ECN
Your energy. Our passion.

ECN
Research and Development in bioenergy

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Tatjana Komissarova, Corporate business developer

FIESP

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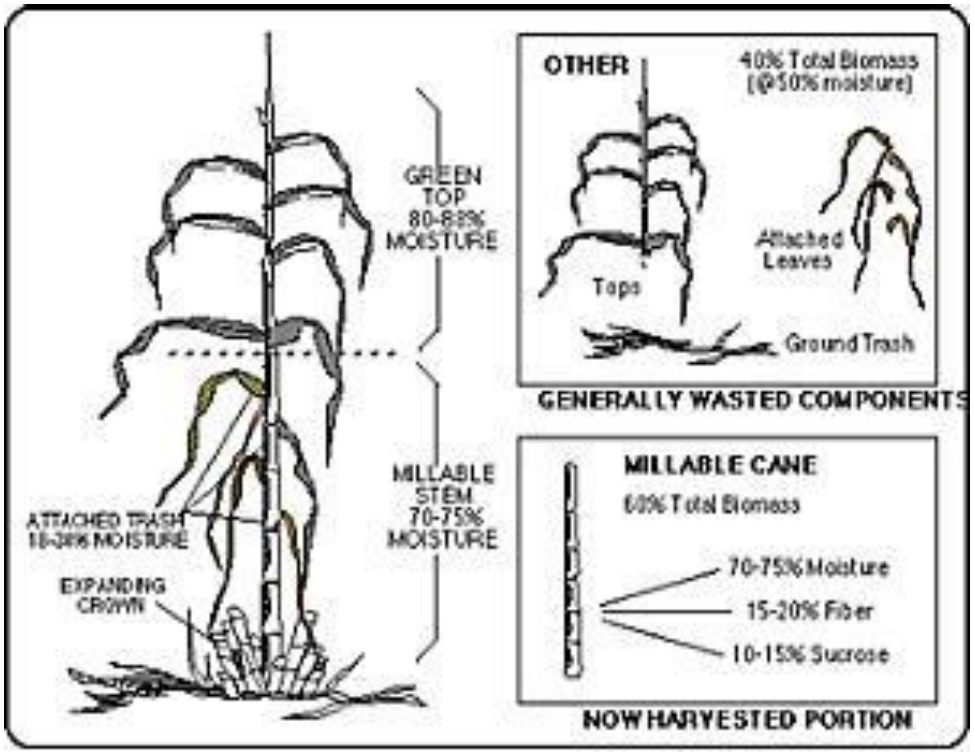
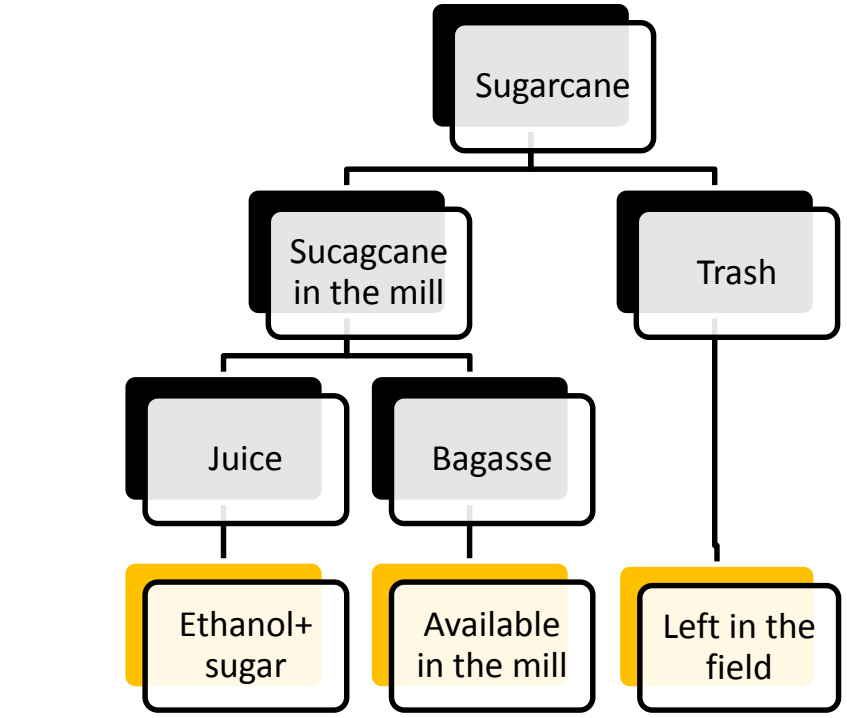
BRAZIL

- Brazil is nowadays the largest and BEST bioethanol producer in the world.
- How can we together make it even BETTER towards 2nd & 3rd generation bioethanol?
- We are here today to explore partnerships with Brazilian Research Institutes, Government and Industry to help to make it better and together contribute to BIO-ECONOMY.

