# Technische uitdagingen in het Energy Island van biobased productieprocessen

J.H.A. Kiel
M.K. Cieplik
E.E. Diemer

Mei 2014
ECN-L--14-026

ECN
Your energy. Our passion.

# Technische uitdagingen in het *Energy Island* van biobased productieprocessen

*IIR Congres Biomassa als grondstof voor de industrie – "Het groene goud van de toekomst"*

**Jaap Kiel,** Mariusz Cieplik en Edze Diemer

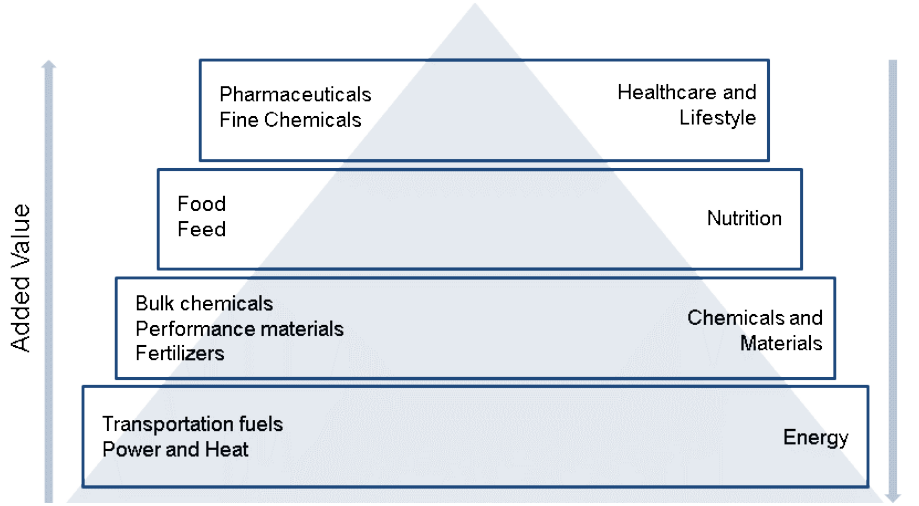
RDM Campus, Heijplaat, Rotterdam
27 mei 2014

# Inhoud

- ECN Biomassa R&D: focus op thermochemische procesopties binnen biobased economy waardeketens
- Energie is een belangrijk onderdeel in biobased productieprocessen
- Reststroom-benutting voor energie is niet triviaal - er zijn vele technische uitdagingen, maar ook mogelijkheden
- Slimme combinatie van praktijkmetingen en lab-schaal onderzoek en slim management van biomassa (reststromen) in het productieproces kan veel problemen voorkomen
- Ook voor reststromen is vaak energie en chemicaliën/materialen co-productie mogelijk (leidend tot extra toegevoegde waarde)

# Biomass utilisation in transition

- From focus on bioenergy to focus on bioeconomy
- Cascading and biorefinery important
- Sustainability is complex issue (e.g., ILUC, C-debt)

