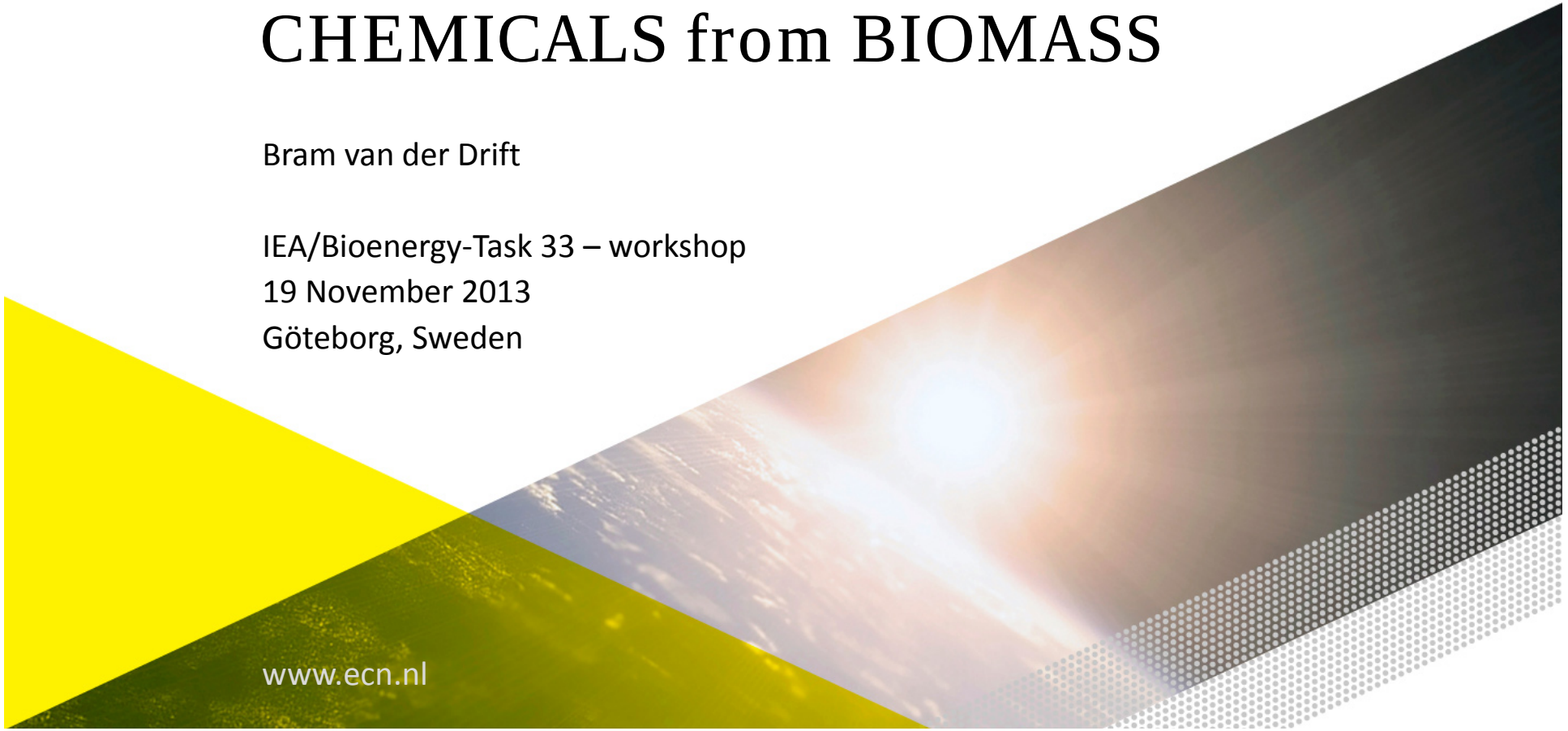
CHEMICALS from BIOMASS

Bram van der Drift

IEA/Bioenergy-Task 33 – workshop
19 November 2013
Göteborg, Sweden



www.ecn.nl

CHEMICAL INDUSTRY

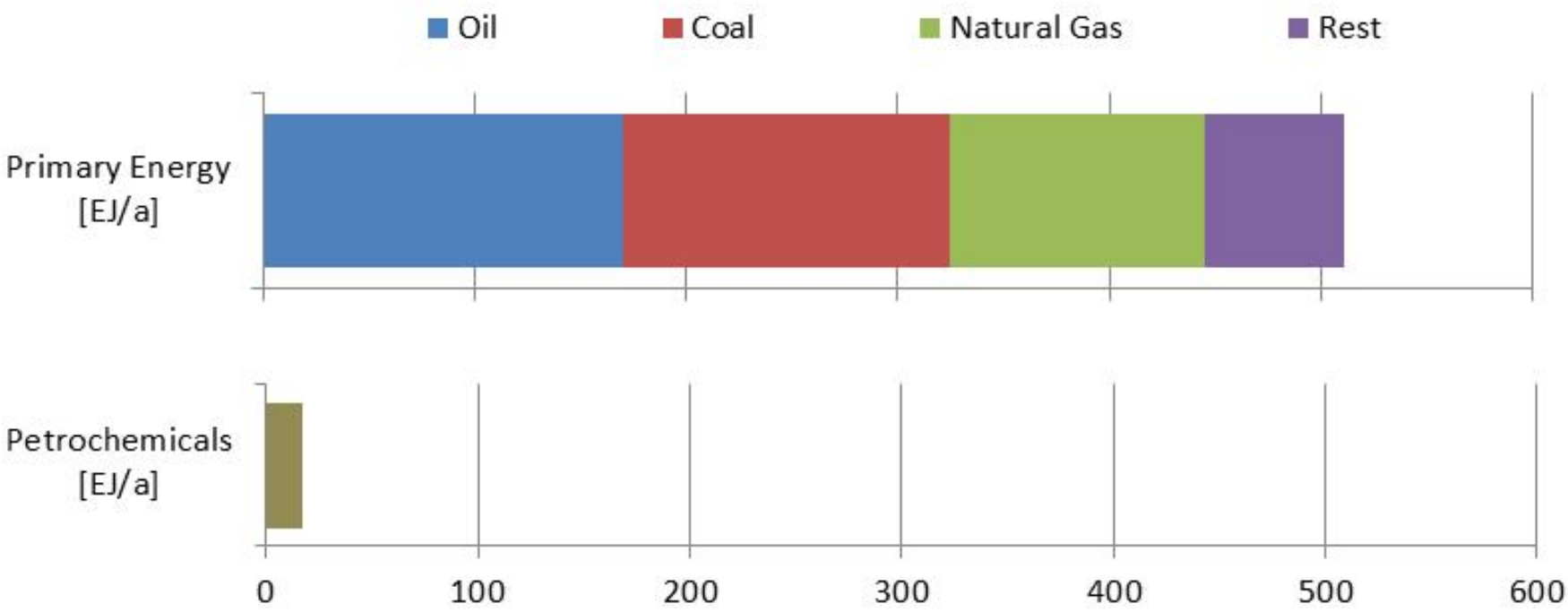
current volumes

