (4) hot gas filter with sinter metal candles at ~350°C; (5) OLGA tar removal unit; (6) water (NH$_3$) scrubber; (7) wet Electro-Static Precipitator (ESP); (8) stripper; (9) booster; (10) low-NOx-burner; and (11) gas engine or SOFC or Fischer-Tropsch reactor. The black circles indicate valves.
TEMPERATURE:
- efficiency
- conversion
- tar problems
- agglomeration

source: report
ECN-C-02-095
ECN CFB GASIFIER research

TEMPERATURE:
- efficiency
- conversion
- tar problems
- agglomeration

![Graph showing tar concentration vs. gasifier temperature]
ECN CFB GASIFIER

research

TEMPERATURE:
- efficiency
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TEMPERATURE:
- efficiency
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lab-scale bubbling bed gasifier

gasifier temperature [°C]

<table>
<thead>
<tr>
<th>gasifier temperature [°C]</th>
<th>tar dew point [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>650</td>
<td>65</td>
</tr>
<tr>
<td>750</td>
<td>75</td>
</tr>
<tr>
<td>850</td>
<td>85</td>
</tr>
<tr>
<td>950</td>
<td>95</td>
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</table>

- after free-board
- just above bed
ECN CFB GASIFIER research

TEMPERATURE:
- efficiency
- conversion
- tar problems
- agglomeration
ECN CFB GASIFIER research

TEMPERATURE:
- efficiency
- conversion
- tar problems
- agglomeration

source: report ECN-C-99-090
ECN CFB GASIFIER

*best temperature*....

- tar condensation
- sensible heat loss
- agglomeration risk
- carbon loss
- water-soluble tar

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Carbon Loss</th>
<th>Sensible Heat Loss</th>
<th>Agglomeration Risk</th>
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<tbody>
<tr>
<td>700</td>
<td></td>
<td></td>
<td></td>
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<td>800</td>
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<td></td>
</tr>
<tr>
<td>900</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1000</td>
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</table>
ESSENT CFB GASIFIER system

wood chips → GASIFIER → GAS COOLER WITH STEAM GENERATION

steam → power block boiler → electricity

feed water CYCLONE → wood gas

450°C

bottom ash

bed material

air

wood silo → wood receiving building

fly ash

bottom ash

-essent ENERGIE
ESSENT CFB GASIFIER

status

original design:

• assumption: N is critical (NO\textsubscript{x})
• cooling (200°C), filter, water scrubbing, tar removal, etc

presently:

• NH\textsubscript{3}-removal not necessary
• cooling (450°C) and cyclone
• 1500 h total gasification time
• longest run: 5 days
ECN CFB GASIFIER

*best temperature...ESSENT*

**Graph:***
- **x-axis:** temperature (700 to 1000)
- **y-axis:**
  - tar condensation
  - agglomeration risk
  - carbon loss

**Legend:**
- Blue line: carbon loss
- Black line: tar condensation
- Light blue line: agglomeration risk

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**Introduction**

CFB

SWR

Conclusions
CBF GASIFIER

fuel price

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fuel price [€/GJ]

electricity costs [€ct/kWh]

- dashed line: clean biomass (dry)
- solid line: demolition wood (dry)

CHP
12 MW<sub>th</sub>

source: report ECN-C-00-080
SWR: SOLID WASTE RESOURCER

- flexible fuel input, also chemical waste
- high-T gasifier removes all organic species
- marketable products

**ECN test rig**

- waste → slow pyrolysis ca. 500°C → gas → high T gasifier ca. 1200°C → electricity
- waste → slow pyrolysis ca. 500°C → solids → smelter ca. 1500°C → metals basalt
- sludges

• flexible fuel input, also chemical waste
• high-T gasifier removes all organic species
• marketable products
SWR
ECN test unit

fuels tested: wood, WEEE, RDF, ASR, coal, paper reject
syngas produced for Fischer-Tropsch and SOFC

feed 5 kg/h
screw pyrolysis reactor
scrubber
high temperature gasifier
solids out
## SWR electronic waste Br recovery

<table>
<thead>
<tr>
<th></th>
<th>WEEE mix</th>
<th>TV backplates</th>
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<tbody>
<tr>
<td></td>
<td>concentration [mg/kg]</td>
<td>recovery in solids [wt%]</td>
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<tr>
<td>Br</td>
<td>5100</td>
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<tr>
<td>Cl</td>
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<td>Cr</td>
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<td>Mn</td>
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<tr>
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<tr>
<td>Sn</td>
<td>691</td>
<td>25%</td>
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<tr>
<td>Sr</td>
<td>289</td>
<td>85%</td>
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<tr>
<td>Zn</td>
<td>6014</td>
<td>146%</td>
</tr>
</tbody>
</table>

*source: report ECN-C-01-110*
SWR

**first commercial plant**

location: Groningen, the Netherlands

in operation: 2005

fuels:

- demolition waste
- RDF
- chemical wastes
- sludges

capacity: 100 kton/year

supplier: RMH, Utrecht, the Netherlands (Resource Management Holding)
CONCLUSIONS

CFB gasification of biomass/waste:

- commercially available, proven technology
- fuel price dominant in econ. viability
- operational problems related to:
  - solids handling
  - tar-related fouling (cooler, …. filter, scrubber, …
  - agglomeration
CONCLUSIONS

SWR two-stage gasification of waste:

• commercially available
• able to handle all kinds of (chemical) waste
• marketable products:
  - electricity
  - basalt
  - metals
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