Brazil – some challenges

towards the use of the whole sugarcane





The potential of sugarcane bagasse is 2/3 of total amount

1/3 total carbon > trash (left in the field)
1/3 > bagasse (usually burned)

Brazil – some challenges

Sugarcane and waste Biorefinery for biochemicals and polymers

Crashed Sugarcane (Juice + trash + bagasse) or Household waste

Sucrose, pentoses, glucose, lignin

Bulk chemicals, fertilizers, performance materials

Acrylic acid, ethanol, organic acids, polymers

Brazil – some challenges

towards optimizing municipial sold waste processing

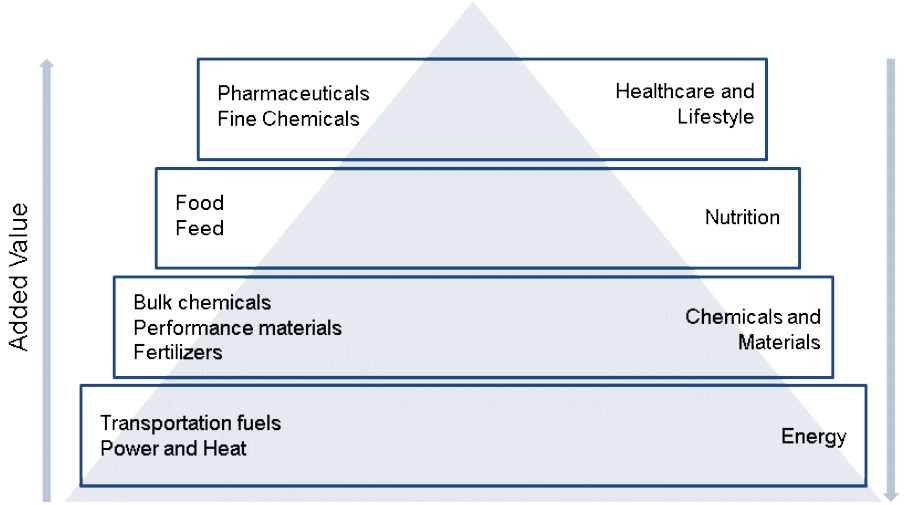
RDF (municipial solid waste)

Waste to energy

Bulk chemicals

Biomass utilisation at ECN

- From focus on bioenergy to focus on bioeconomy
- Cascading and biorefinery important
- Sustainability is complex issue (Indirect Land Use Change, Carbon Debt)

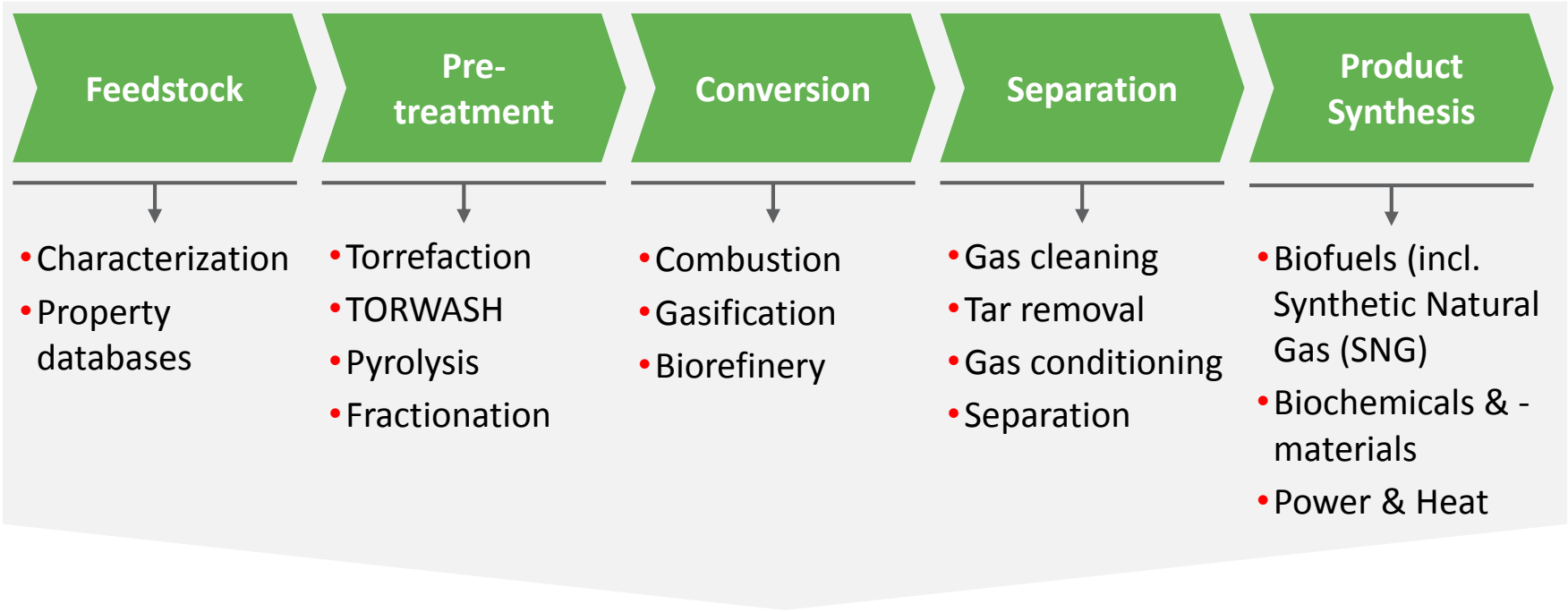


- But energy component remains:
  - Energy sector orders of magnitude larger than chemical sector
  - Some parts of the energy sector difficult to cover with other renewables (e.g., biofuels for heavy vehicles, aviation, marine applications)
  - Not all biomass qualifies for high-value applications (e.g., low grade biomass, heterogeneous and/or contaminated residues)

Direct biomass-to-energy value chains will remain important

Making bioenergy work

Focus on thermochemical processing



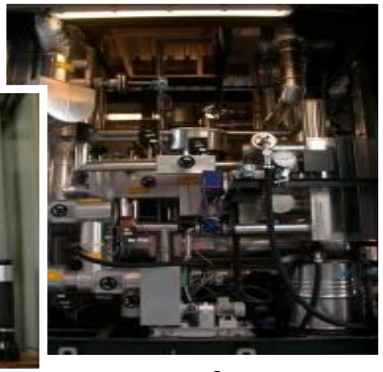
» Higher efficiencies, higher availability, lower environmental impact, higher public acceptance, lower CAPEX/OPEX, new applications

Feasibility studies, techno-economic evaluations, LCA, sustainability assessments

Example: the ECN OLGA tar removal technology

- ECN developed this technology with its partners to succesfull commercial implementation.

2 m³/h



200 m³/h

2 000 m³/h

25 000 m³/h

1992	*1996*	*2004*	*2009*
Lab scale	Bench scale	Pilot plant	Demo plant	Full commercial
• ECN demonstrated principle	• *0.5 MW pilot at ECN*	• *3-5 MW plant in Romania,* *3 MW plant in Tzum NL*	• 4MW plant in Portugal • Technology available for licensing via Dahlman (partner)

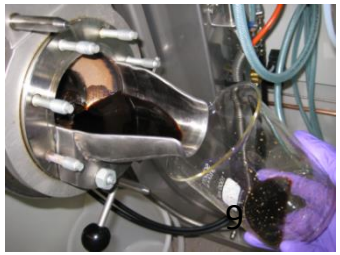
Four main ECN Biomass R&D areas

- Upgrading: Biomass to commodity fuel
  - Torrefaction: ECN technology available on full scale
  - New technology for torrefaction of wet biomass: TORWASH

- Gasification: Production of power or fuels
  - Development of gasification technology: MILENA
  - Tar removal and product synthesis
  - Test equipment and expertise to provide services

- Biorefinery: Technology for a biobased economy
  - Organosolv fractionation: conversion into cellulose, hemicellulo
  - Conversion of fractions into marketable products
  - Seaweed biorefinery

- Combustion: Biomass boilers and Co-firing
  - Fuel behaviour during combustion
  - Ashes, slags, agglomeration behaviour



Torrefaction

brings biomass close to coal properties

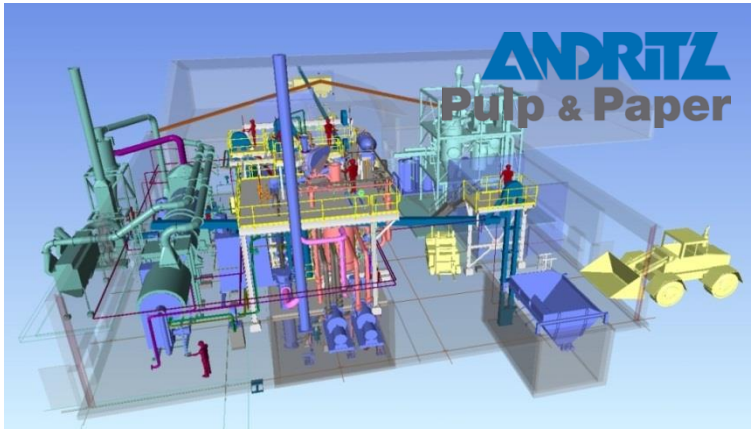
	Wood chips	Coal	Black pellets
LHV (MJ/kg)	9 - 12	23 - 28	18 - 24
Bulk Density (kg/m^3)		800-850	650 - 800
Bulk Energy Density (GJ/m^3)		18 - 24	12-19
	Difficult to grind	Easy to grind	Easy to grind
	Short storage time	Long storage time	Long storage time

Torrefaction

brings biomass close to coal properties

- Status of technology
  - Batch scale reactor at ECN
  - Test-equipment on pelletisation
  - Technology licensed to Andritz Pulp & Paper
  - Demo plant (1 ton/hour) in Denmark
  - Commercially available

- We look for partners
  - Pelletizing companies
  - Biomass trading/exporting companies
  - Biomass producers (plantations)
  - R&D organizations for jointly optimizing process for residue streams

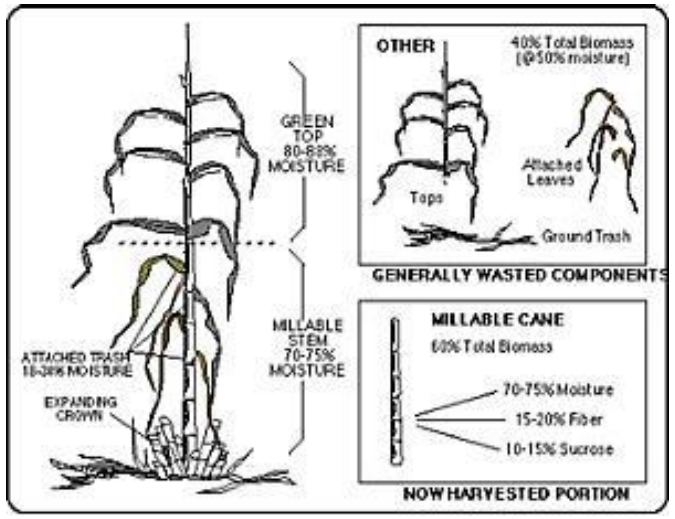


TORWASH

for upgrading low-rank biomass to commodity fuel

- Low-rank biomass streams
  - Too high water content
  - Too high salt content
  - Seasonal variations and bio-degradable
  - Bulky material with low energy density
  - Tenacious, springy materials
  - Grass, straw, food/agro residues

- Commodity fuel
  - Constant quality
  - Suitable for standard combustion
  - All year availability
  - Reliable supply
  - Tradable on spot market



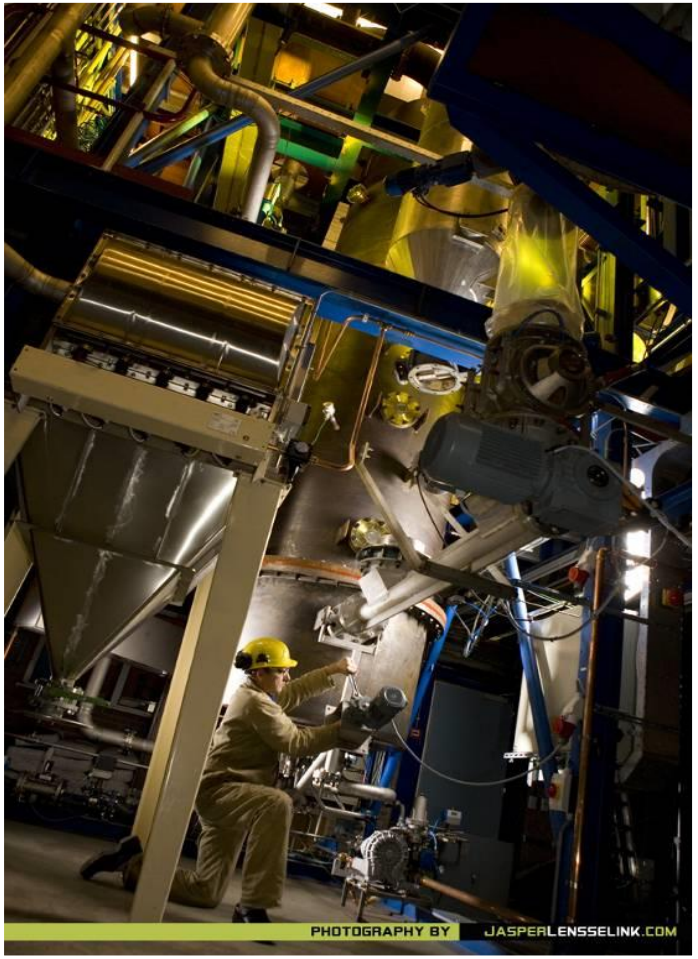
TORWASH

for upgrading wet low-rank biomass to commodity fuel

- ECN developed TORWASH at lab-scale
- We look for partners for demonstration and industrial scale up
  - Plantations
  - Pelletizing companies
  - EPC companies
  - Government and R&D organizations working on biomass valorization

Milena thermal gasification
multi fuel biomass conversion

- Fuel flexible: biomass, waste, coal, …
- High conversion efficiency (carbon free ash)
- High calorific value of product gas
- One single vessel: compact design
- Scalable from 4 to 250 MWth



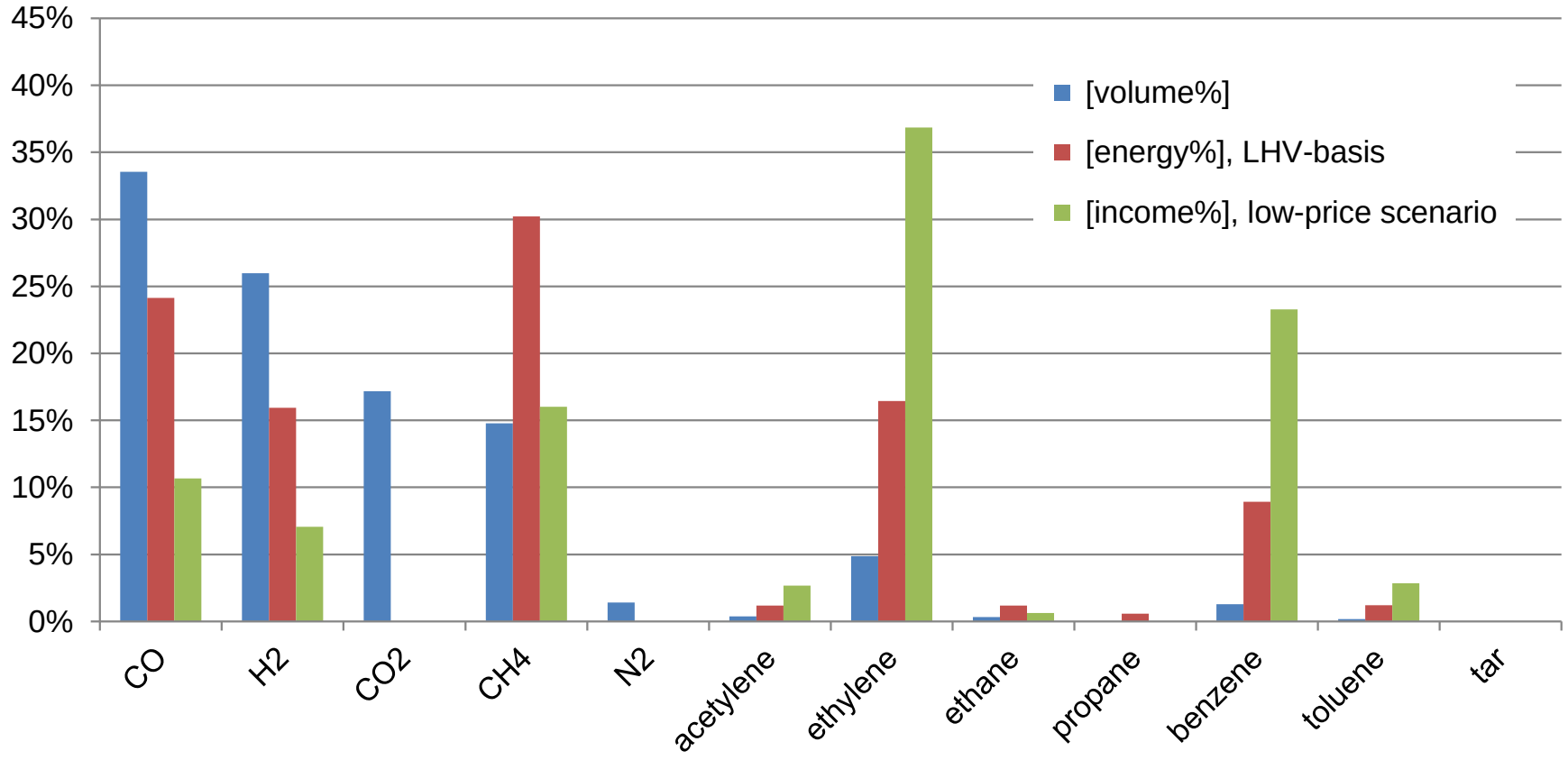
Milena thermal gasification

Markets for MILENA gasifier

- Combined heat and power. On-site conversion of waste to energy
  - In combination with gas engine or small gas turbine
  - Milena produces high calorific gas, not diluted with nitrogen
- Substitute Natural Gas production:
  - High methane content of producer gas makes Milena very suitable for SNG production
- Production of liquid fuels or chemicals

Fluidised-bed gasification

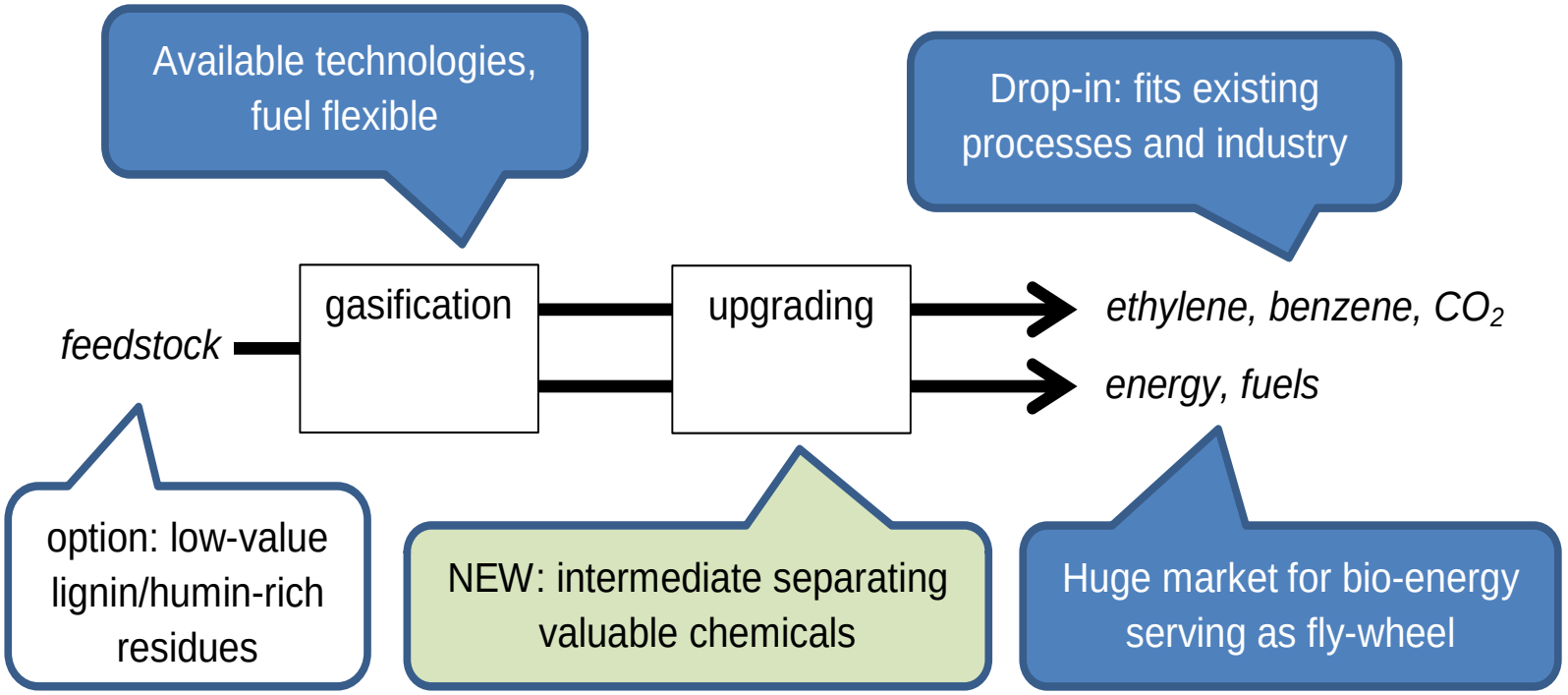
Potential of chemicals separation



Example of gas composition of fluidised-bed gasifiers. Composition depends on fuel and gasifier conditions. Double ethylene and benzene have also been measured.

Milena thermal gasification

"PLUG-and-PLAY" BIO-REFINERY



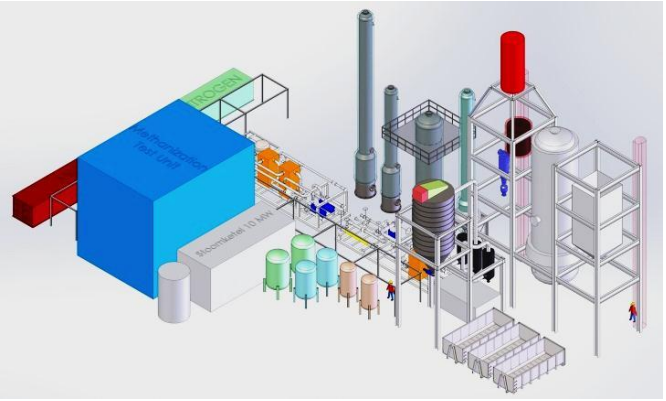
"While we are here…, let's take out the more valuable stuff first"

Milena thermal gasification

Technology status

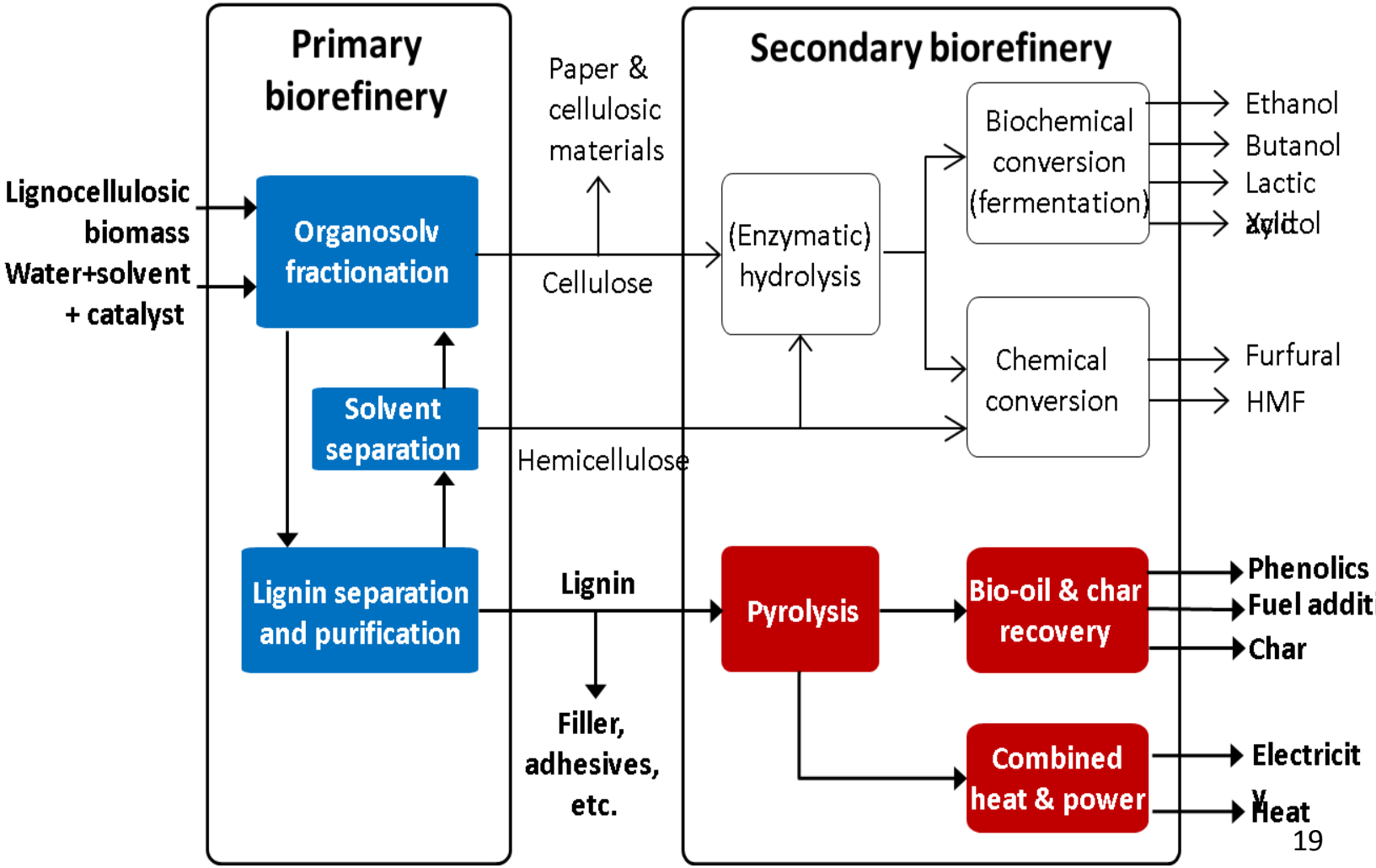
- Technology status
  - Demonstrated at 1 MW_{th} at ECN
  - 4 MW_{th} demo plant scheduled in India on soy stalks
  - 12 MW_{th} demo plant scheduled in The Netherlands on waste wood
  - 22 MW_{th} demo plant scheduled in the UK on waste (Refuse Derived Fuel/Solid Recovered Fuel - consists largely of combustible components of municipal waste such as plastics and biodegradable waste).

- We look for partners for industrial demo and commercial plants
  - Plantations
  - EPC companies
  - Energy suppliers and users
  - Local/regional/central authorities



ECN lignocellulosic biorefinery

Organosolv fractionation from any biomass resource



Lignin applications

- Potential feedstock for wide range of chemicals (aromatics!) and performance products.
- Valorisation lignin improves carbon footprint & economics lignocellulose biorefinery.

low volume - high value market 10000 €/ton



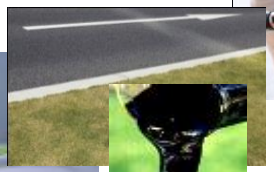
specialty chemicals

bio-plastics

bio-resins for wood-adhesives


activated carbon, carbon-fibres and carbon-black

fuel-additives



bio-bitumen for asphalt

bio-fuel for CHP

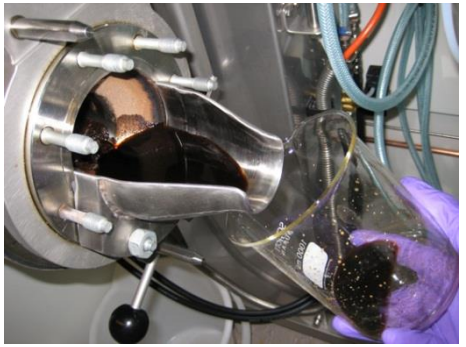
bio-char for soil improvement

high volume - low value market 100 €/ton

Biorefinery
producing chemicals from biomass

- ECN developed biorefinery organosolv technology at lab-scale for various feedstocks.

- We look for partners for demonstration and industrial scale up
  - For designing processing of biomass residues
  - For the primary as well as the secondary biorefinery processes
  - For development of lignin applications



- Type of partner organizations
  - Plantations
  - Users of primary and secondary biorefinery products
  - Government and R&D organizations working on biomass valorization

Last word

- Biomass research and technology of ECN focus on producing a combination of Energy and Chemicals by:

  - By **upgrading** and bringing low value biomass closer to coal properties
  - By **gasifying** the biomass and separating it down into valuable chemical building blocks and energy
  - By **organosolv fractionation** of biomass to convert fractions into lignin and various products, such bio plastics

- We are excited to work together with Brazilian partners on bio-innovations that enable Bio economy and a transition to sustainable world

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Thank you for your attention

Tatjana Komissarova
komissarova@ecn.nl
T: +31 88 515 4053 | M: +31 6 12383466
P.O. Box 1, NL-1755 ZG Petten
Westerduinweg 3, 1755 LE Petten
www.ecn.nl | twitter.com/ecn