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
Bioplastics (PE, PET30, PLA)	*1.2*	*0.05*

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

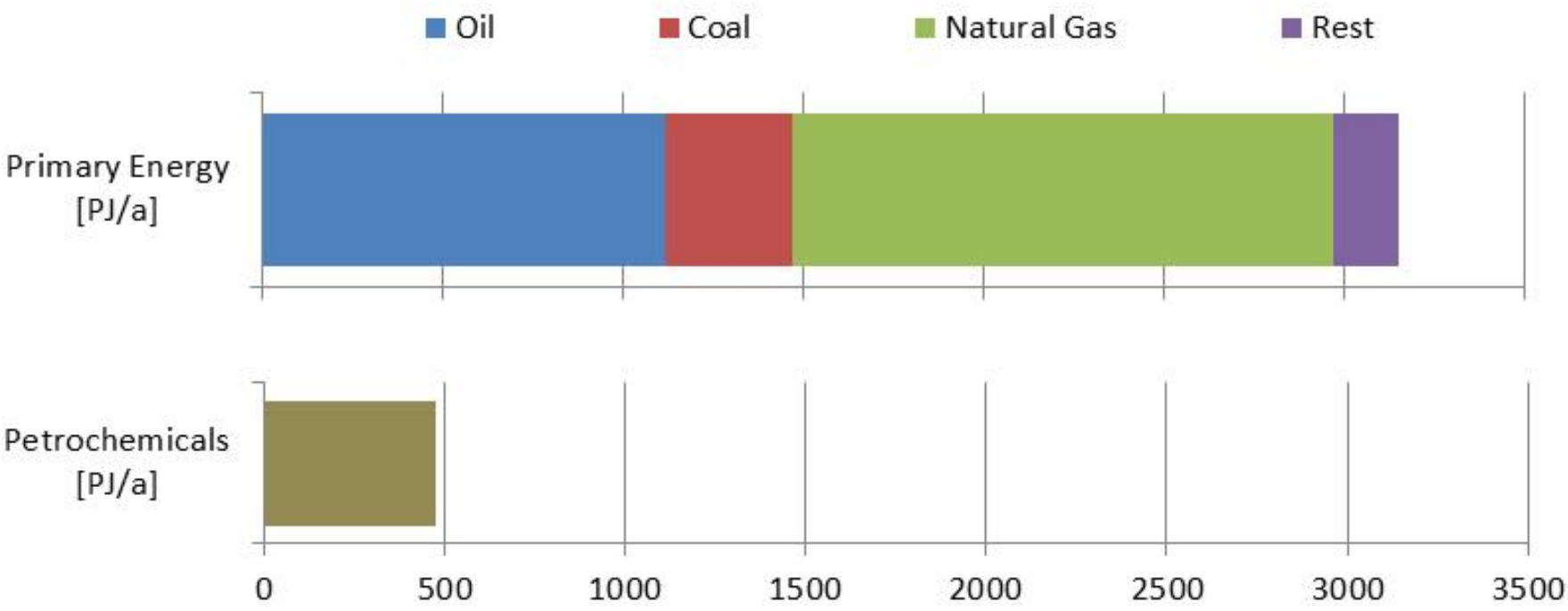
COMPARED TO ENERGY

chemistry is modest (3%)



