

Chemicals from Biomass

A. van der Drift

November 2013
ECN-L--13-083



CHEMICALS from BIOMASS

Bram van der Drift

IEA/Bioenergy-Task 33 – workshop

19 November 2013

Göteborg, Sweden

CHEMICAL INDUSTRY

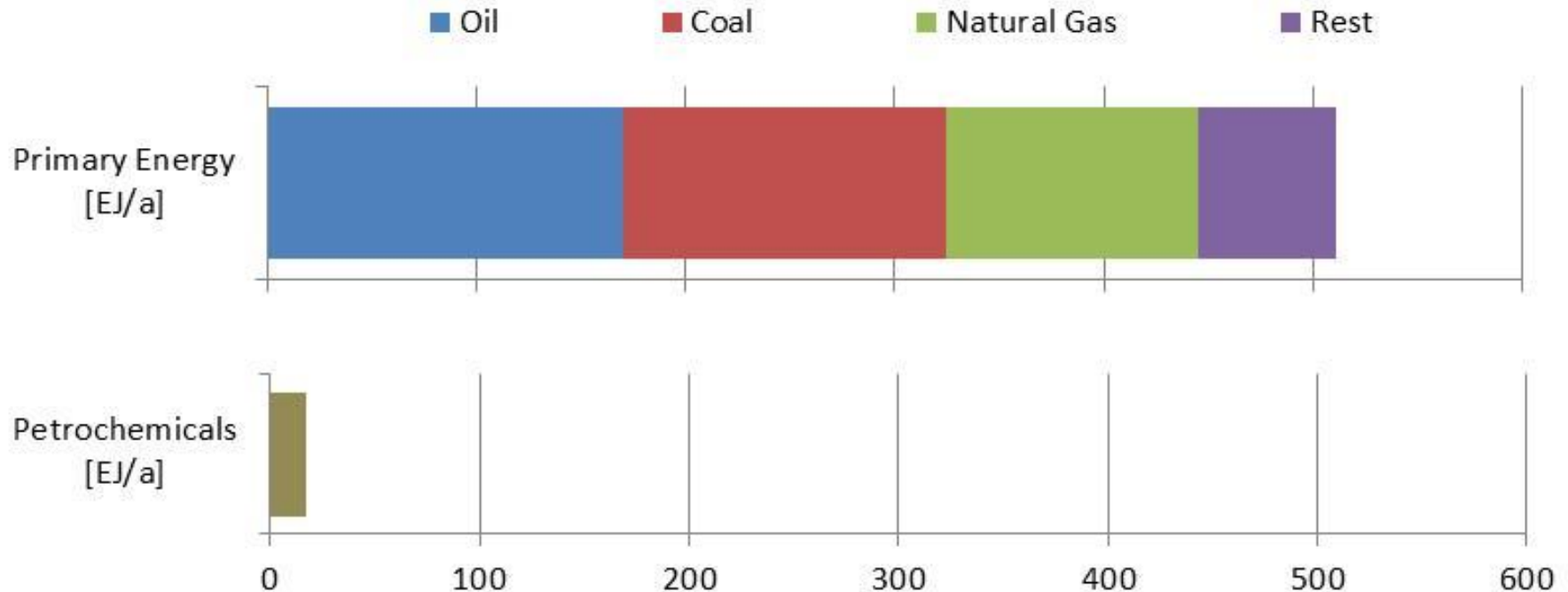
current volumes

World	Mass [Mton/y]	Energy [EJ/y]
Ammonia	163	3.6
Ethylene	128	6.1
Propylene	80	3.6
Benzene	42	1.7
Xylene	22	0.9
Toluene	20	0.8
Butadiene	10	0.4
<i>Bioplastics (PE, PET30, PLA)</i>	<i>1.2</i>	<i>0.05</i>

2010/2011 values, energy content refers to the product, not the primary energy input

