Overcoming Technical Barriers Related to Biomass Co-combustion in Large-Scale Power Plants

Sven Unterberger,
Jörg Maier, Klaus R.G. Hein

Institut fuer Verfahrenstechnik und Damfpkesselwesen (IVD)
Institute of Process Engineering and Power Plant Technology
Universitaet Stuttgart, Germany

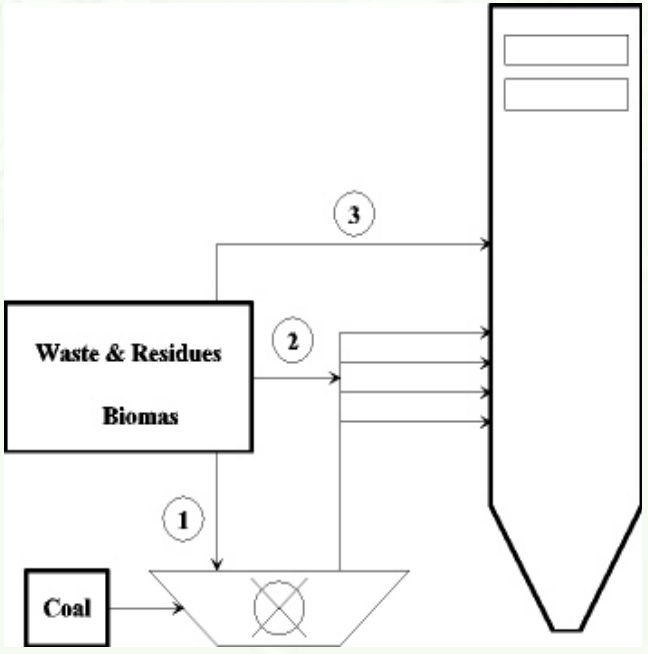
BIO-ENERGY
ENLARGED PERSPECTIVES

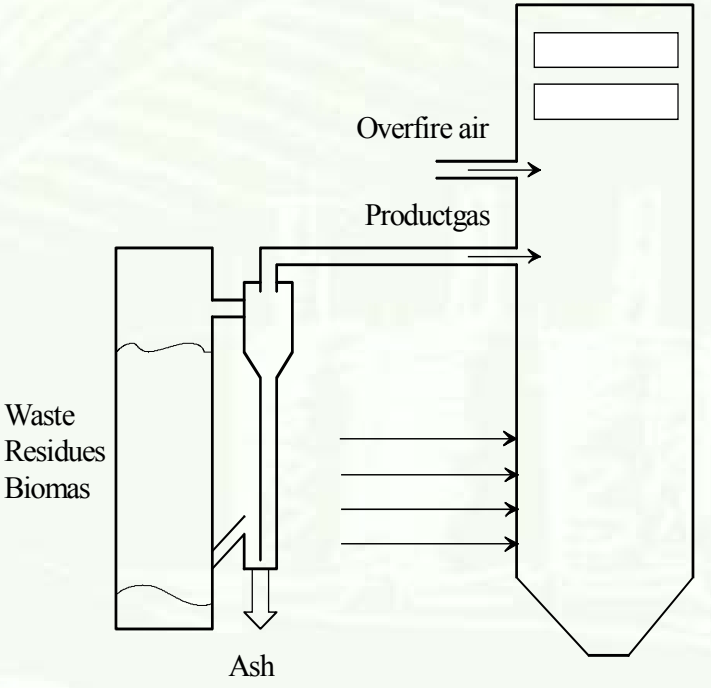
Budapest ,16-17 October 2003

Why Biomass Co-Combustion?

- Large, already existing capacities
- Comparable low investment costs
- High (electric) efficiency, low emissions
- Low operational effects at low biomass shares
- Seasonal fluctuations of biomass can be minimised
- Substitution of coal for CO_2 reduction