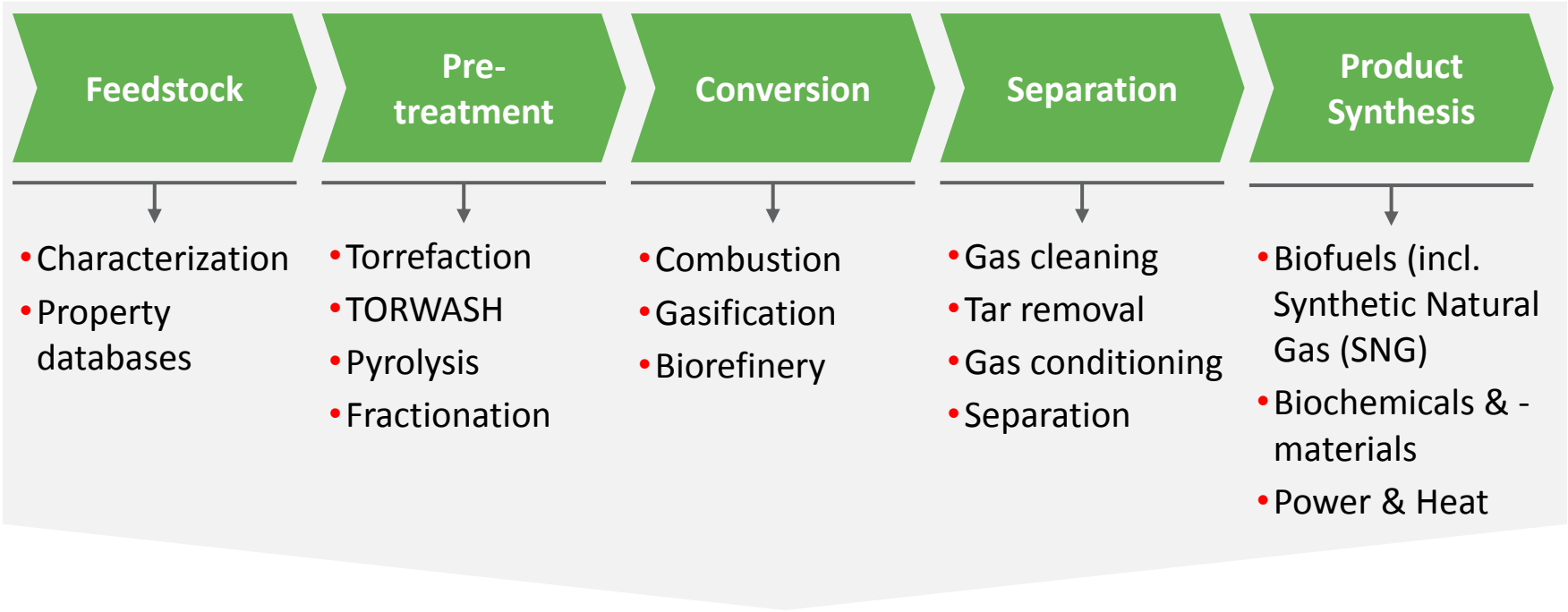



- But:
  - Energy sector orders of magnitude larger than chemical sector
  - Some parts of the energy sector difficult to cover with other renewables (e.g., biofuels for heavy vehicles, aviation, marine applications)
  - Not all biomass qualifies for high-value applications (e.g., heterogeneous and/or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

**Direct biomass-to-energy value chains will remain important**

# ECN Biomass R&D

*Focus on thermochemical processing*




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

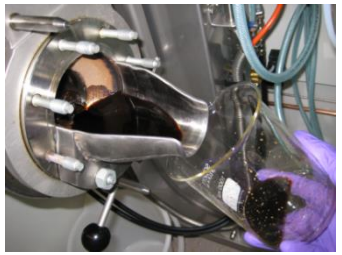
Feasibility studies, techno-economic evaluations, LCA, sustainability assessments

# 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

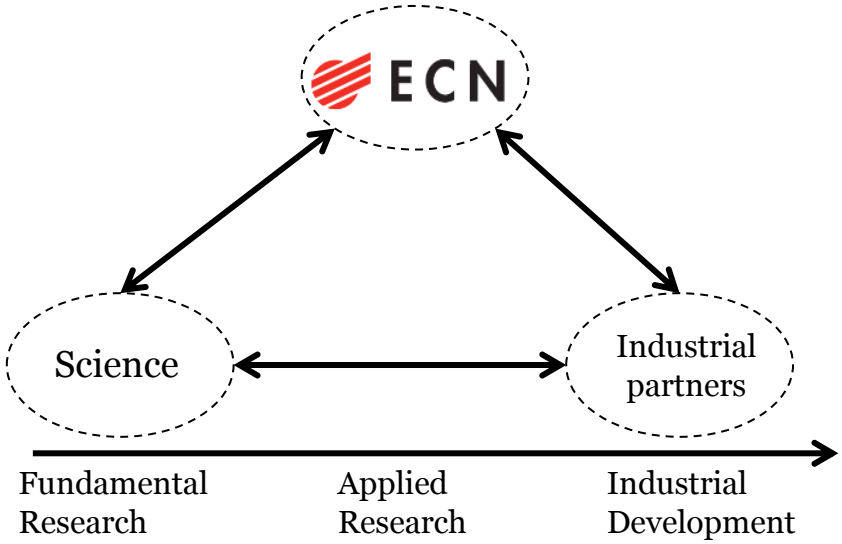
- Combustion: Biomass boilers and Co-firing
  - Fuel behaviour during combustion
  - Ashes, slags, agglomeration behaviour

- Gasification: Production of power or fuels
  - Development of gasification technology (MILENA)
  - Tar removal (OLGA) and product synthesis
  - Test equipment and expertise to provide services
- Biorefinery: Technology for a biobased economy
  - Organosolv fractionation: conversion into cellulose, hemicellulose, and lignin
  - Conversion of fractions into marketable products
  - Seaweed biorefinery



# ECN

## Bridge between science and corporate innovation




### What we do

Problem solving
*Using our knowledge, technology, and facilities to solve our clients' issues*

Technology development
*Developing technology into prototypes and industrial applications*

Studies & Policy support
*Creating insights in energy technology and policy*

### How we can work with you

Consultancy & Services
*Serving your short-term business and R&D needs*

Contract R&D
*Support your R&D with our knowledge, technology and (test) facilities*

Technology development & Transfer
*Implement our technology in products & processes*

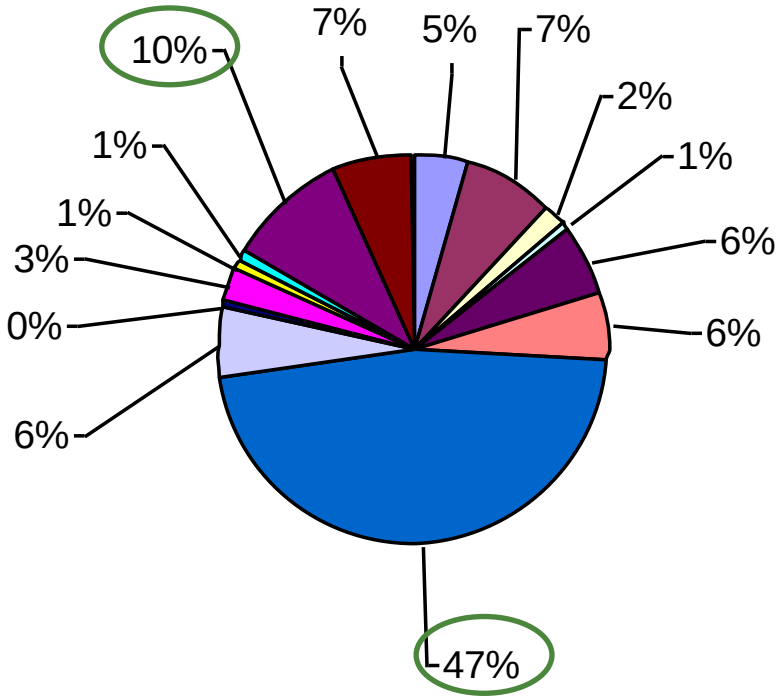
Joint Industry Projects
*Developing tomorrow's technology together*

# Lignocellulosic ethanol production

## Straw-based, 100 t/h input, stand-alone plant

- Estimated capital cost – Energy island major cost factor

***2nd Largest investment: Pre-treatment and pre-hydrolysis unit***

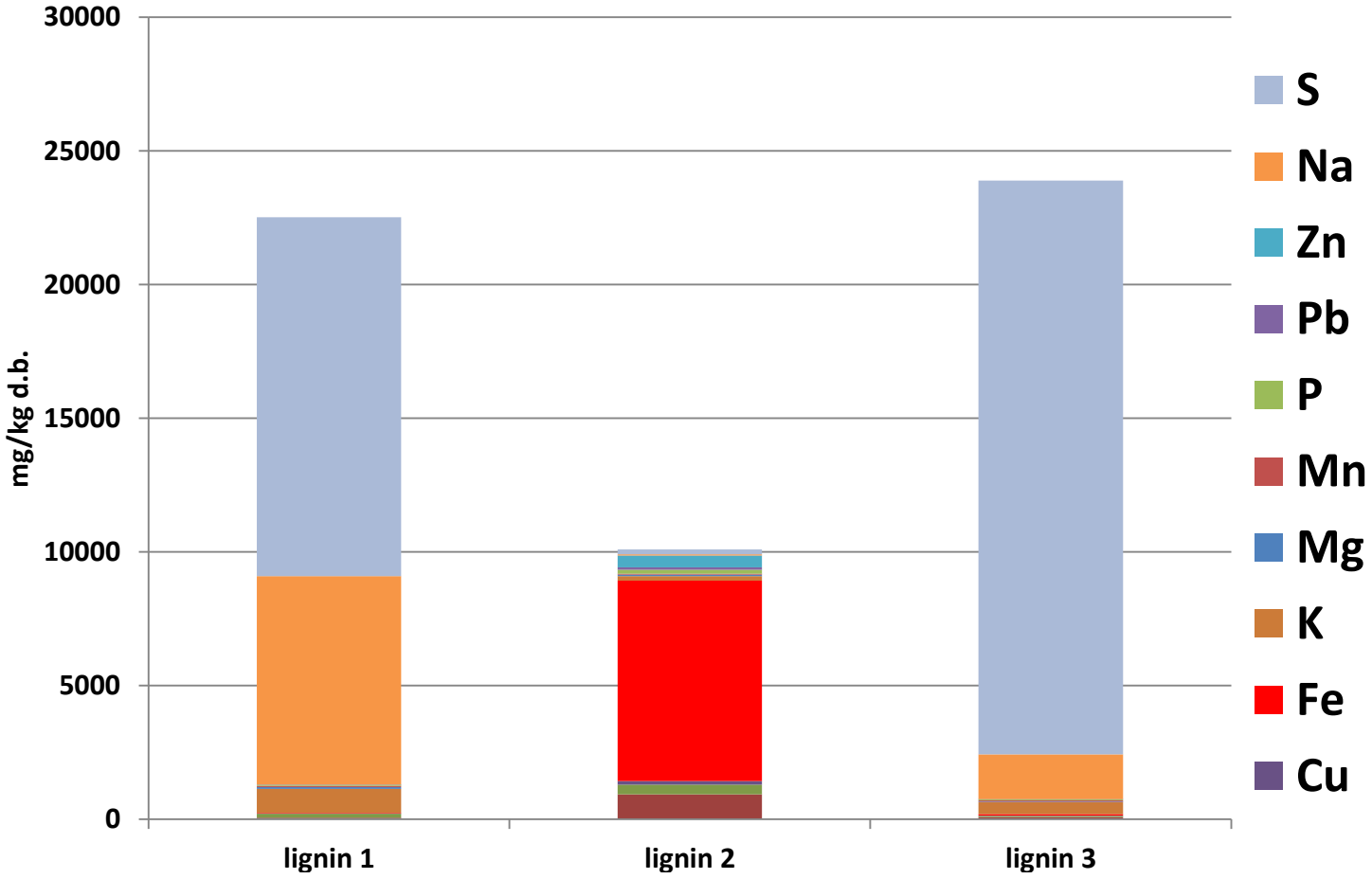



***Largest investment: CHP unit***

*From: Final report, EET project K01116, 2007*

# Residues for heat and power

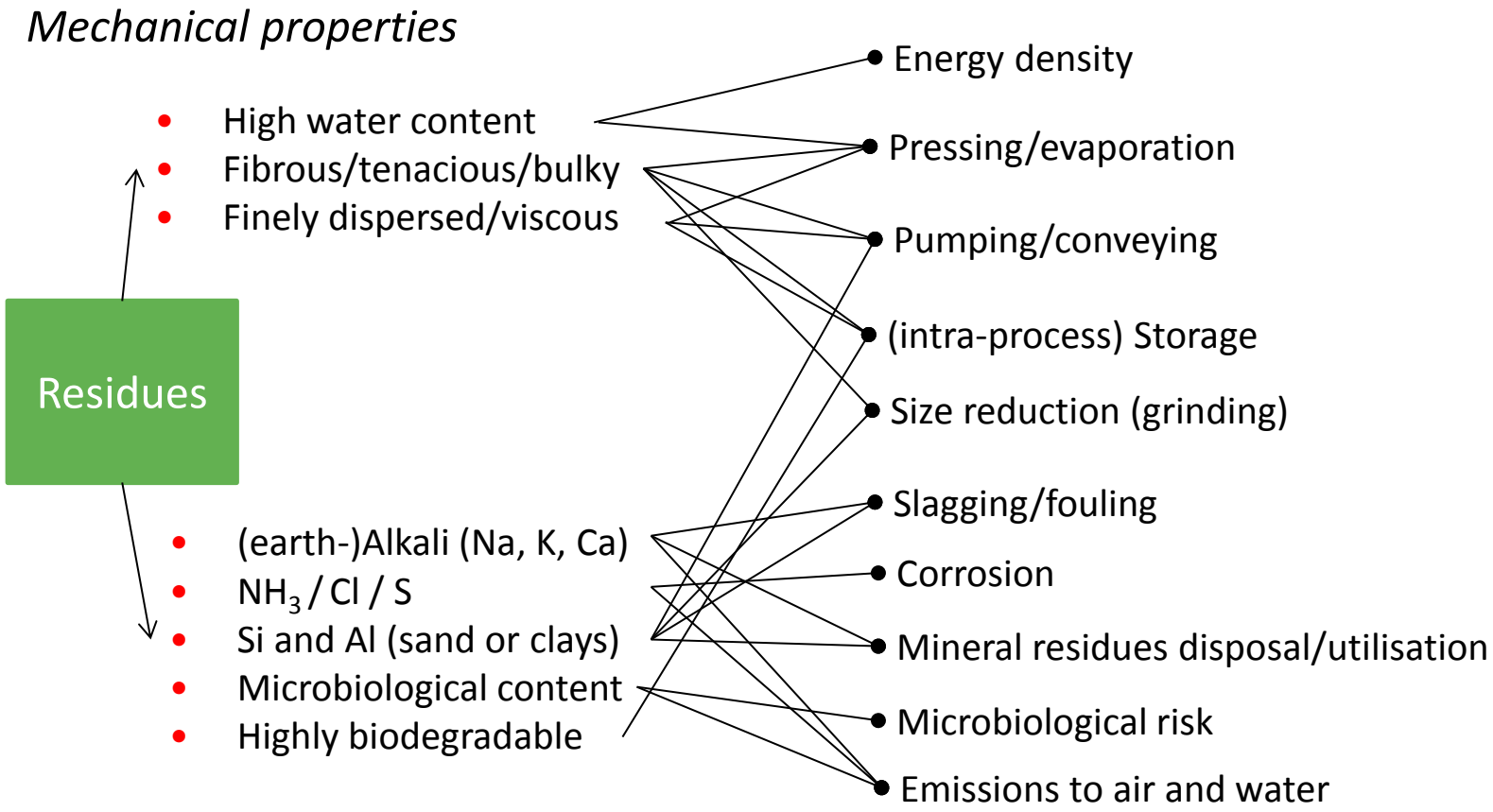
## Large differences in (inorganics) composition




*From: Beis et al. (2010), Bioresources 5(3), 1408-1424*

# Residues for heat and power

## Technical challenges



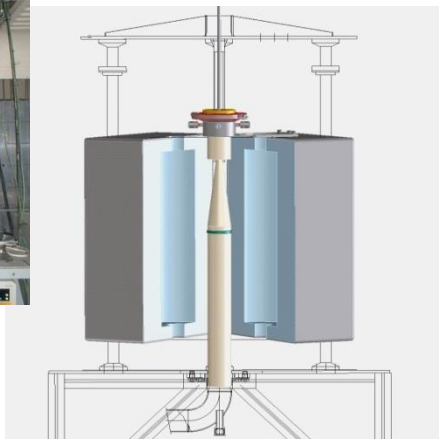
# Know your process enemies

- Future Bio-based processes still in early stage of market introduction
  - Currently many residues only available on < 1kg scale
  - Large variations in compositions of seemingly similar residues (“Craft” lignin vs lignosulphonates vs organic extraction lignins)
  - Few pilot/demo plants doing energy recovery from residues, hence limited experience
  - E-technology providers are not willing to guarantee performance

- Solution: smart combination of lab-scale tests and pilot/full-scale diagnostics

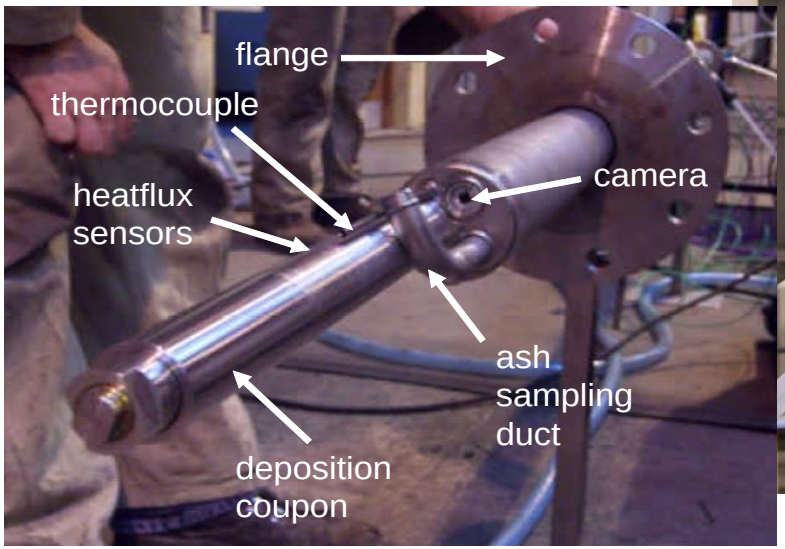
# Biomass Combustion: Service and Technology Offering

- Consultancy on available biomass types, analysis of biomass composition
- Lab-scale Combustion Simulator and Lab-scale Fluidised Bed (WOB) systems: validated against real life boiler data, suited for solid and liquid fuels, for combustion and gasification
- Bench-scale systems to test combustion, gasification or pyrolysis of all feedstock
- On-site measurement systems, such as gas analysis, probes for determining slagging and fouling, agglomeration
- Abatement of particulates, tars, NOx, and dioxins



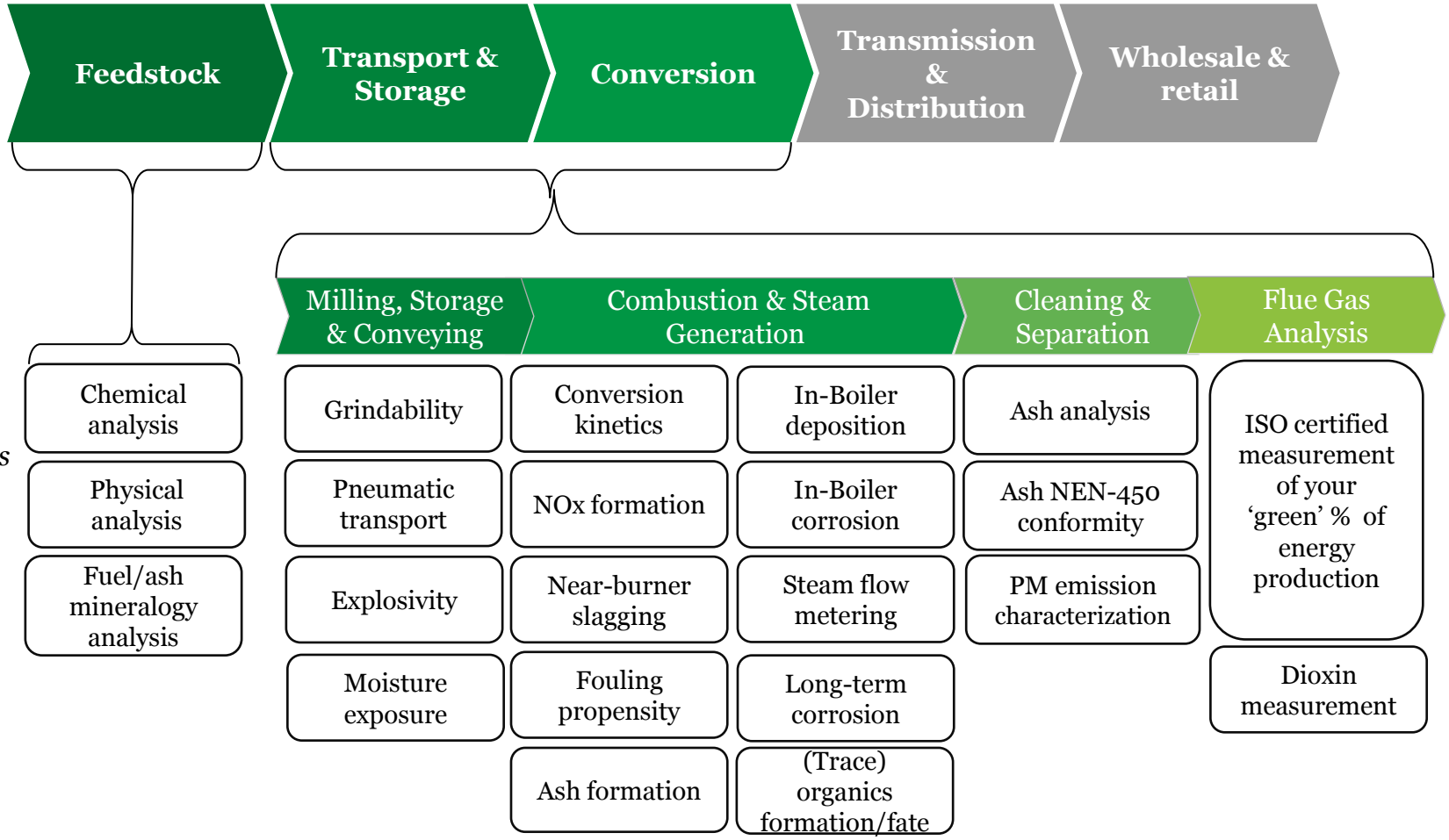
# Full-scale probe measurements

## for in-boiler and stack emission diagnostics

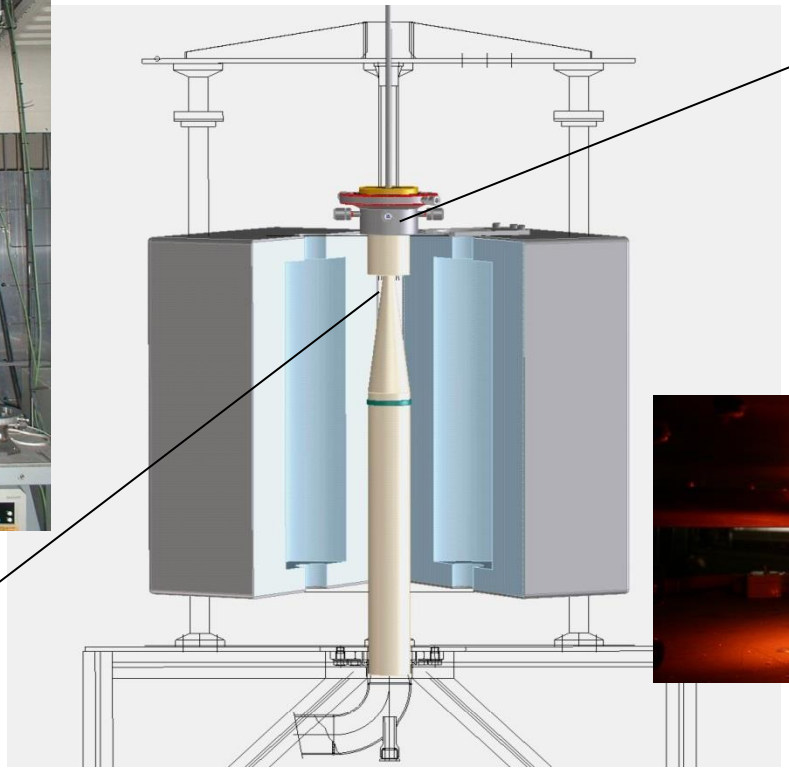
# Biomass combustion

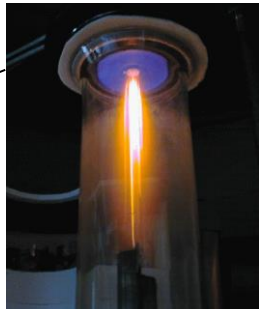
## Overview of R&D services



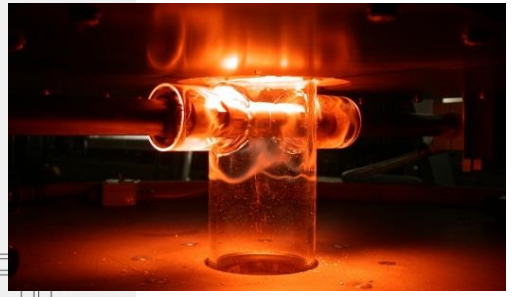
# Lab-scale Combustion Simulator (LCS)

## Mimic pulverised-fuel combustion and high-temperature gasification conditions





Staged gas burner: high heating rate + proper gas atmosphere



Fouling probe

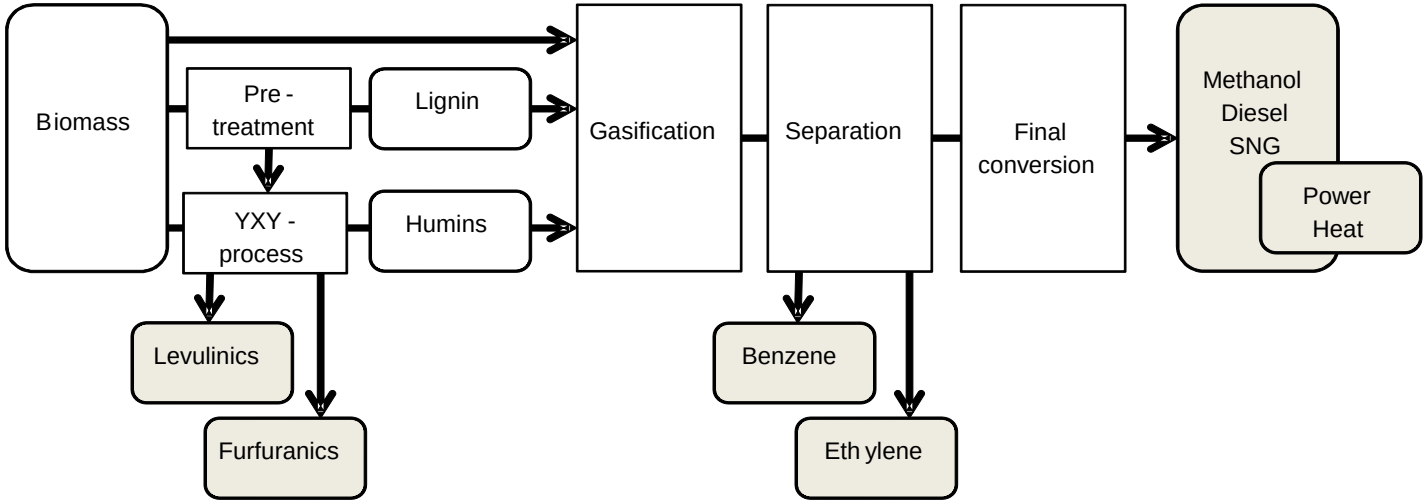
Particle sampling probe

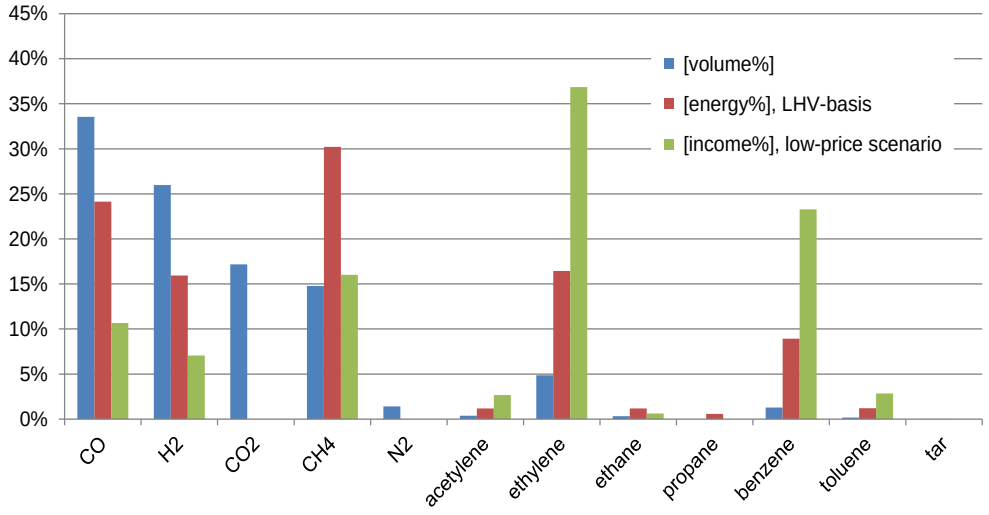
Special reactor design: 1-2s residence times with only limited total reactor length

# Example:

## Co-production of bio-energy and green chemicals from biorefinery residues via gasification

TKI-BBE Project TEBE113008



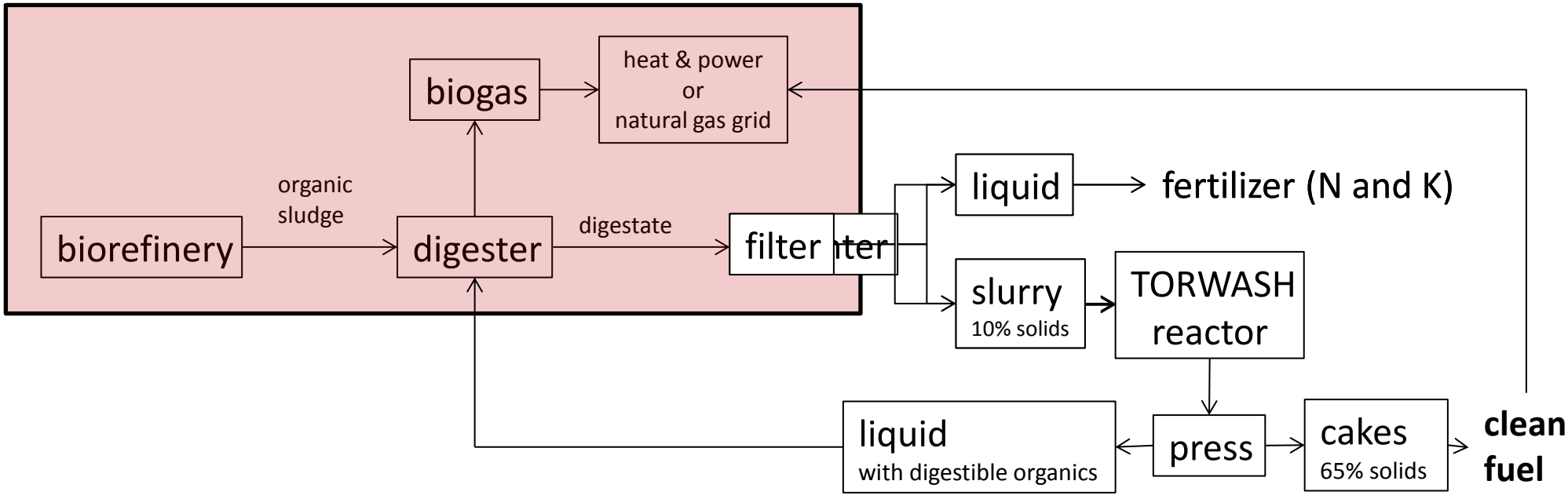




*Example of gas composition of fluidised-bed gasifiers. Composition depends on fuel and gasifier conditions. Double ethylene and benzene have also been measured.*

# Example:

Negative value solid residue becomes clean fuel by smart process integration

- Implementation of TORWASH process solves digestate problem!
- Also for wet residues from biorefinery and bio-ethanol production



# Example:

## Trace organics emission/abatement study for a leading biochemicals/bioplastics producer

*Organic emissions sampling unit*

### Project target and scope

- Characterization and advice on operational improvement of a newly-developed thermal conversion process
- Focus on trace organics emission reduction

### Activities

- Thermal conversion process characterization
  - **Lab- through bench-scale** tests at ECN
  - **Pilot- and full-scale analytical and diagnostic assistance**
- Trace organics emissions characterization
  - Formation and distribution amongst process streams
  - Interaction with (in)organic aerosol formation
  - Advice on process optimization and end-of-pipe abatement options

### Results

- Improved process control and end-of-pipe emission mitigation strategy

# Thank you for your attention!

For more information, please contact:

**Jaap Kiel**
Programme Development Manager
Biomass

T +31 88 515 45 90
F +31 88 515 84 88
kiel@ecn.nl

P.O. Box 1, 1755 ZG PETTEN
The Netherlands
www.ecn.nl

**ECN**
Westerduinweg 3
1755 LE  Petten

Postbus 1
1755 LG Petten

T 088 515 4949
F 088 515 8338
info@ecn.nl
www.ecn.nl