

Bio-Aromatics from Gasification

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BIO-AROMATICS from GASIFICATION

The Future of Aromatics 2014
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Bram van der Drift

CONTENT

- Gasification
- Separation of gases
- Quantities
- ECN developments



GASIFICATION

what is gasification?

Energy sector point-of-view:

- Gasification turns a difficult solid (or liquid) fuel into a easy gaseous fuel
- This can be used for e.g. heat and power, or at best as feedstock (H_2 and CO) for synthesis of chemicals

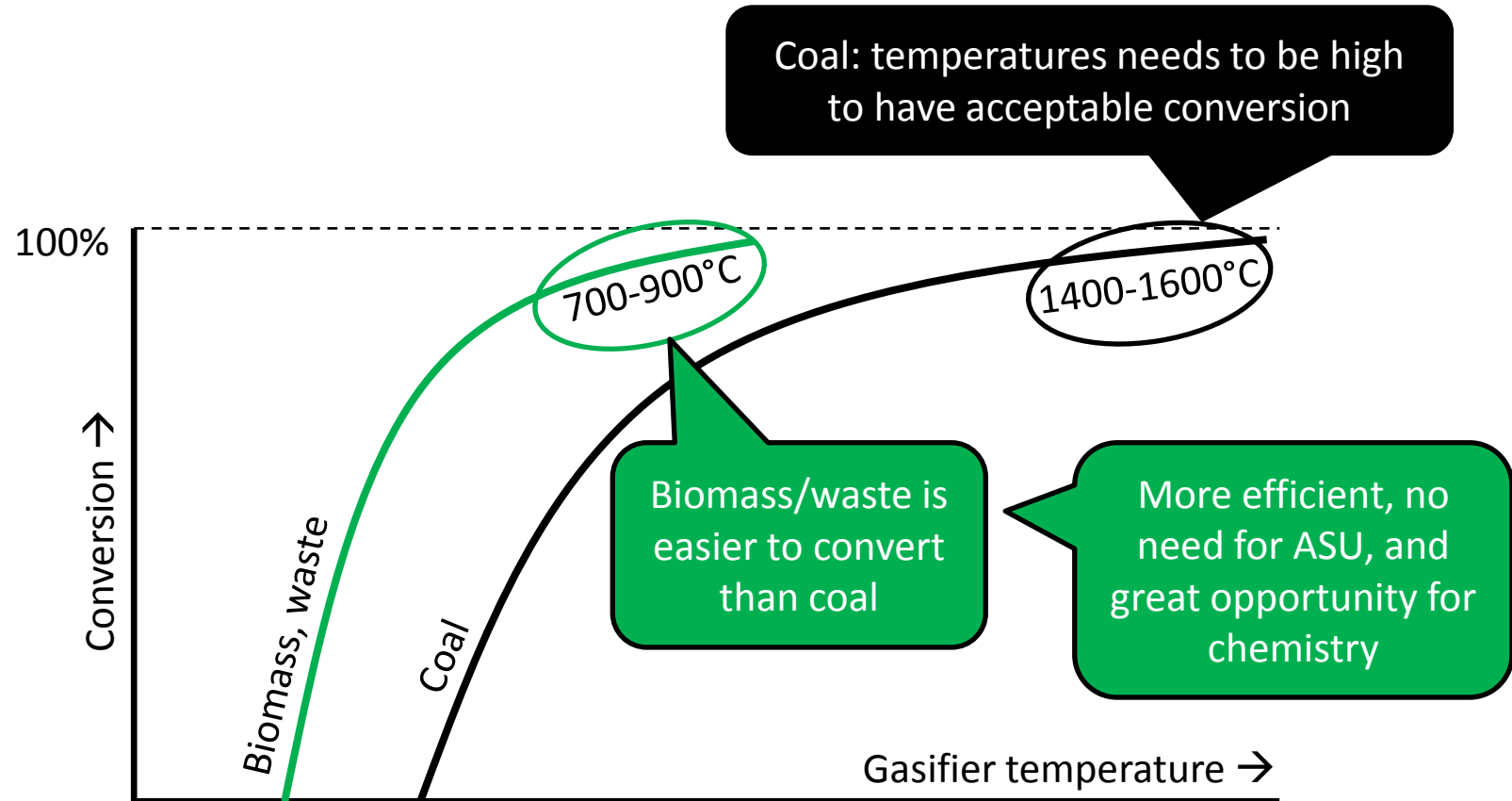


Chemical sector point-of-view:

- Gasification is like naphtha cracking
- Gas is Pygas
- Containing all kind of valuable components

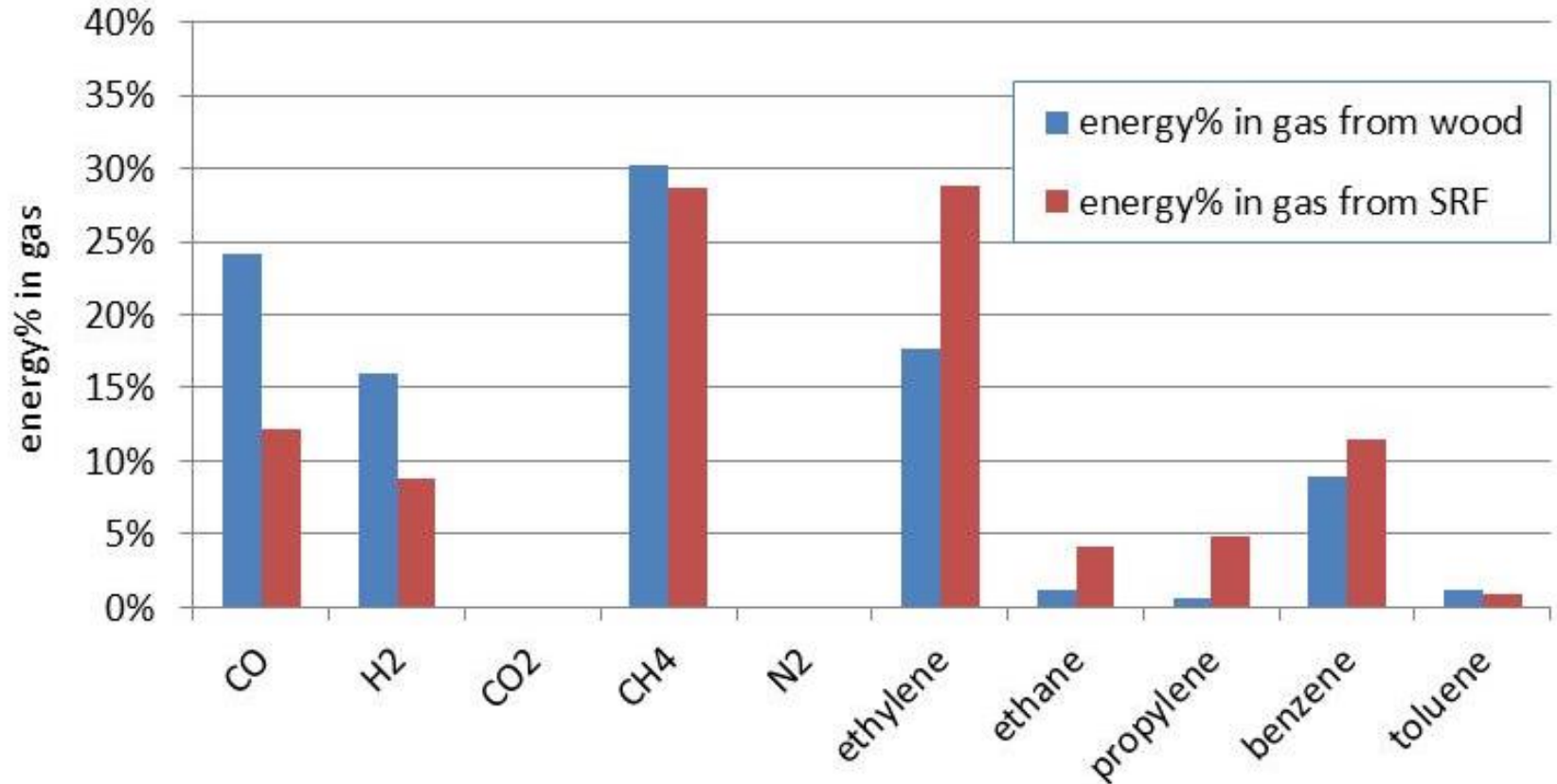


GASIFICATION TEMPERATURE

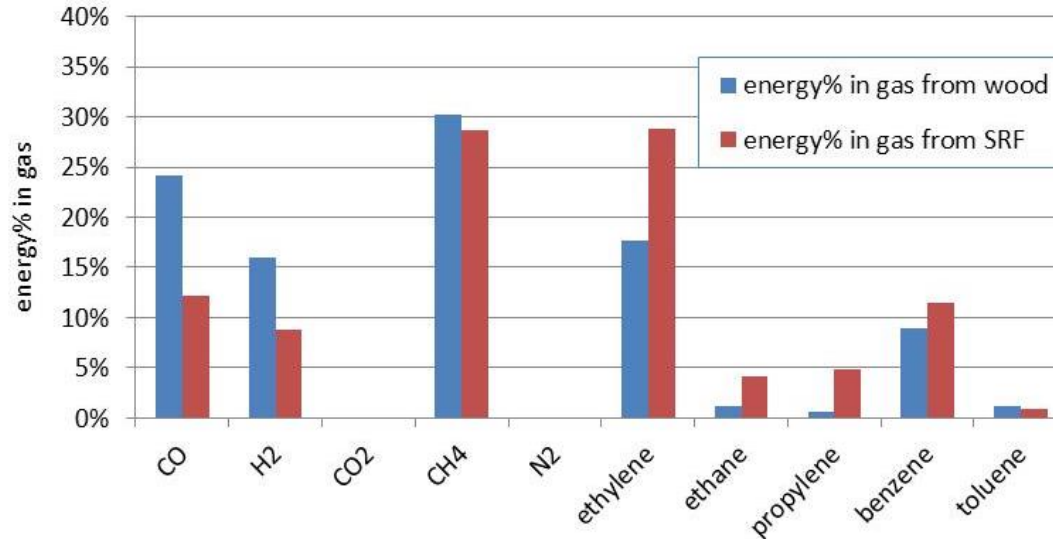


GASIFICATION GAS

wood and RDF (=plastic/paper waste) at $\sim 850^{\circ}\text{C}$



WHERE DO THE MOLECULES GO?



valuable for chemical synthesis

energy carrier to substitute natural gas (SNG)

valuable as chemicals

ENERGY or CHEMISTRY?

Energy sector point-of-view:

- Bio-energy through green Natural Gas (bio-methane, bioSNG) is an easy way of having flexible green energy
- Requires gasification and subsequent methanation:
 - CH_4 already present is an efficiency winner
 - H_2 and CO are converted to CH_4
 - Ethylene, benzene are converted to CH_4
- High-volume ambitions in Europe

Chemical sector point-of-view:

- Why convert valuable chemicals into lower-value energy?

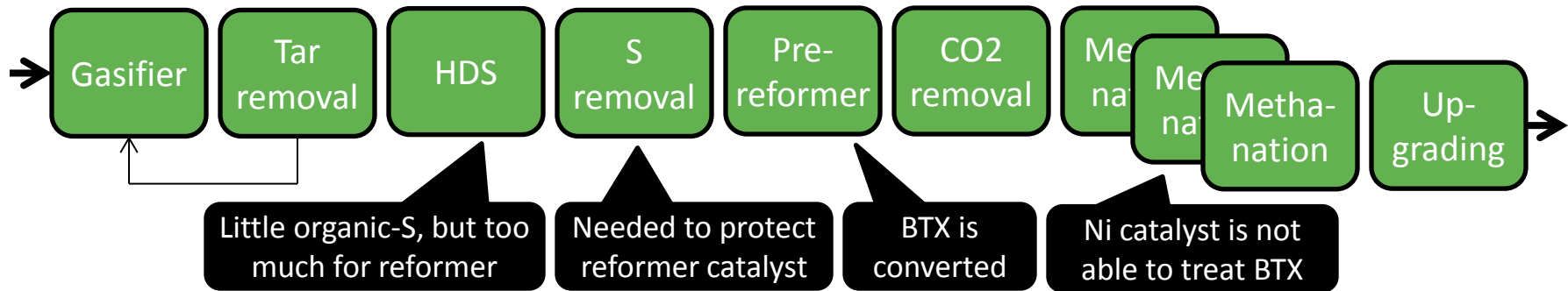
My point-of-view:

- Combine both: separate the chemicals and use the rest for energy

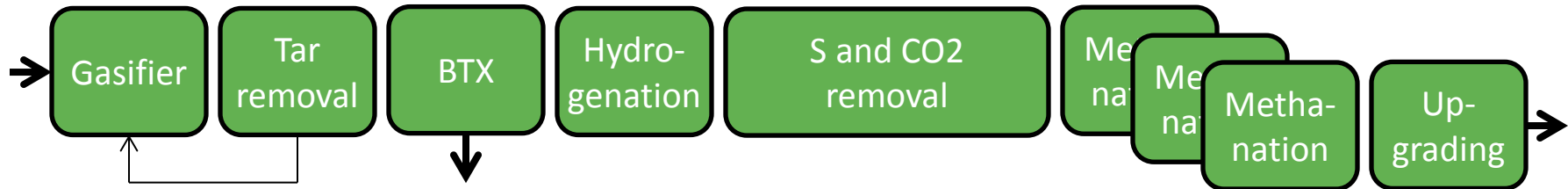
ENERGY and CHEMISTRY

two cases compared

Everything converted into methane (reference case)



Leaving BTX intact: co-production



Gasifier: Fluidized Bed Gasifier operating at temperature below 1000°C

HDS: HydroDeSulphurization (converting organic S molecules into H_2S)

BTX: Benzene, Toluene, Xylene (~90%/9%/1% in case of fluidized bed gasification at ~800°C)

CO-PRODUCTION!

energy AND chemicals versus energy-only

1. Higher priced products



2. Higher efficiency



3. Simpler process

$$1 + 1 = 3$$

BENEFITS of CO-PRODUCTION

1. higher priced products

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



BENEFITS of CO-PRODUCTION



2. higher efficiency

- Less steam needed (to avoid coking)
- No conversion loss



BENEFITS of CO-PRODUCTION



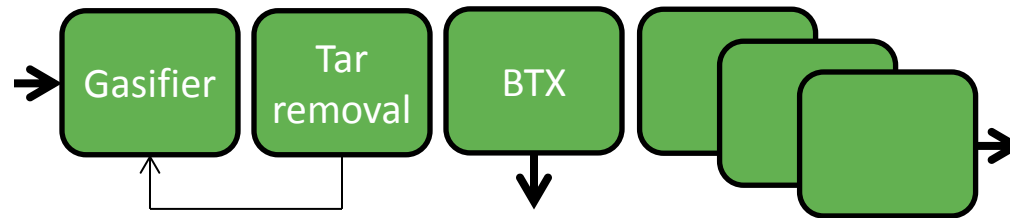
3. simpler process

- Reformer not needed
- Organic sulphur can be removed simply with activated carbon
- One unit for sulphur and CO₂ removal instead of two



PRODUCTION of BENZENE

- Operate biomass/waste gasifier like a naphtha cracker
- Remove higher hydrocarbons (tar)
- Remove BTX (mainly benzene)
- Remaining gas available for
 - Bio-energy production
 - Bio-ethylene separation and subsequent bio-energy production
 - Cryogenic separation (e.g. bioLNG and clean bio-syngas)
 - ...



QUANTITIES

little benzene or too much?

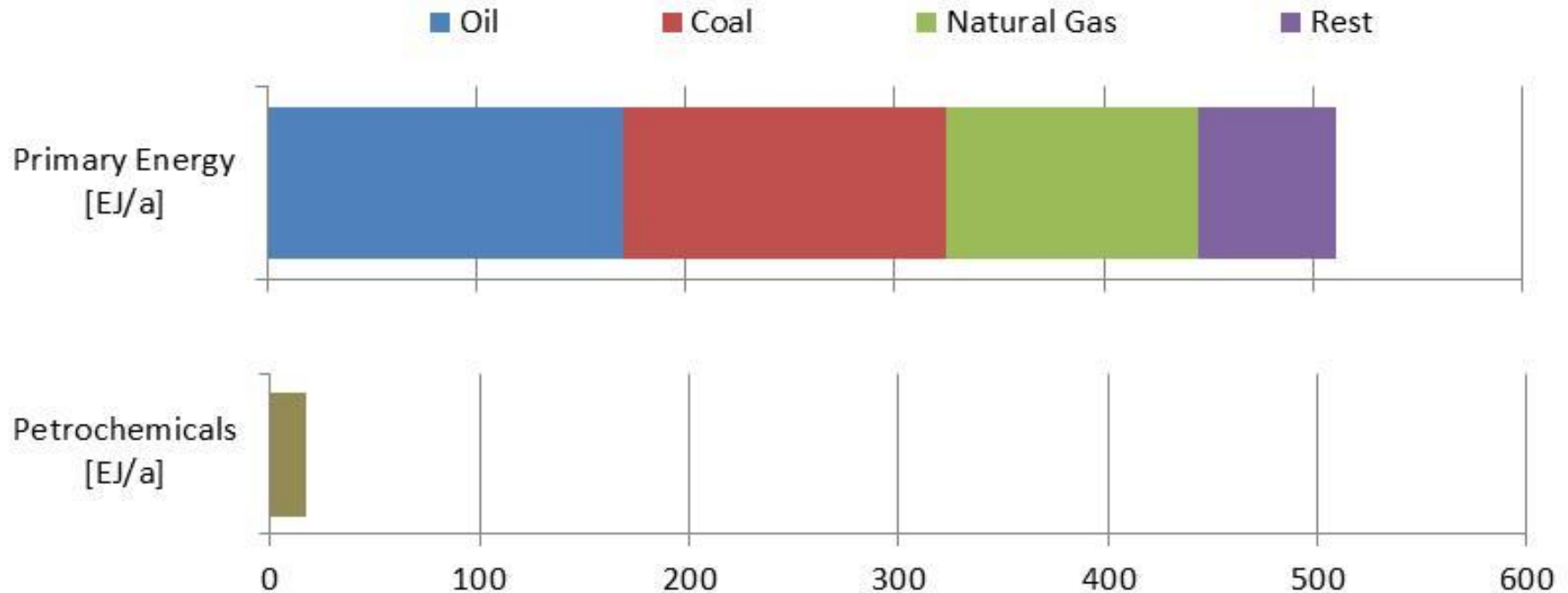
- Approx. 10% benzene yield may seem too little to care, but:
 - It refers to conditions optimized for energy production
 - Can be doubled or may even be tripled
 - Is more than needed when compared to energy consumption:
- The current ratio of benzene ^(a) to primary energy ^(b) is only:
 - World: 0.3%
 - Netherlands: 2%

(a) Energy value of benzene

(b) Total primary energy consumption (oil, coal, natural gas, ...)

COMPARED TO ENERGY

chemistry is modest (3%) in world



Petrochemicals are defined as: ammonia, ethylene, propylene, benzene, xylene, toluene, butadiene

QUANTITIES

cases in NL



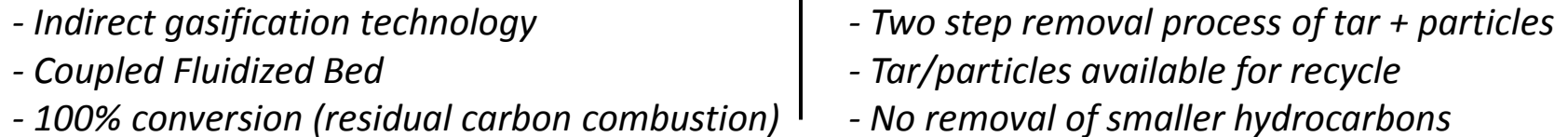
kton: million kg
bcm: billion cubic meters

	One 500 MW biomass input plant	Substituting 10% of natural gas (NL) with bioSNG	Production capacity 2010 (NL) (reference)
kton/y (bio-) ethylene	49	1100	3900
kton/y (bio-) benzene	28	600	1900
bcm/y (bio-) natural gas	0.23	5	50

500 MW scale
equals large
paper mill

5 bcm/y bioSNG
expected (NL)
2030-2040

Bio-energy demand
creates huge production
volume of C2 and C6



ECN DEVELOPMENTS

complete test system available



- Gasifier: www.milenatechnology.com
- Tar removal: www.olgatechnology.com
- New BTX scrubbing process



MILENA gasifier



OLGA tar removal



BTX scrubber



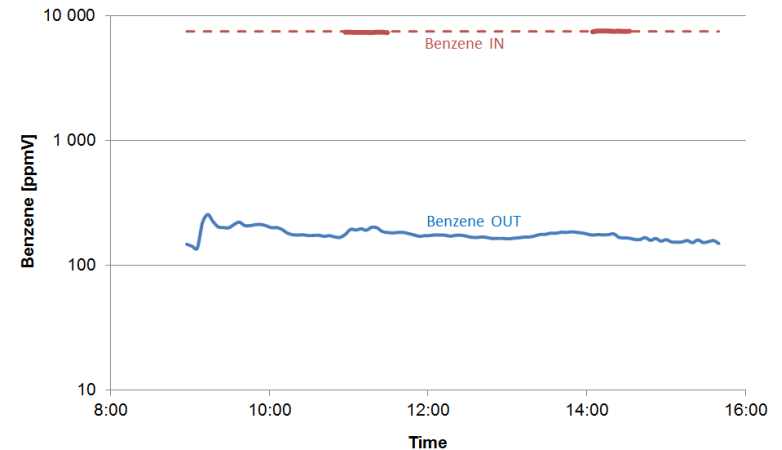
*Series of further gas cleaning
and methanation*

ECN DEVELOPMENTS



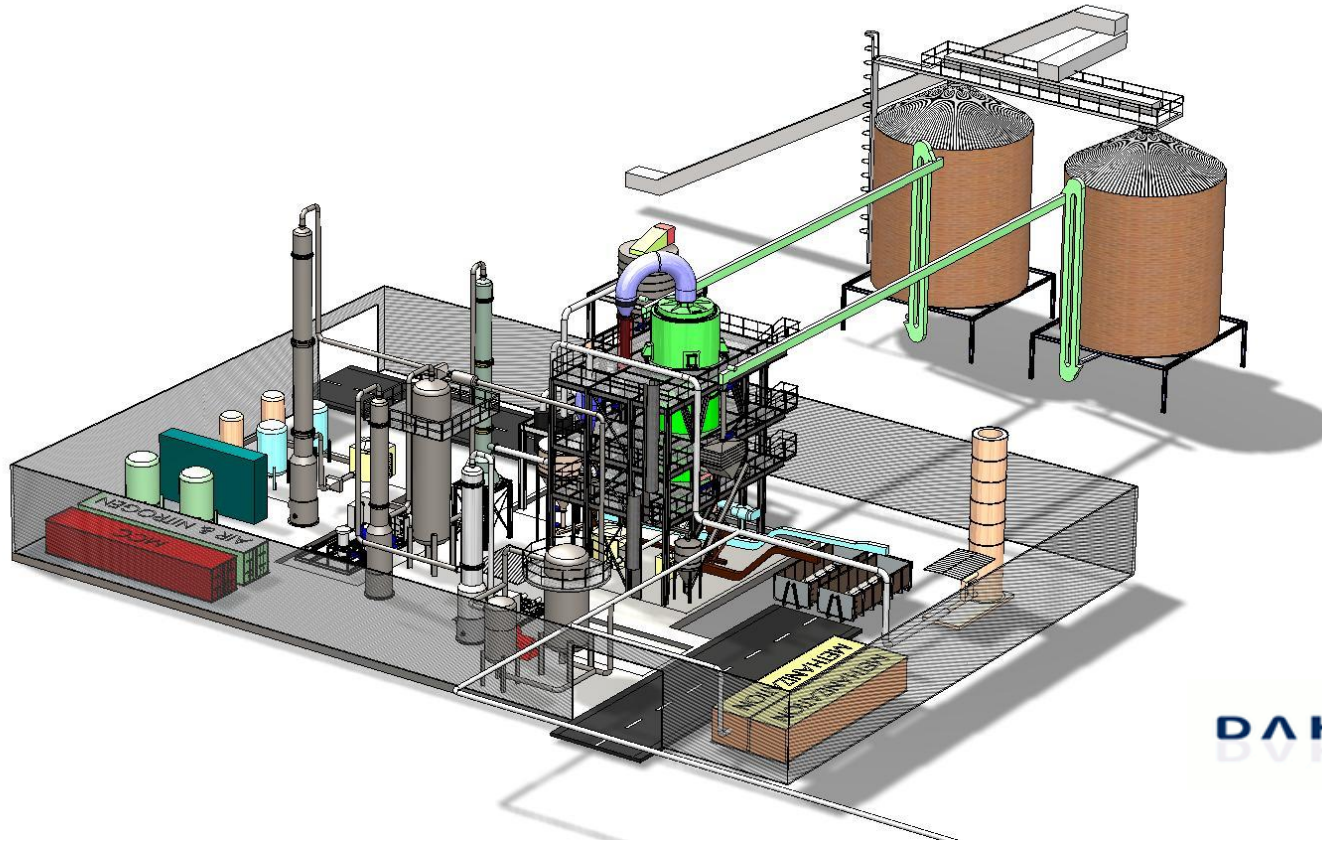
first BTX test results

- Stable operation downstream wood-operated MILENA gasifier and OLGA tar removal in $\sim 1 \text{ Nm}^3/\text{h}$ test facility
- >97% benzene removal
- >99% toluene removal
- >90% organic sulphur removal
- Next steps:
 - Harvest bioBTX in liquid form
 - Perform integrated test with bioSNG production to prove synergy (better value products, higher efficiency, simpler/cheaper process)
 - Additional bio-ethylene removal
 - Increase benzene and ethylene yield in gasifier (first test showed tripling of benzene)
 - Combination with bioLNG and ultra clean syngas



DEMONSTRATION PLANT

4 MW wood-to-SNG plant in Alkmaar (NL)



DEMONSTRATION PLANT

22 MW waste-to-power plant in UK



DAHLMAN 

FINAL REMARKS

- Biomass for only energy is not future-proof
- Low-temperature gasification (<1000°C) perfectly fits biomass and waste
- This generates valuable bio-hydrocarbons like bio-benzene and bio-ethylene
- Separating these bio-molecules makes much sense: higher value products, better efficiency, and simpler/cheaper process
- Having a large volume market for bio-energy creates the large-scale needed to be *economic* as well as *significant*
- *In other words: if only part of the bio-energy ambition will become reality, the bio-benzene (and bio-ethylene) production will be a game changer*
- High yield of ethylene (and styrene) when using plastic waste as feedstock, creates new way of recycling the monomers / depolymerization

MORE INFORMATION

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OLGA: www.olgatechnology.com / www.renewableenergy.nl
SNG: www.bioSNG.com / www.bioCNG.com

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