Co-Combustion Techniques



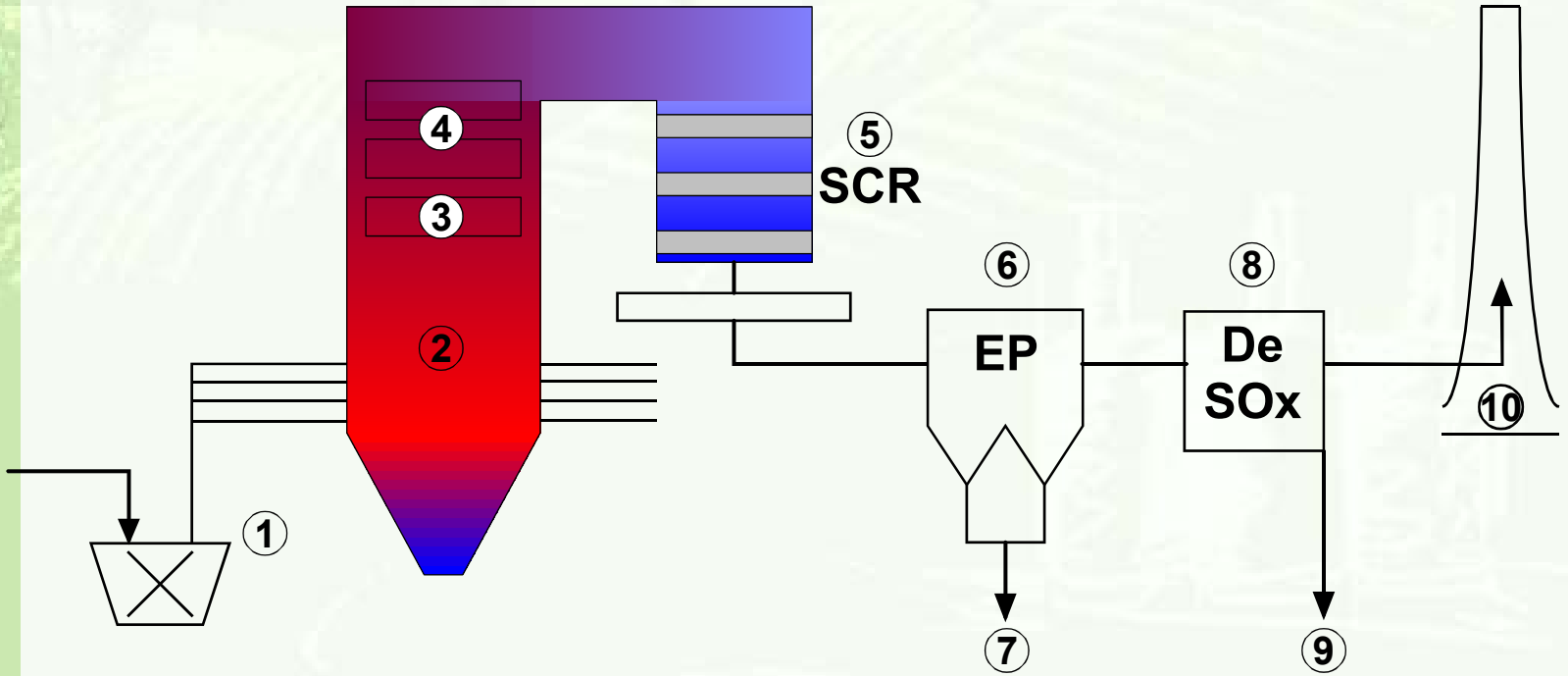


Direct co-combustion

Indirect Co-Combustion

- Pyrolysis
- Gasification
- Pre-Combustion

Areas of Concern



1 milling system: capacity, wear
2 furnace: slagging
3 super heater: corrosion
4 convective heat exchanger: fouling, erosion
5 DeNOx: deactivation, capacity, erosion
6 precipitator: capacity
7 ash: utilisation
8 DeSOx: capacity
9 DeSOx-residues: utilisaton
10 flue gas: emissions

Previous EC-Projects @ IVD

- Co-Utilisation of Coal, Biomass and Waste
  APAS, 1993 - 1994
- Operational Problems, Trace Emissions and By-Product Management of Industrial Biomass Co-Combustion
  OPTEB, 01.01.1996 - 31.12.1998
- Prediction of ash and deposit formation for biomass co-combustion
  DEPOSIT PREDICTION, 01.07.1998 - 30.06.2000
- Slagging and Fouling Prediction by Dynamic Boiler Modelling
  SLAGMOD, 01.06.2000 - 31.05.2002
- Quality of Secondary Fuels for Pulverised Fuel Combustion
  SEFCO, 01.08.2000 - 31.07.2002
- Utilisation of Residues from Biomass Co-Combustion
  UCOR, 01.10.2000 - 30.09.2003

Conclusions

- Biomass preparation and co-firing with coal technically feasible
- Limited operational problems at lower shares of biomass (< 10 $\%_{th}$)
- Effects of biomass constituents on
  - by-product quality (UCOR)
  - air pollution control devices (CATDEACT)
  - emissions of toxic metals (TOMERED)

  are not completely understood
- Co-utilisation of bio-wastes and refuse-derived-fuels (RDF) not investigated

Quality of Secondary Fuels for Pulverised Fuel Combustion

SEFCO

ERK5 - CT99 - 00021

01/02/2000 - 31/01/2003

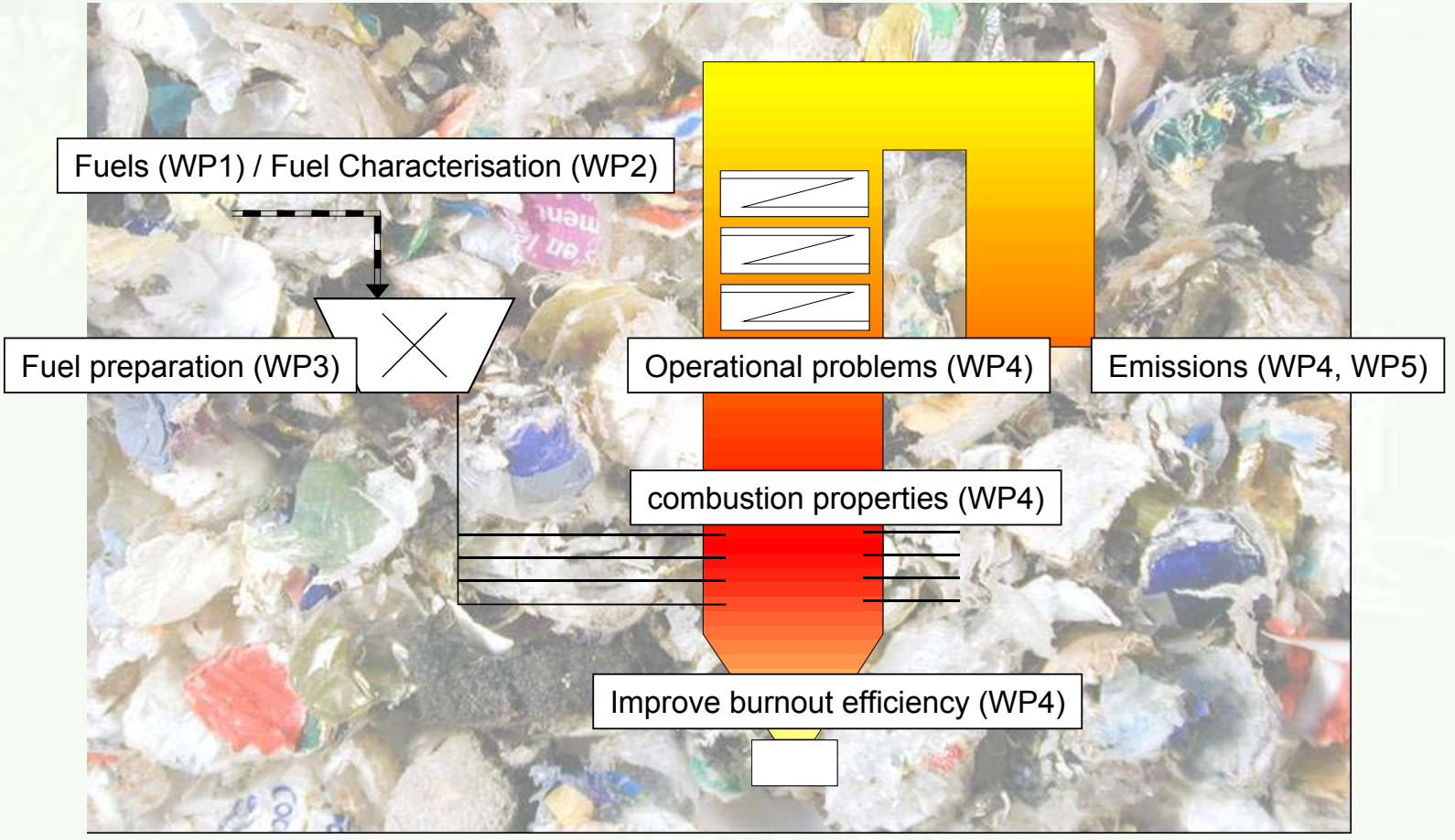
BIO-ENERGY
ENLARGED PERSPECTIVES

Budapest ,16-17 October 2003

Motivation & Approach

- Prevention of operational problems is essential for introduction of wastes into pc power plants
  - fuel preparation, storage and feeding
  - combustion behaviour
  - fate of critical components
- Approach
  - investigation on selected waste mixes and major components
  - preparation, storage, feeding, combustion tests
  - development of advanced fuel characterisation methods

Topics / Project Structure



Project Structure

WP1: Status Quo / Fuel selection

WP2: Laboratory fuel characterisation

- Fuel database
- Thermogravimetric investigations (characteristics / determination of composition)

WP3: Fuel preparation and handling

- Grinding tests at cutting and hammer mill

WP4: Co-combustion tests: Lab and technical scale

- Co-firing tests at 0.5 MW_{th}
- Combustion behaviour / Emissions / Slagging fouling / Trace elements

WP5: Co-combustion tests: Full scale

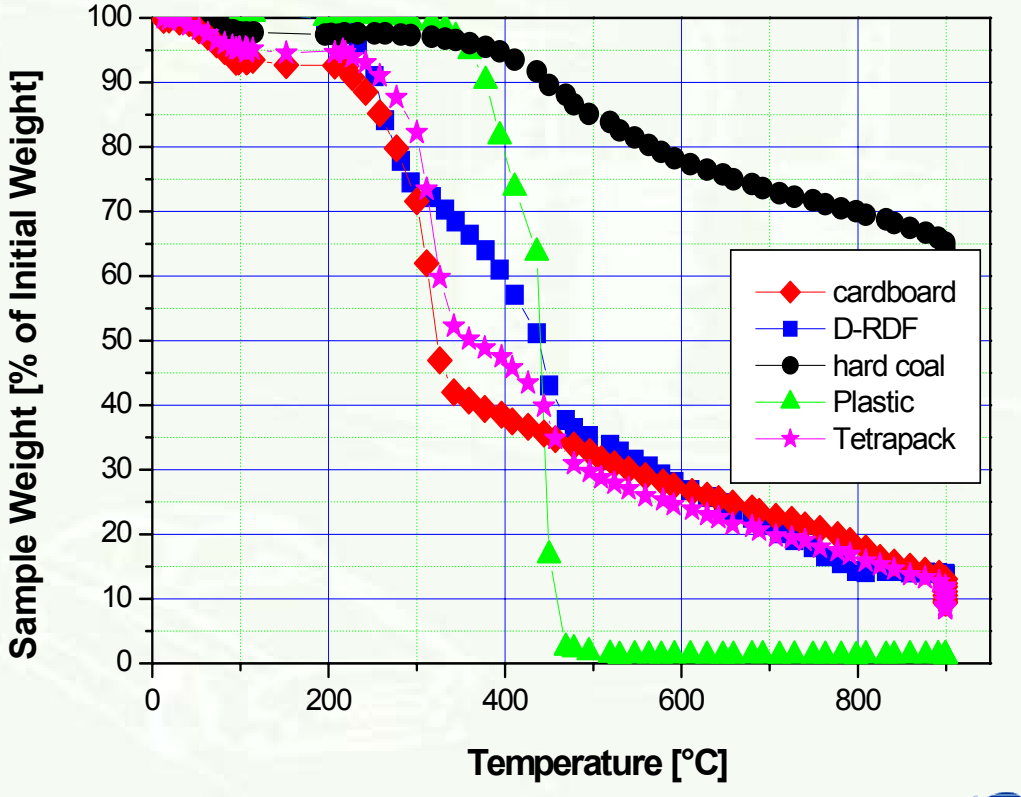
Laboratory Fuel Characterisation

- 50 materials (waste fuels / pure waste fuel components)
  - