Indirect gasification of waste to create a more valuable gas

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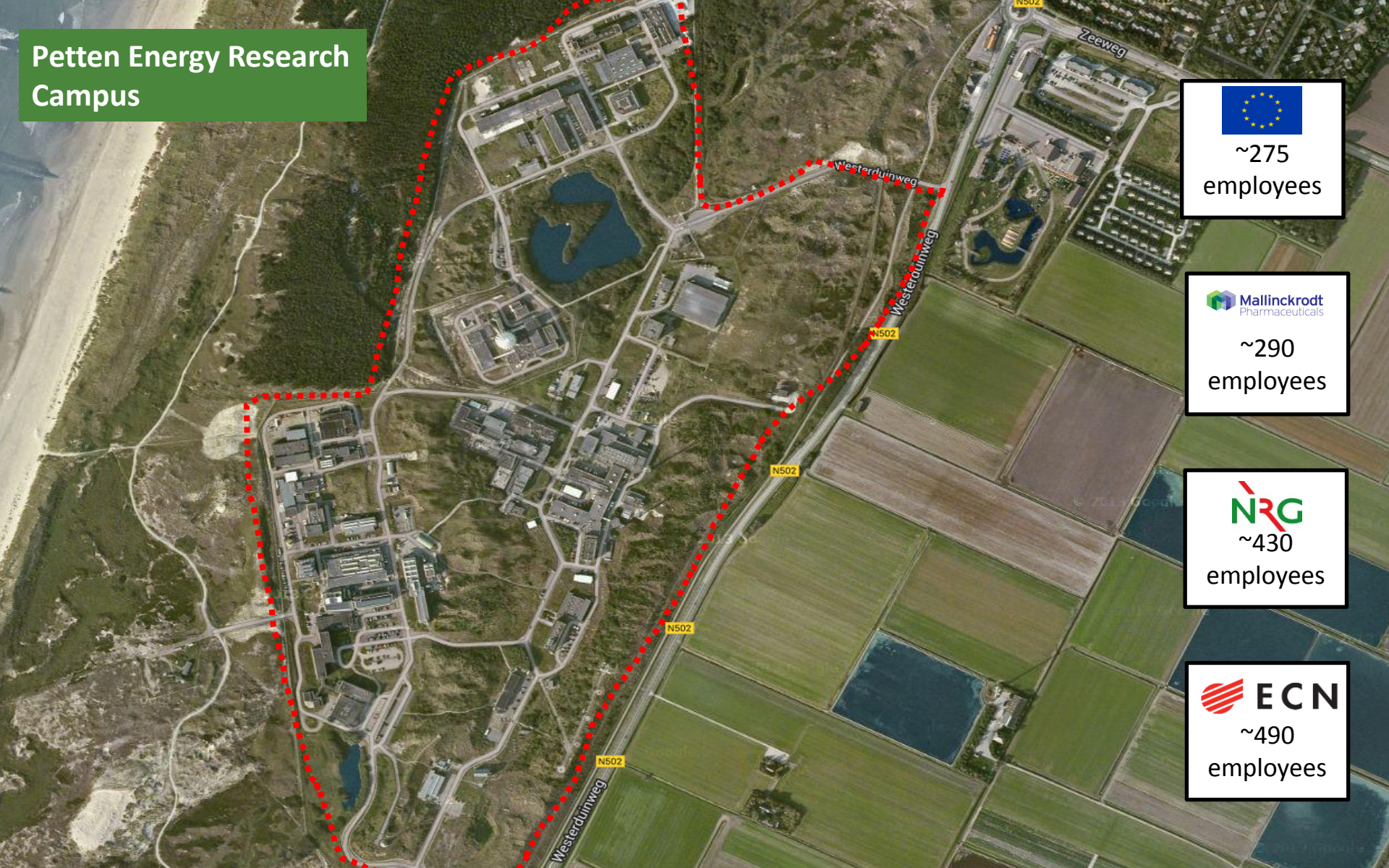

Petten Energy Research Campus
Zeeweg
Westerduinweg
N502
~275 employees
Mallinckrodt Pharmaceuticals
~290 employees
NRG
~430 employees
ECN
~490 employees

A bridge between science and corporate innovation

What we do

- Problem Solving
- Technology development
- Studies & Policy Support

How we work with our partners

- Consultancy & Services
- Contract R&D
- Tech development & Transfer
- Joint Industry Projects