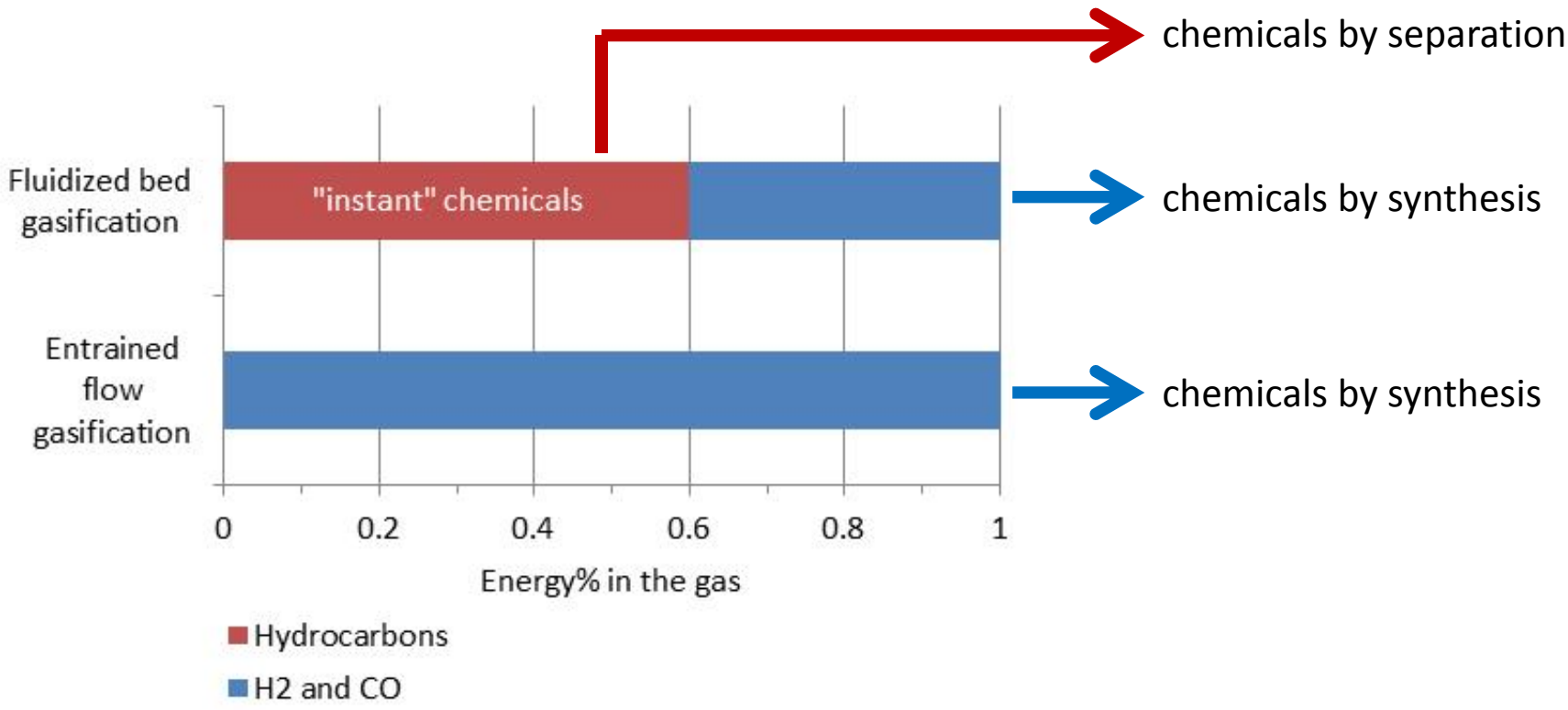
COMPARED TO ENERGY

Netherlands (15%)



BIOMASS to CHEMISTRY (1)

two options



BIOMASS to CHEMISTRY (2)

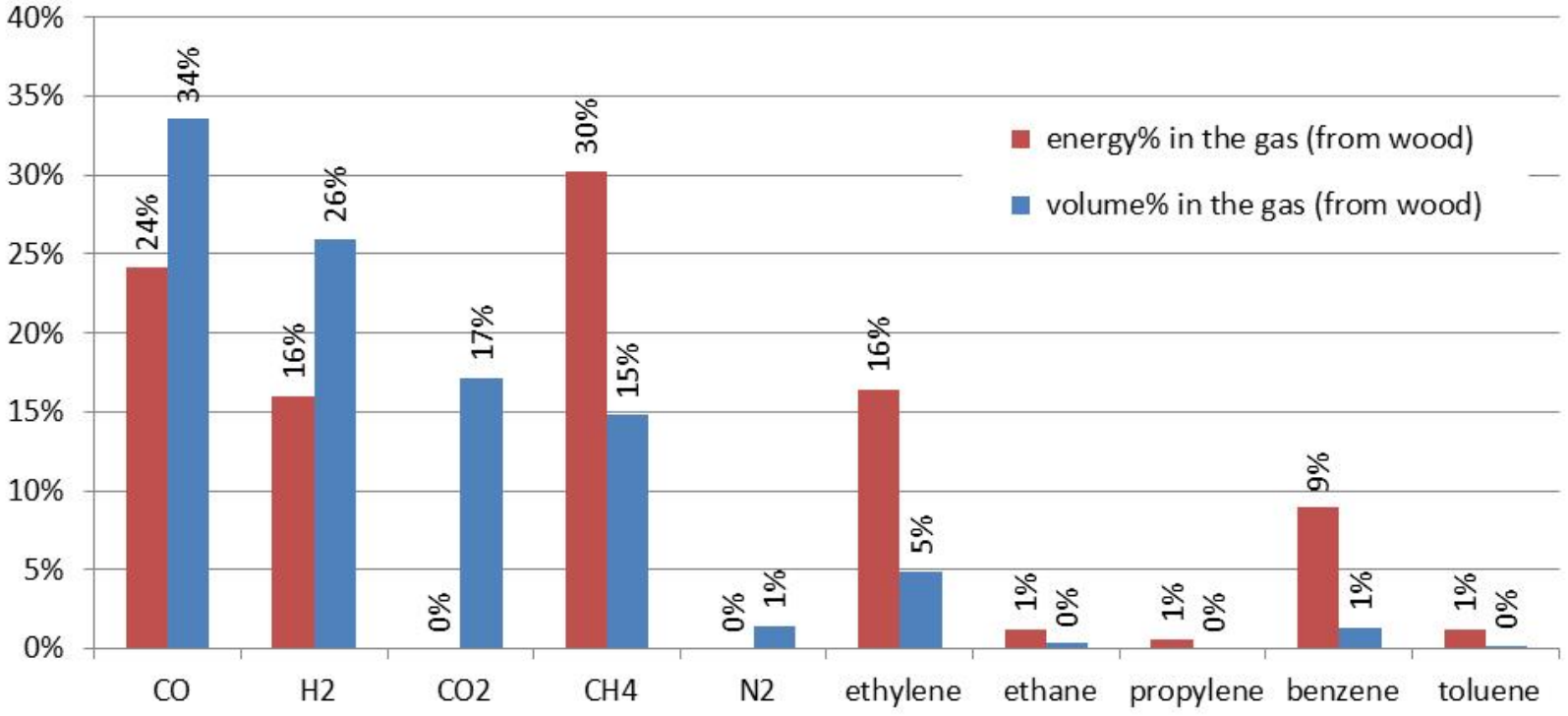
two options

- Chemicals by synthesis:
  - H2 + CO (syngas) → 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 H2 and CO2

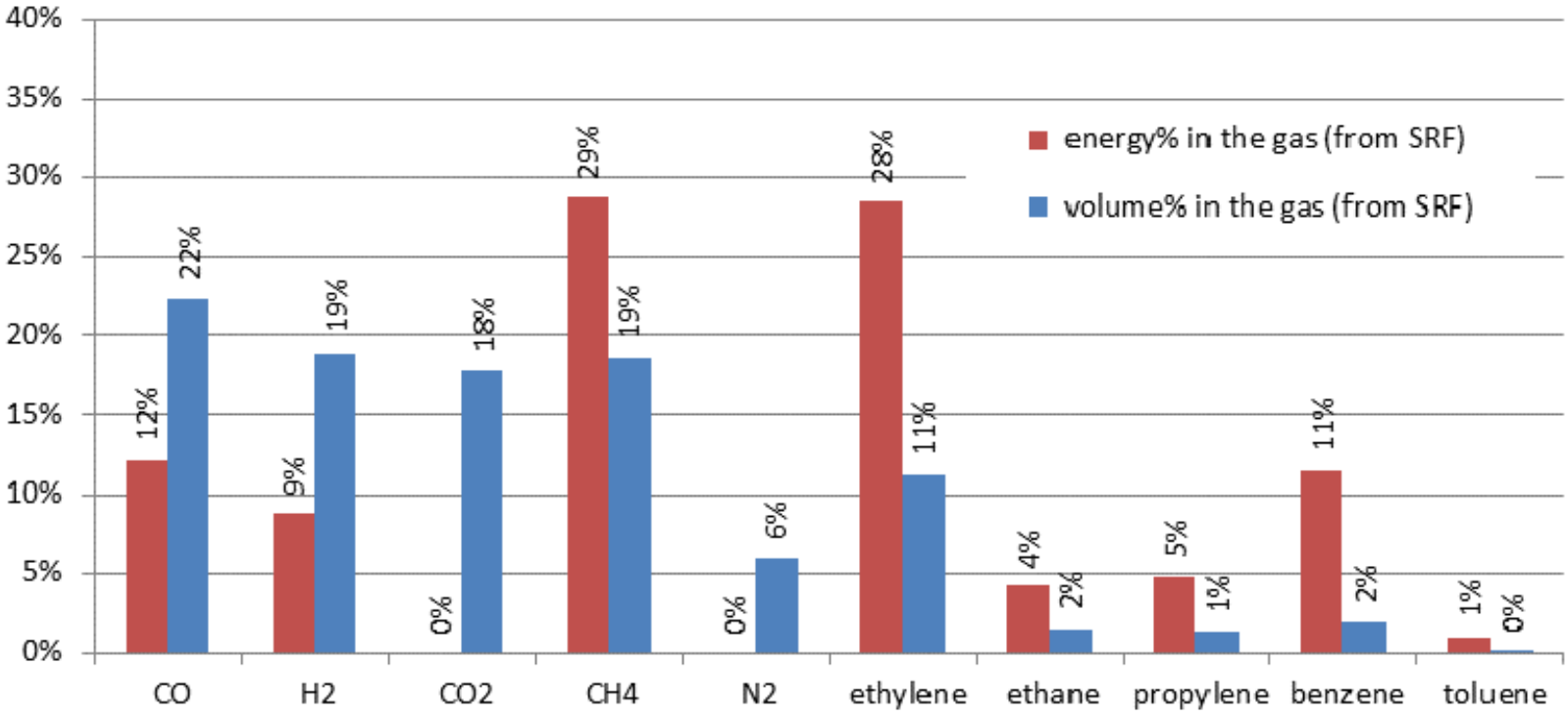
GAS COMPOSITION

fluidized bed – 850C – wood

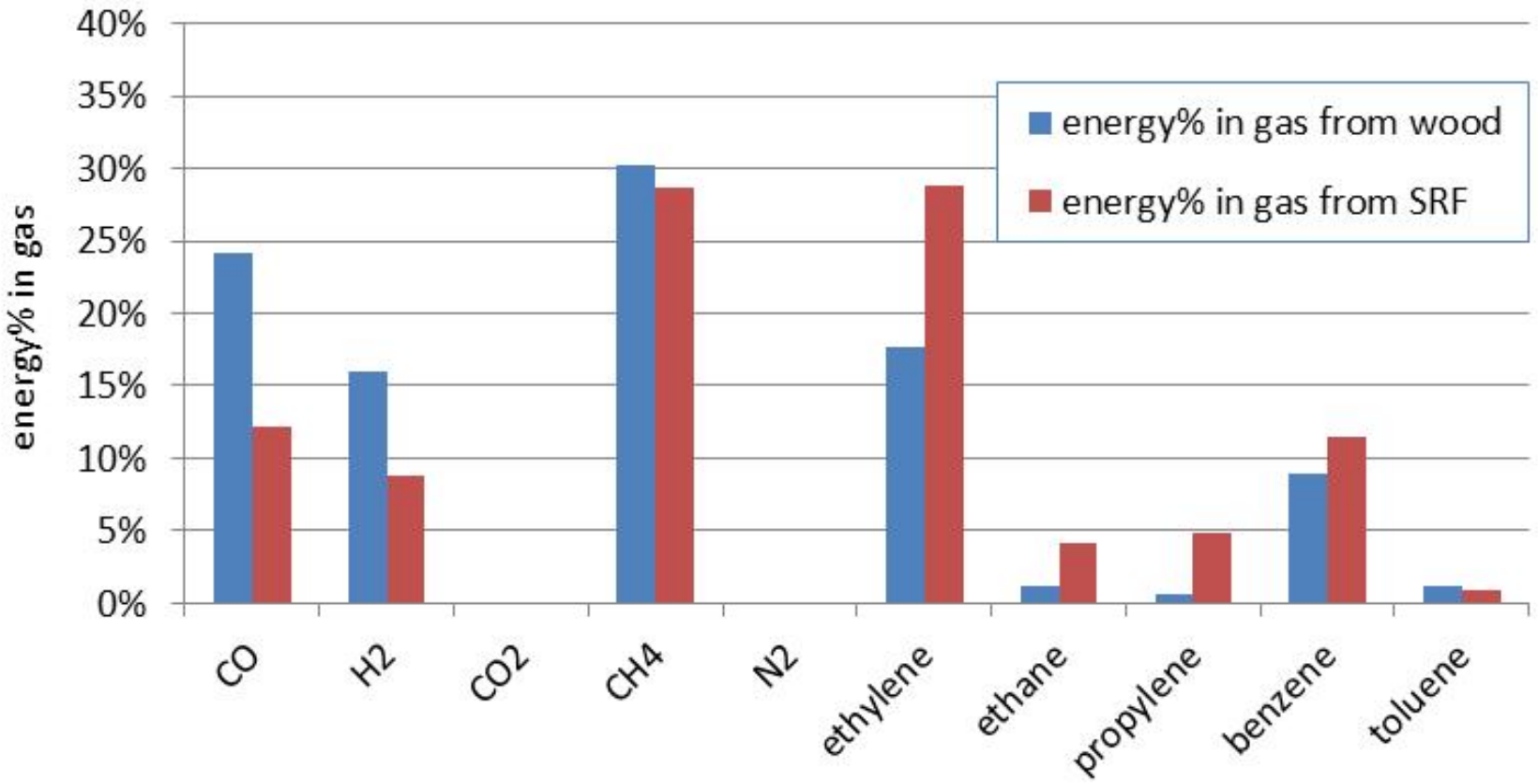


GAS COMPOSITION

fluidized bed – 850C – SRF

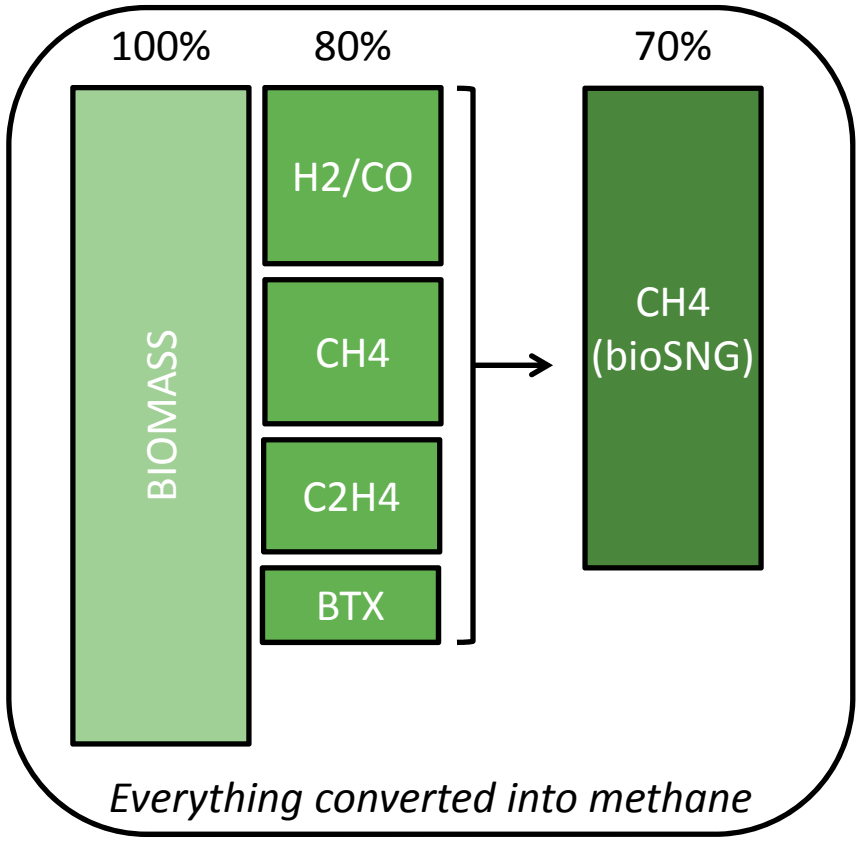


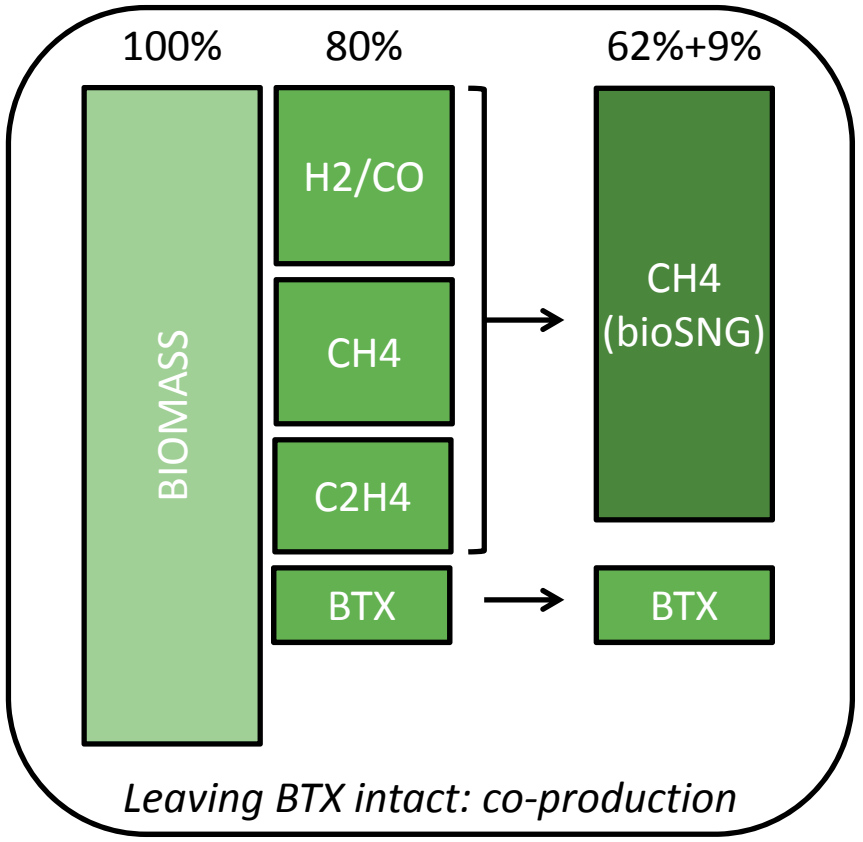
WOOD and SRF


40%
35%
30%
25%
20%
15%
10%
5%
0%
energy% in gas
energy% in gas from wood
energy% in gas from SRF
CO
H2
CO2
CH4
N2
ethylene
ethane
propylene
benzene
toluene

BioSNG PROCESS (1)

the cases

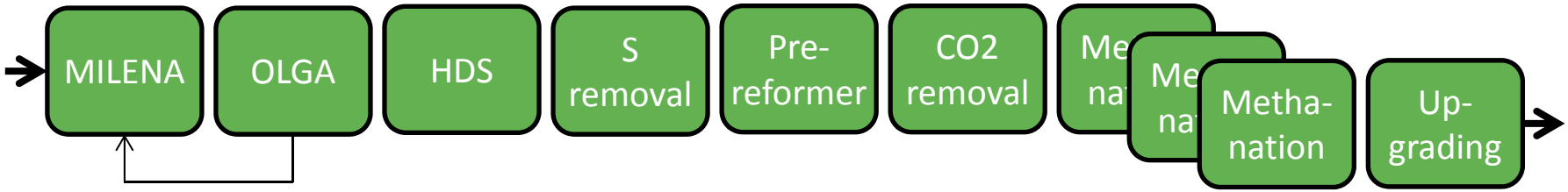




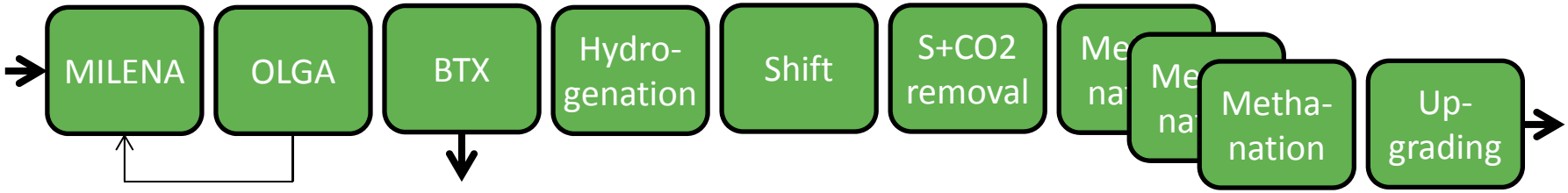
BioSNG PROCESS (2)

the cases

Everything converted into methane



Leaving BTX intact: co-production

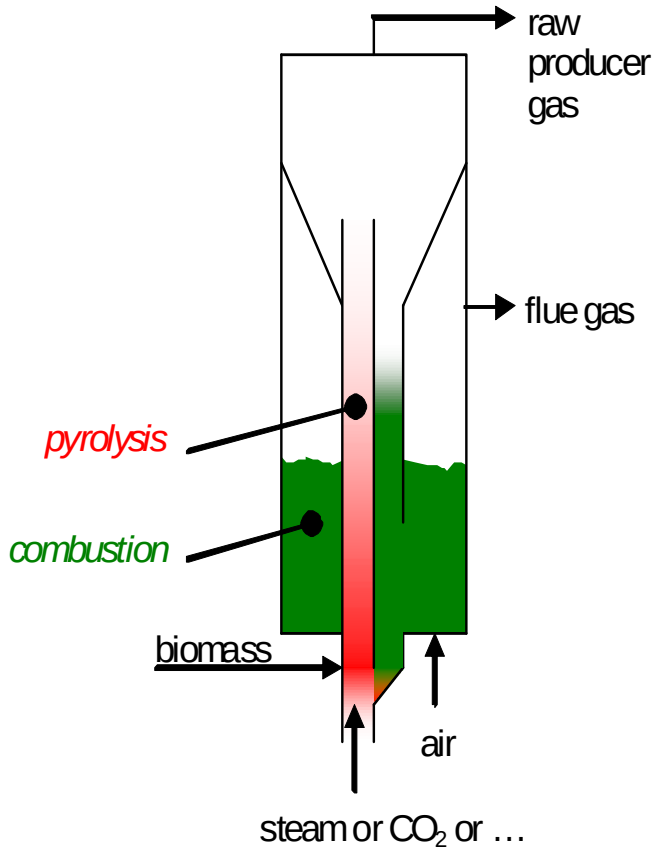


MILENA: gasifier, "indirect", www.milenatechnology.com
OLGA: tar removal, scrubber technology, www.olgatechnology.com

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



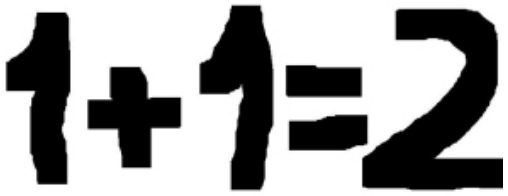
BENEFITS of CO-PRODUCTION

three steps forward

1. Higher priced products

2. Higher efficiency

3. Simpler process



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 $MW_{th}/MW_{th\_biomass\text{-}input}$

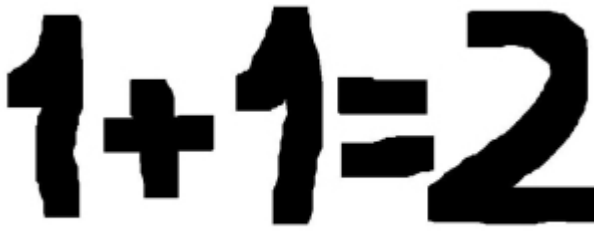
- No BTX-to-CH4 conversion loss:

  0.002 $MW_{SNG}/MW_{th\_biomass\text{-}input}$

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



BTX REMOVAL TECHNOLOGY

developments

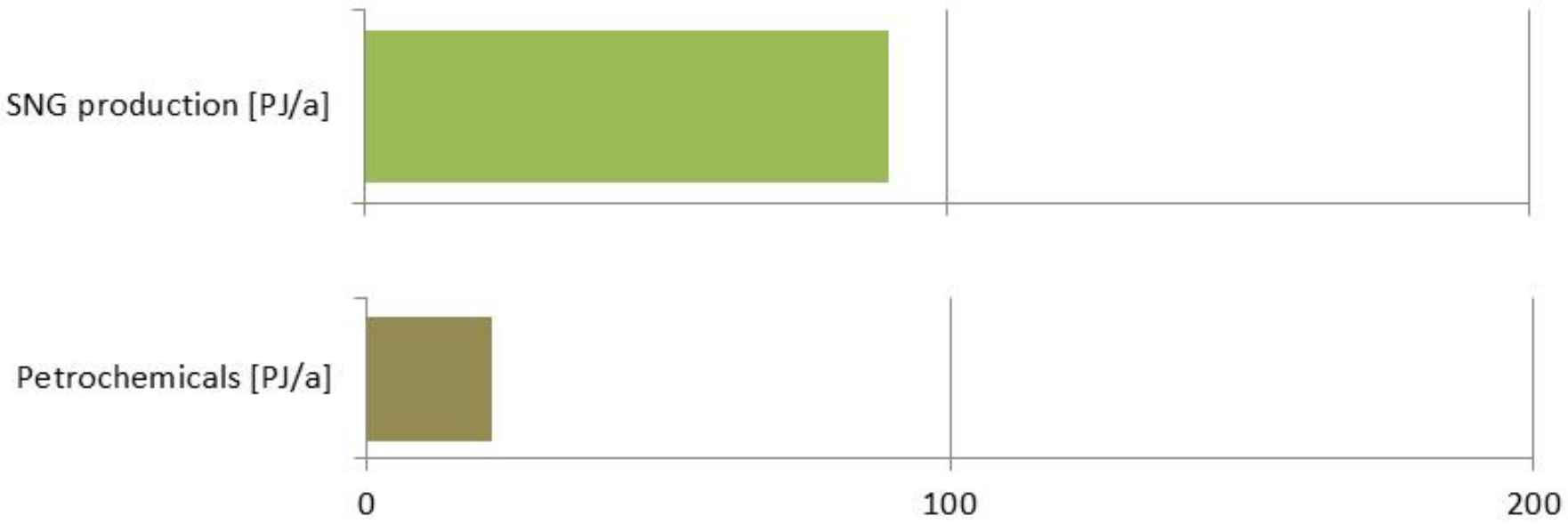
- OLGA tuned not to remove BTX
- BTX scrubber technology choice similar to OLGA technology 2nd step
- BTX solvent selected
- Batch test in real gas: absorption and stripping
- Micro-tests to create vapour/liquid data
- Design lab-scale continuous facility

<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

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