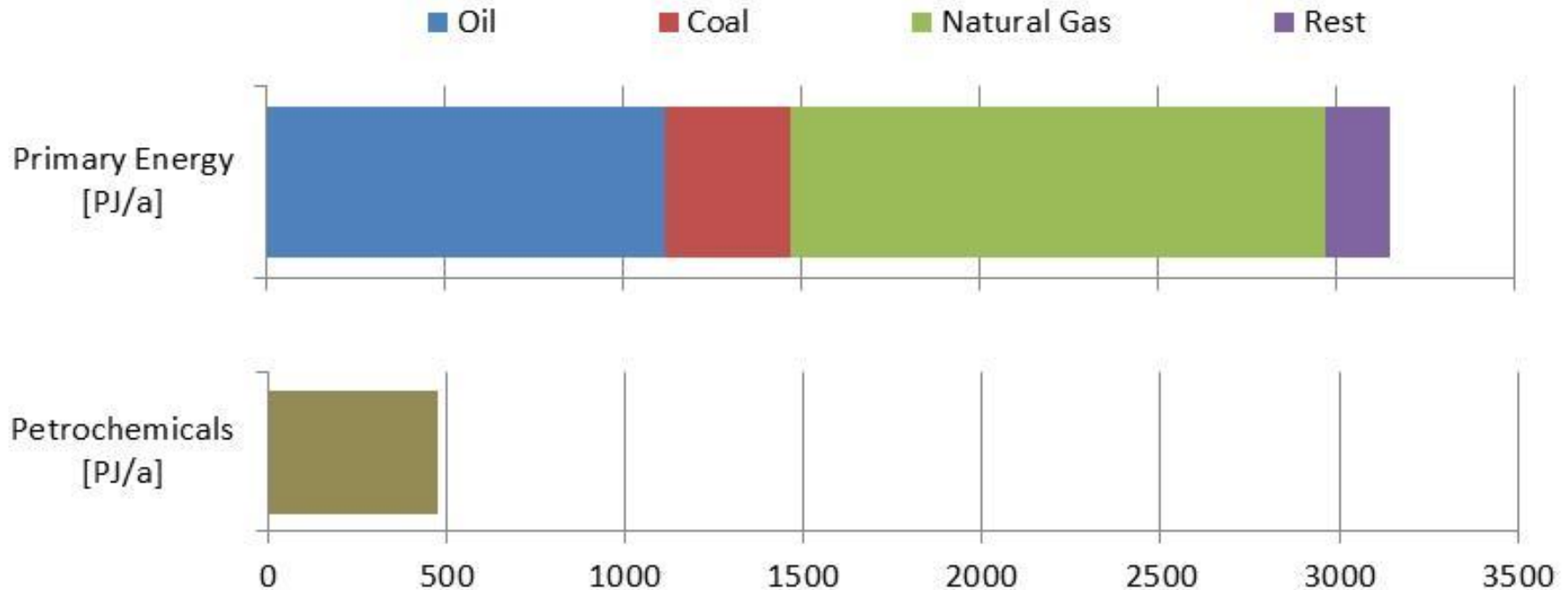
COMPARED TO ENERGY

chemistry is modest (3%)