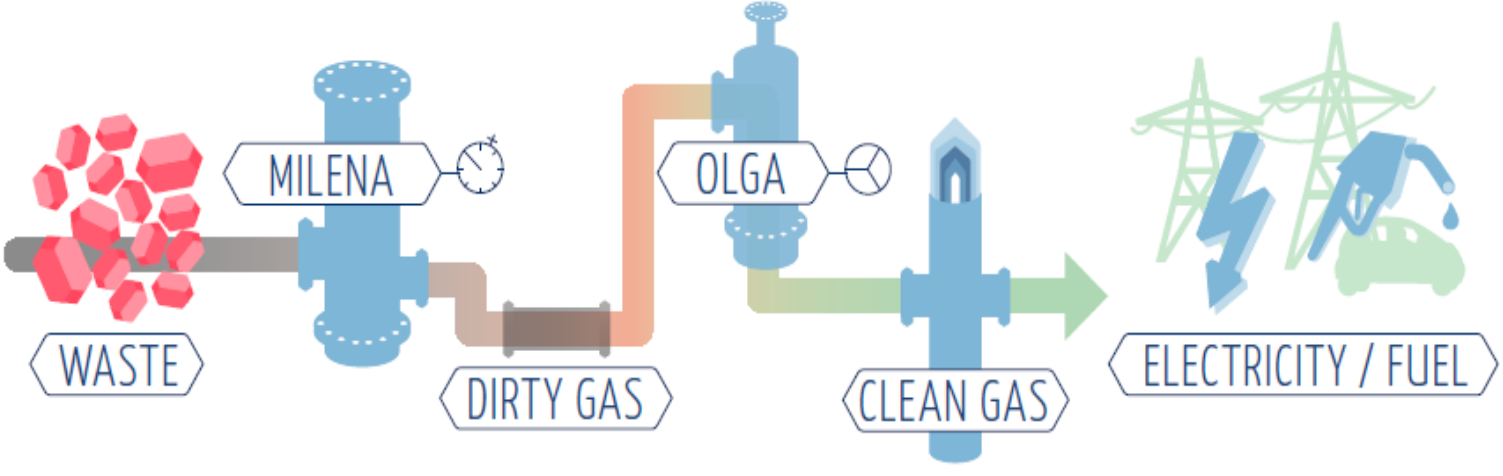
Royal Dahlman

- Tech company, established in 1886
- serving the oil & gas and power market
- Developing gasification, syngas cooling & purification technologies in cooperation with ECN since 2001
- License holder for MILENA gasifier, OLGA tar removal
  (both patented by ECN) and inventor of ELANA cooler
- Enabling complete biomass & waste fueled gasification projects for multiple end users

4 MW MILENA-OLGA in India

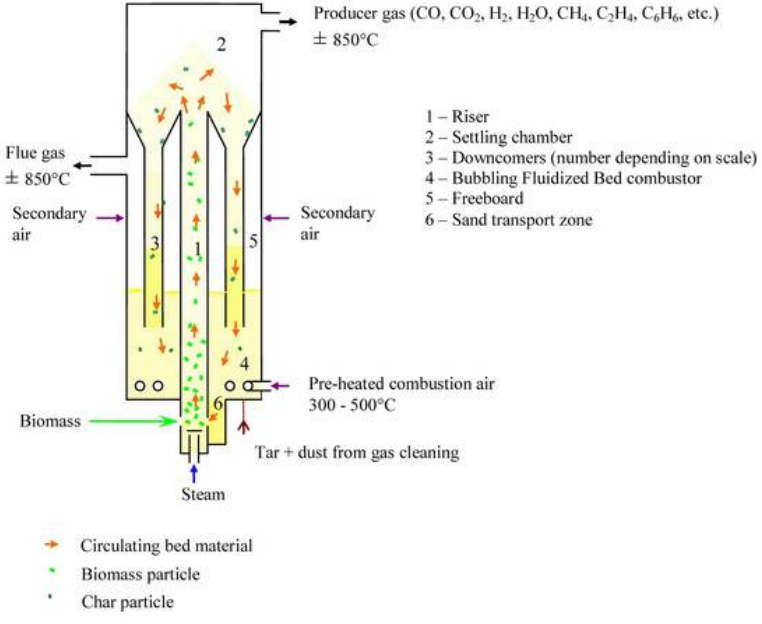
Waste to Energy & Chemicals through gasification

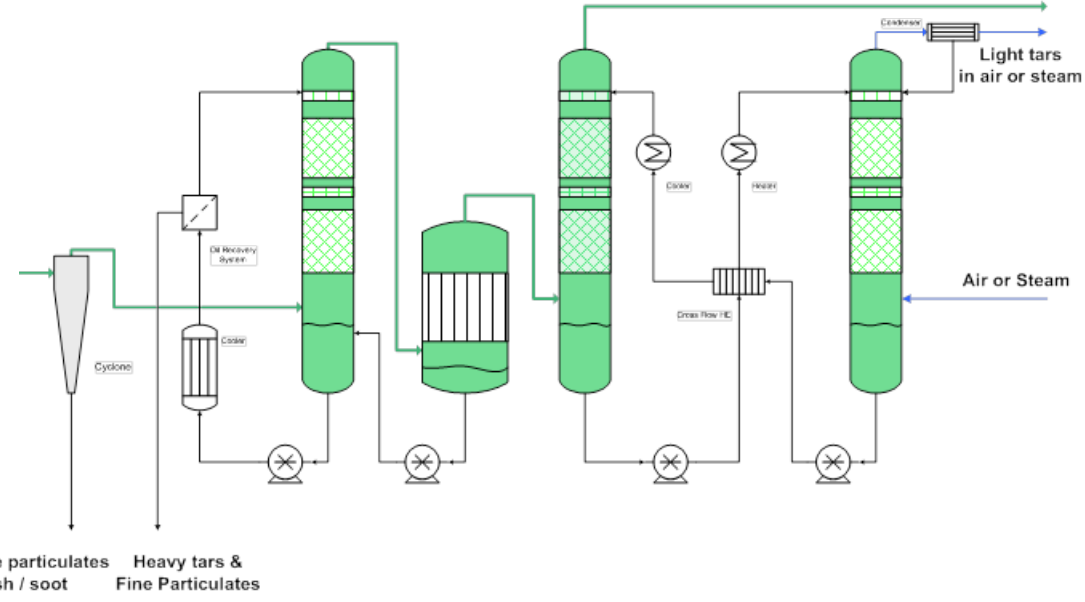
- Waste is a valuable resource
- Gasification converts a solid feedstock into gaseous chemical building blocks
- Clean syngas is the basis for production of energy, fuels and chemicals
- Gasification is not perfect, the raw product gas (syngas) contains tars



MILENA & OLGA

- MILENA = indirect gasifier (separated gasification & combustion)
- OLGA = multi-stage tar scrubber



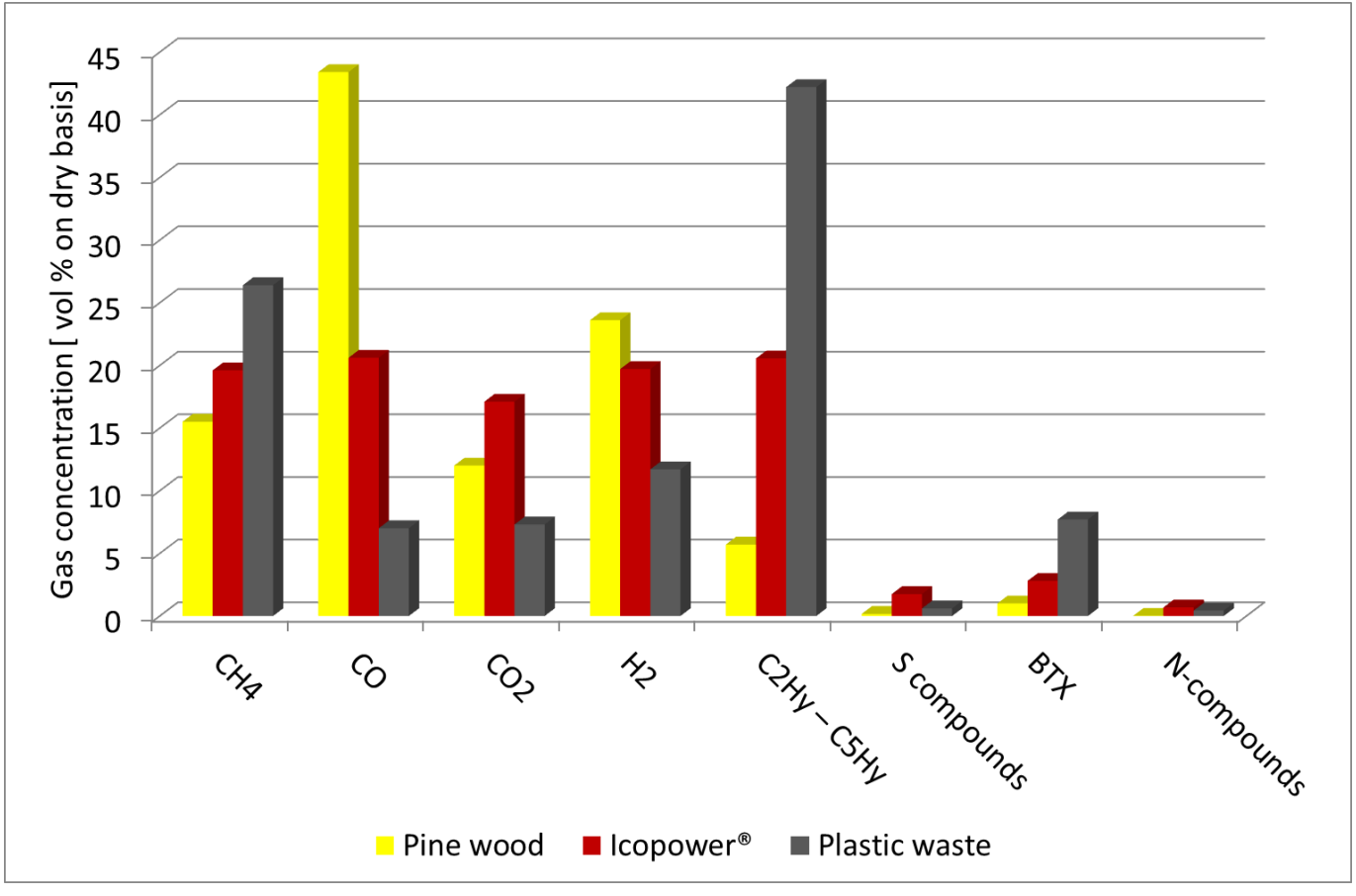


Pilot experiments: fuels

	Pine wood	Icopower®	Plastic waste
Gasification temperature (°C)	810	750	700
C (wt. % d.b.)	50.0	52.4	65.0
H (wt.% d.b.)	6.4	7.3	9.8
S (wt.% d.b.)	0.02	0.18	0.08
O (wt.% d.b.)	45	27.3	14.4
Cl (wt.% d.b.)	0.008	1.16	1.58
Ash 815°C (wt.% d.b.)	0.46	12.8	9.8
HHV (MJ/kg d.b.)	20.1	24	32.6

Pilot MILENA

Comparison of gas composition (N_2-free basis)



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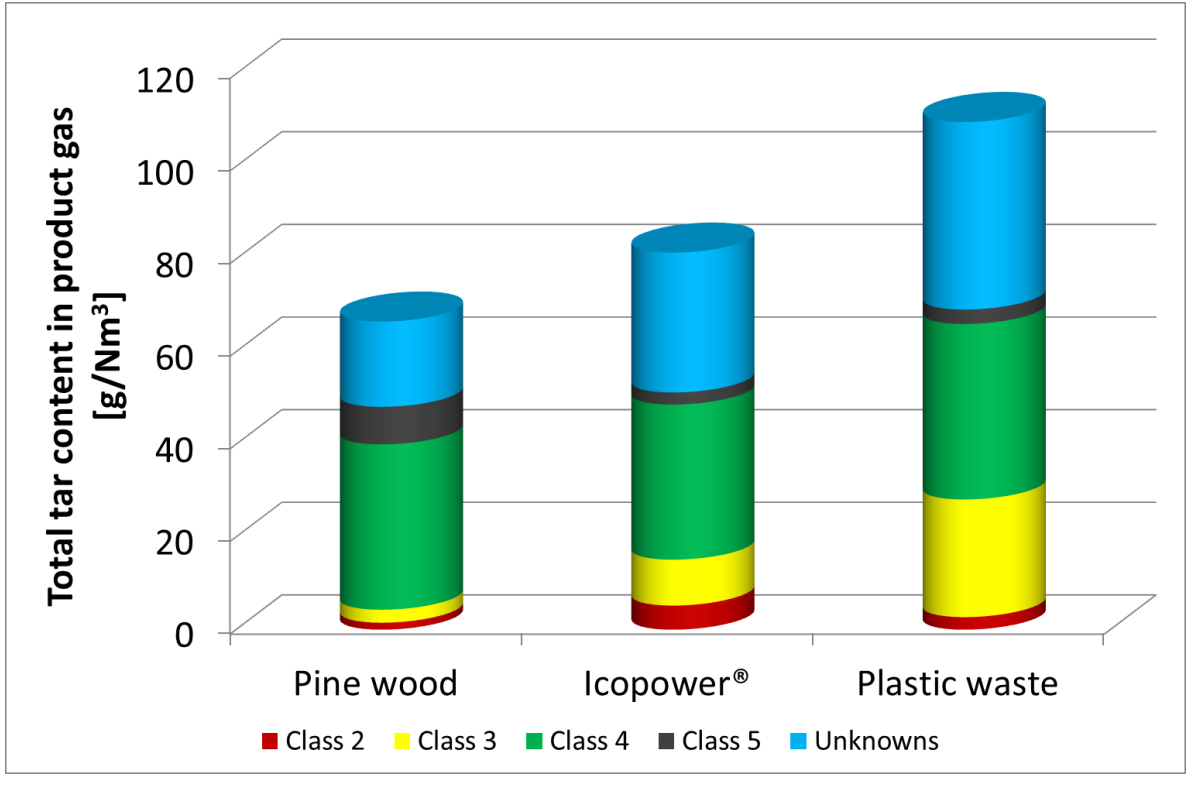


Tar classification:

2 = heterocyclic (e.g. phenol)

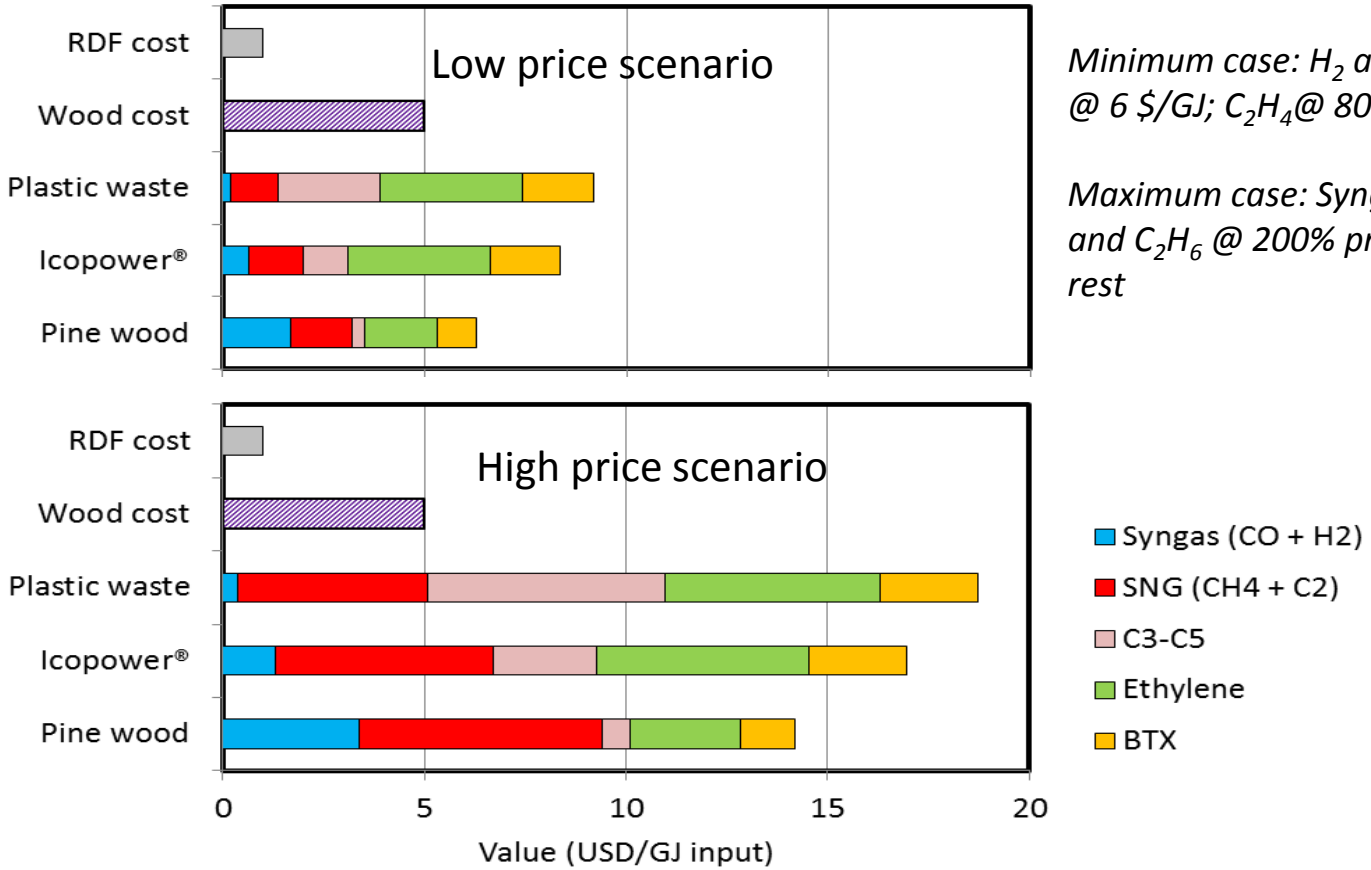
3 = 1-ring aromatic (e.g. xylene)

4 = 2, 3-rings (e.g. naphthalene)

5 = > 3-rings (e.g. coronene)

Class 5 = condense @ high T @ low concentrations

Waste gasification -> valuable gas



Minimum case: H_2 and CO @ 5 $/GJ; CH_4 and C_2H_6 @ 6 $/GJ; C_2H_4@ 800 $/ton; BTX @650 $/ton

Maximum case: Syngas with an 100% premium; CH_4 and C_2H_6 @ 200% premium as biofuel; 30% for the rest

Producer gas from waste gasification

Waste gasification (compared to wood gasification):

- High calorific value gas
- More methane (SNG)
- More unsaturated HCs (co-production)
  - No hydrogenation & pre-reformer
  - Lower SNG production price
  - Circular economy (e.g. ethylene, propylene recovery)
  - BTX & ethylene recovery technology

  under development at ECN and partners

Image source: www.energenz.com

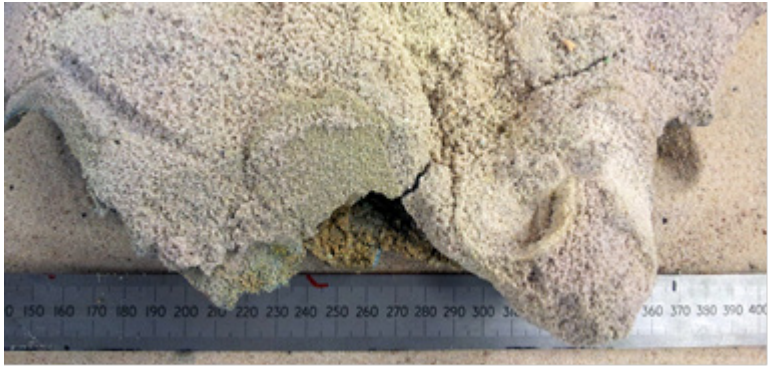
Waste gasification challenges

Experiments at pilot scale revealed some issues with initial MILENA design:

- Inhomogeneous material (feeding problems, unstable operation)
- High ash and chlorine content (agglomeration, fouling, corrosion)

Dahlman and ECN modified initial design and operating philosophy:

- Improved system design (reactor, gas cleaning)
- Waste pretreatment, lower gasification temperature, use of additives



Agglomerate found in Bubbling Fluidized Bed

Small pieces of metal, sieved out of bottom ash

Summarizing the valorization considerations for waste

- Type of waste? (contaminants, price, availability, amount, composition)
- What is the gas composition? (syngas, hydrocarbons)
- What is the local market? (heat, power, chemicals, fuel or natural gas)
- What are local price conditions? (e.g. natural gas fluctuates globally)
- Are there subsidies, benefits, penalties, credits, premiums etc. set by national or local government?

Conclusions

- Indirect gasification is a key technology in valorizing the potential of (biogenic) waste streams
- Product gas particular suitable for synthesis and co-production
- Short term application is CHP
- Higher plastic content -> increased concentration of valuable HCs
- Recovering BTX and ethylene is promising and R&D is ongoing

Waste is a valuable feedstock ready to contribute to Greening the future, producing Green BTX, Green Ethylene, Green Gas etc.

Come develop technology with ECN and don't let this resource go to waste!

THANKS FOR THE ATTENTION

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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
BTX: www.bioBTX.com

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