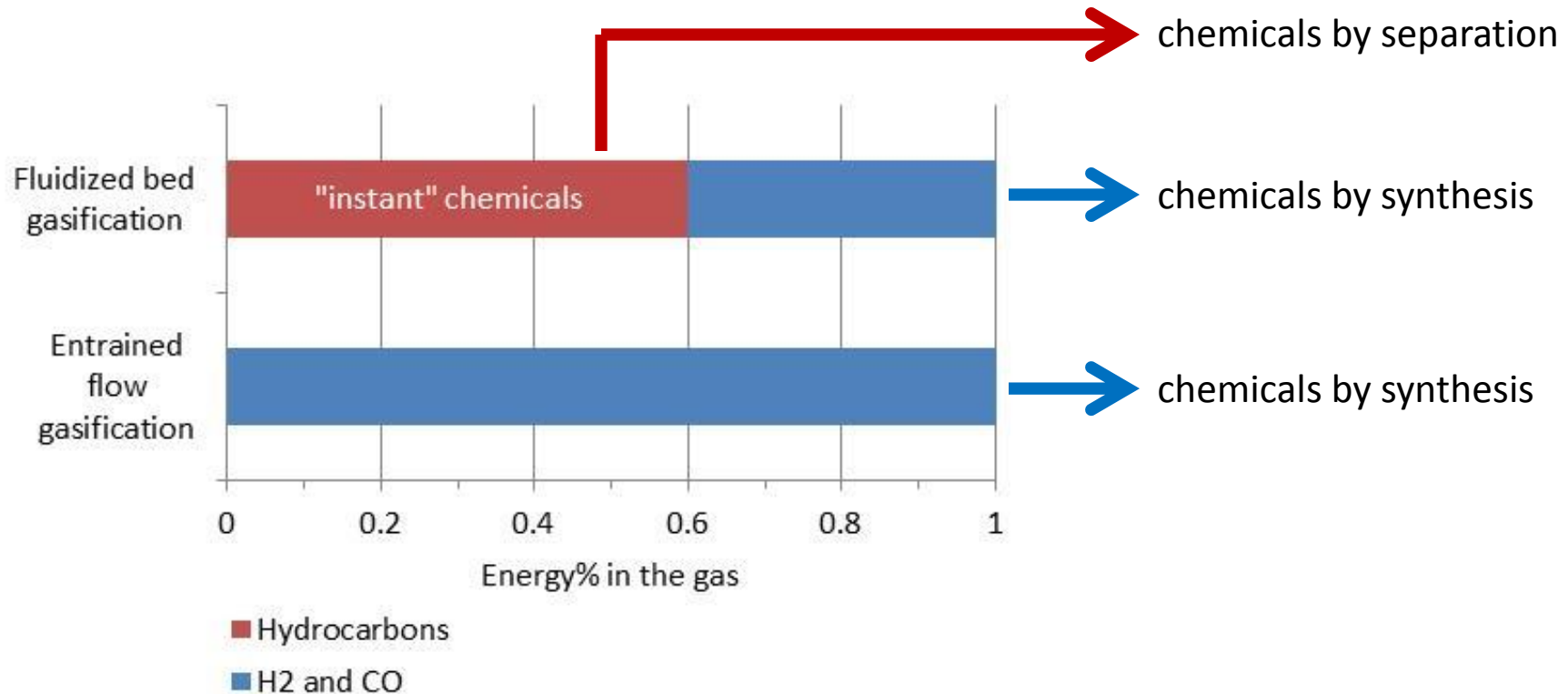
COMPARED TO ENERGY

Netherlands (15%)



BIOMASS to CHEMISTRY (1)

two options

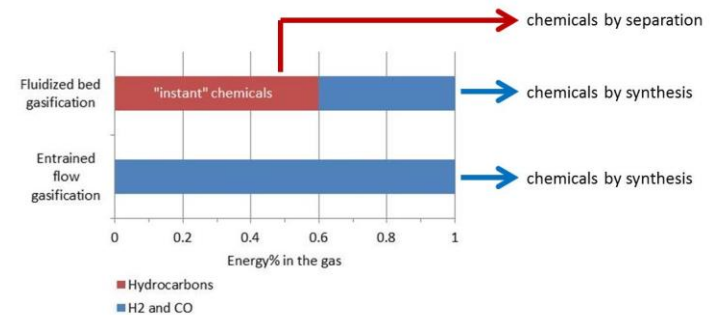


BIOMASS to CHEMISTRY (2)

two options

- Chemicals by synthesis:

- $H_2 + CO$ (syngas) $\rightarrow$ chemicals
- Mature and available technology
- Typically 80% energy efficient

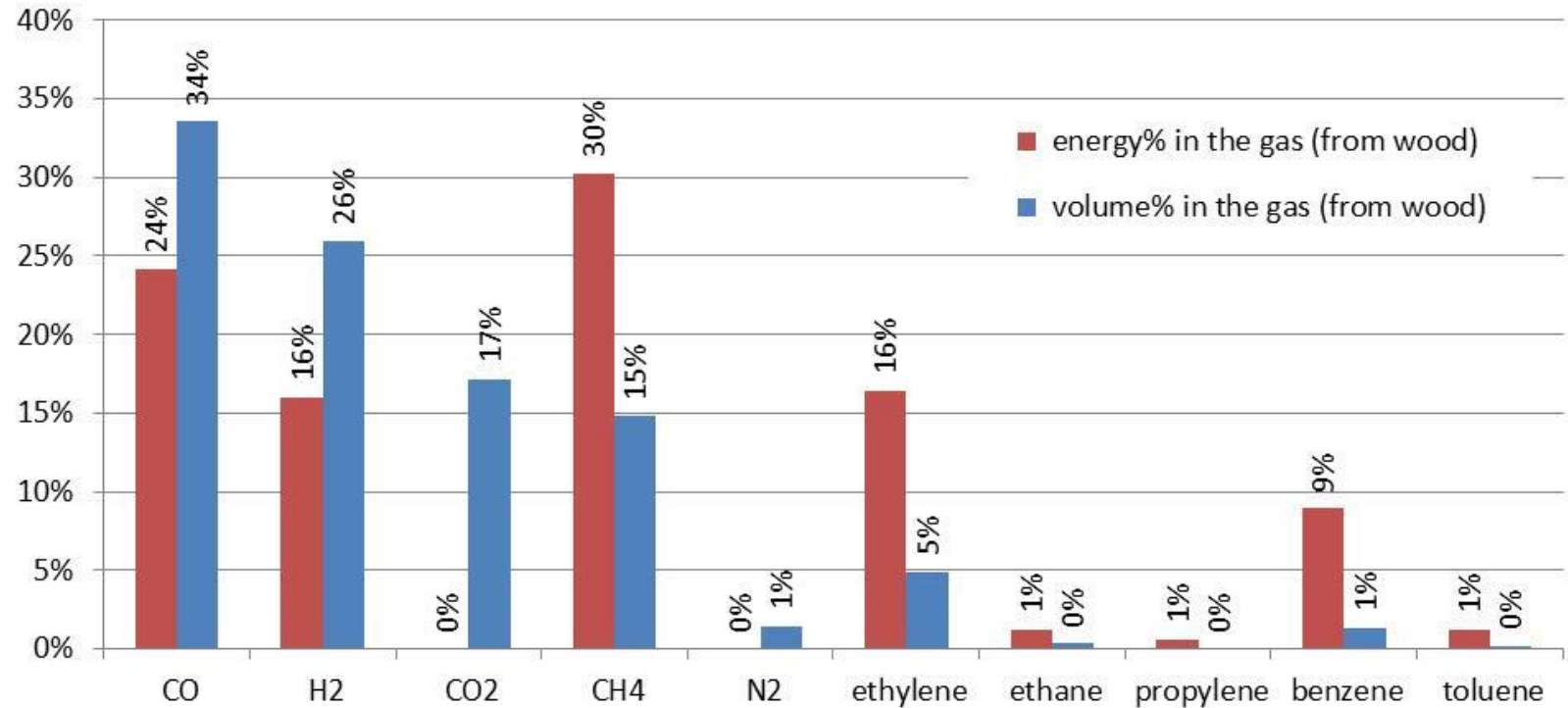


- Chemicals by separation:

- Separate already existing molecules from gas
- Requires mild gasifier conditions (<1000C) to keep hydrocarbons alive
- Concerns mainly benzene, ethylene, methane
- Matches very well with biomass/waste: low temperature suffices
- Double energy benefit: not broken down in gasifier and not having to synthesize from syngas
- But may also include H_2 and CO_2

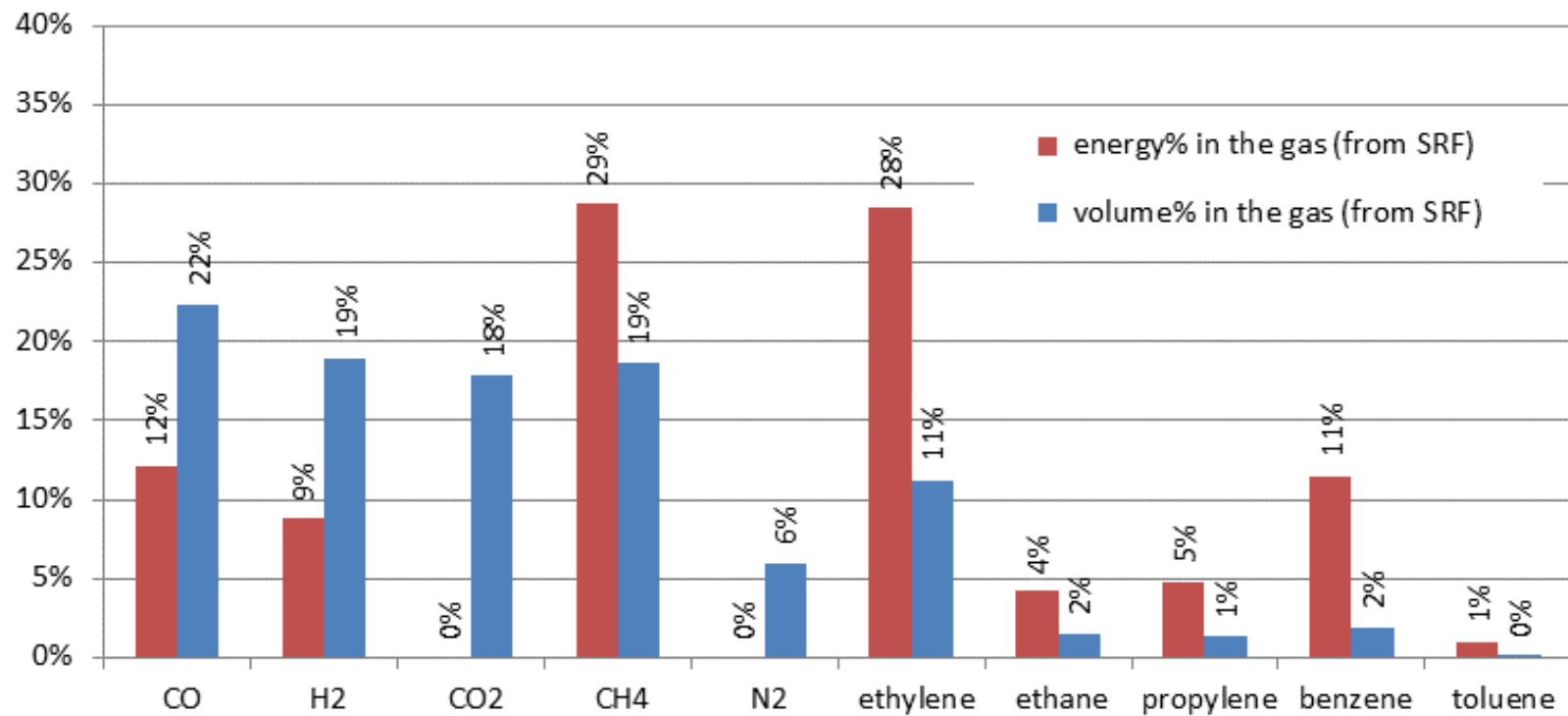
GAS COMPOSITION

fluidized bed – 850C – wood

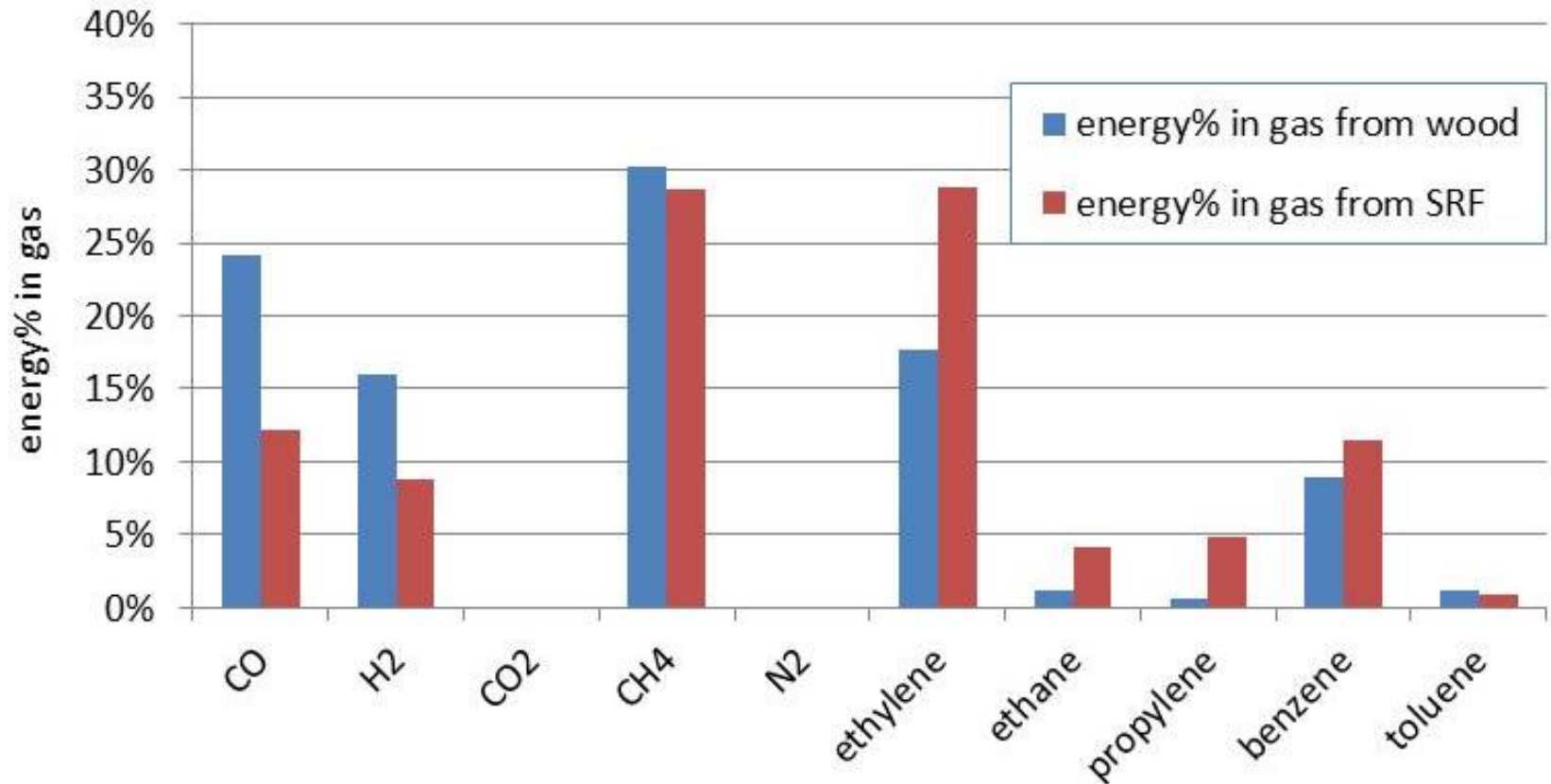


GAS COMPOSITION

fluidized bed – 850C – SRF

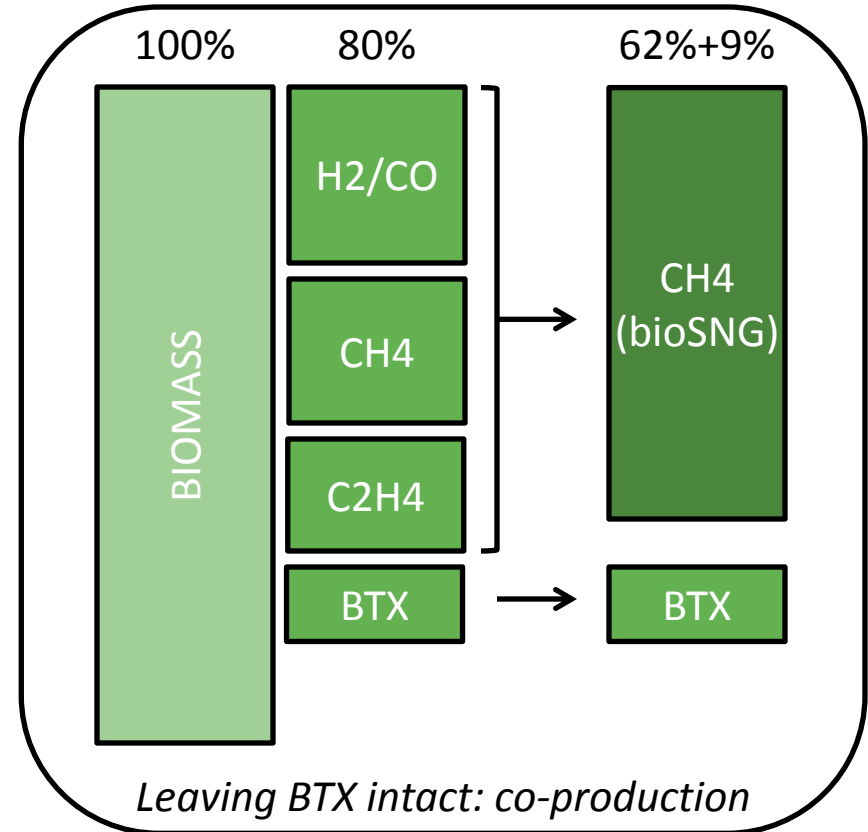
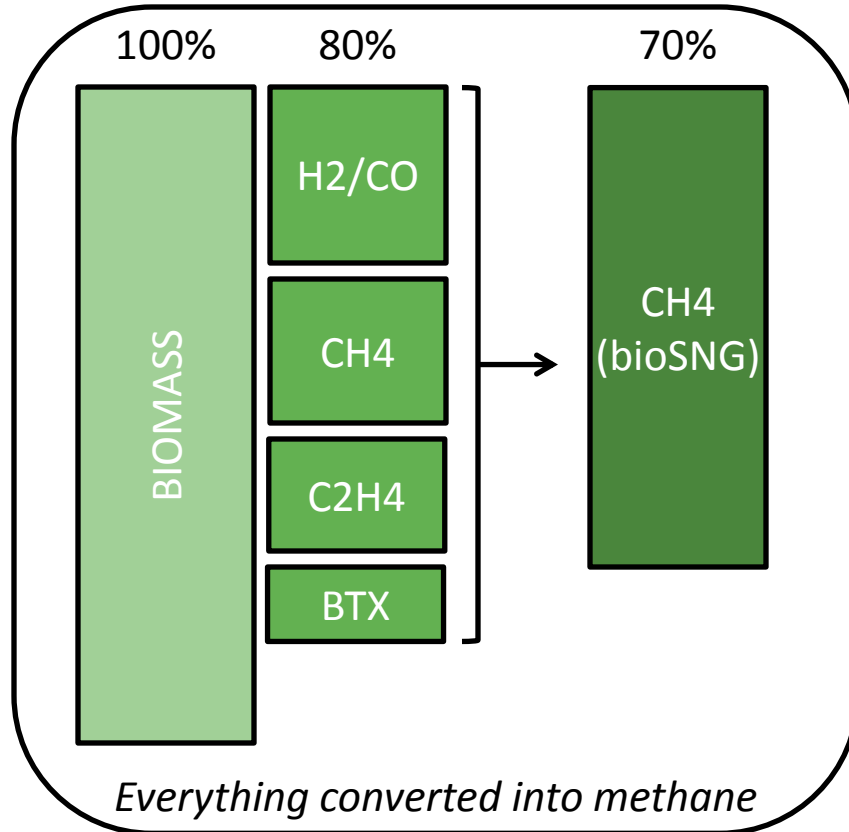


WOOD and SRF



BioSNG PROCESS (1)

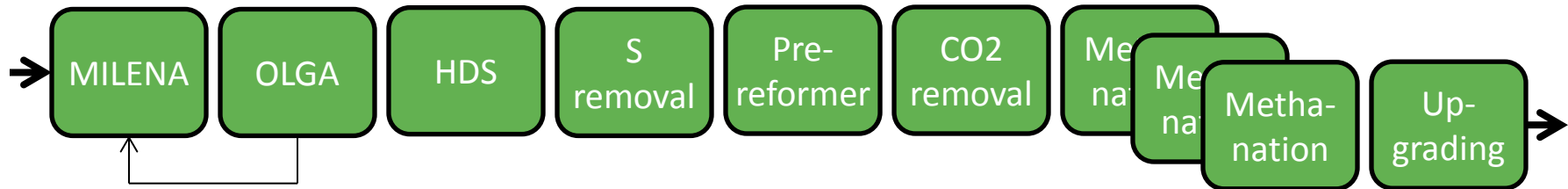
the cases



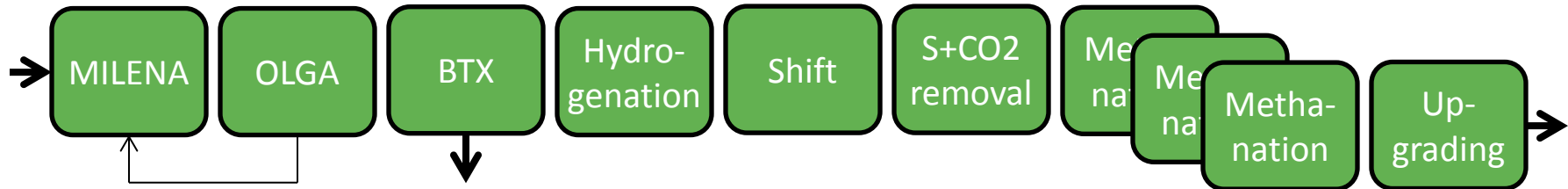
BioSNG PROCESS (2)

the cases

Everything converted into methane



Leaving BTX intact: co-production



MILENA: gasifier, “indirect”, www.milenatechnology.com

OLGA: tar removal, scrubber technology, www.olgatechnology.com

BioSNG PROCESS (3)

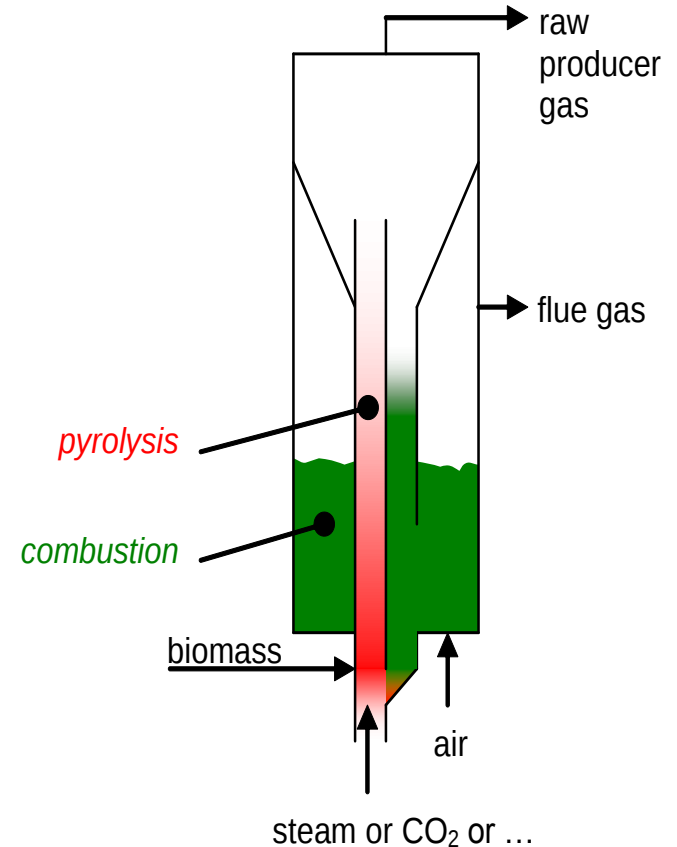
the cases

- Reference:

- Tar recycle to Milena
- Organic sulphur conversion in HDS
- Ethylene hydrogenation in HDS
- Pre-reformer for benzene with high amount of steam
- CO₂ removal, 80-90% removal suffices
- Conventional methanation in multiple fixed beds

- BTX system

- Tar recycle to Milena (more fuel not needed)
- BTX scrubber removes BTX and organic sulphur
- HDS becomes only sour shift reactor and hydrogenation
- Pre-reformer not needed



BENEFITS of CO-PRODUCTION

three steps forward

1. Higher priced products



2. Higher efficiency



3. Simpler process

$$1+1=2$$

BENEFITS of CO-PRODUCTION

1. higher priced products

- Methane: 6 euro/GJ (0.20 euro/m³)
- Benzene: 24 euro/GJ (1000 euro/ton)



- Picture changes when methane becomes biofuel (bioCNG)

BENEFITS of CO-PRODUCTION

2. *higher efficiency*

- Less steam needed (no pre-reformer, lower shift temperature):

$$0.05 \text{ MW}_{\text{th}}/\text{MW}_{\text{th_biomass-input}}$$

- No BTX-to-CH₄ conversion loss:

$$0.002 \text{ MW}_{\text{SNG}}/\text{MW}_{\text{th_biomass-input}}$$



BENEFITS of CO-PRODUCTION



3. simpler process

- Hydrogenation and sour shift instead of HDS and pre-reformer
- One unit for sulphur and CO₂ removal instead of two

$$1+1=2$$

BTX REMOVAL TECHNOLOGY

developments

- OLGA tuned not to remove BTX
- BTX scrubber technology choice similar to OLGA technology 2nd step
- BTX solvent selected
- Batch test in real gas: absorption and stripping
- Micro-tests to create vapour/liquid data
- Design lab-scale continuous facility

<today>

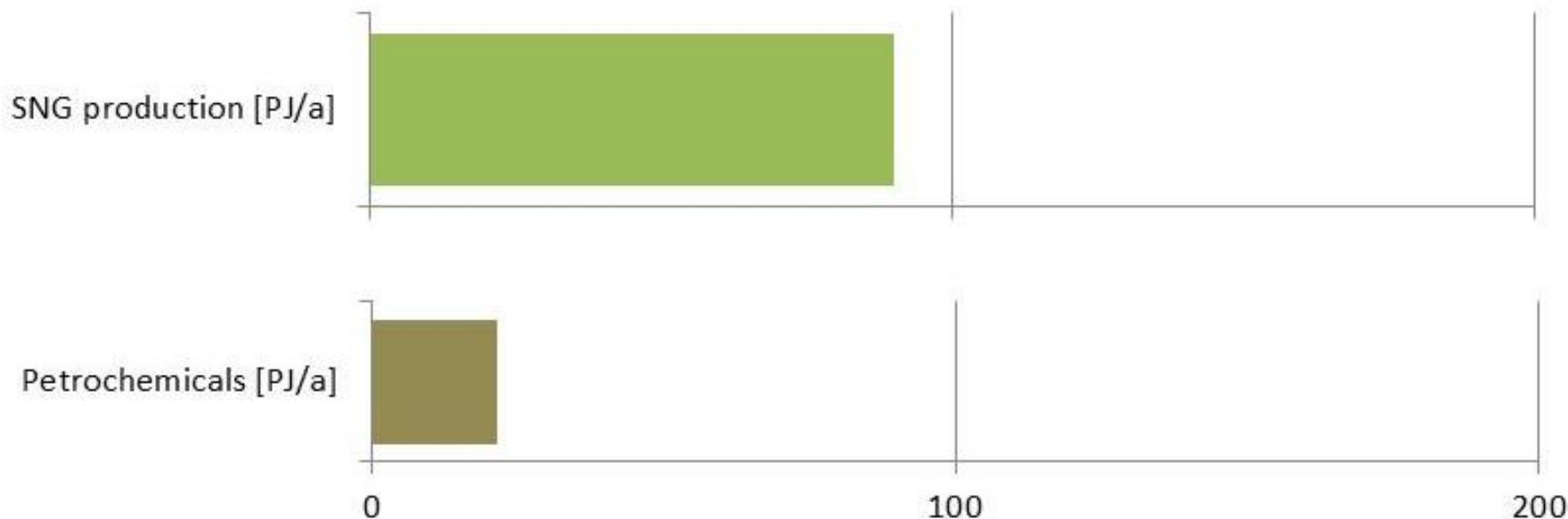
- Perform tests and verify models
- Produce BTX samples and determine quality
- Test in integrated biomass-to-SNG system



ALREADY 30 YEARS:



Dakota Syngas: lignite to SNG + naphtha/phenols + ...



Plus: ammonium-sulphate, ammonia, CO₂, Kr, Xe

OUTLOOK

more options for co-production

- Ethylene removal
- Use H₂ and CO to produce chemicals
- LNG production
- Optimize yields from gasifier



THANKS FOR THE ATTENTION

Bram van der Drift

ECN

Westerduinweg 3
1755 LE Petten
The Netherlands

P.O. Box 1
1755 ZG Petten
The Netherlands

T +31 224 56 45 15
M +31 61090 9927

vanderdrift@ecn.nl
www.ecn.nl

publications: www.ecn.nl/publications
fuel composition database: www.phyllis.nl
tar dew point calculator: www.thersites.nl
IEA bioenergy/gasification: www.ieatask33.org
Milena indirect gasifier: www.milenatechnology.com
OLGA: www.olgatechnology.com / www.renewableenergy.nl
SNG: www.bioSNG.com / www.bioCNG.com

ECN

Westerduinweg 3
1755 LE Petten
The Netherlands

P.O. Box 1
1755 LG Petten
The Netherlands

T +31 88 515 4949
F +31 88 515 8338
info@ecn.nl
www.ecn.nl

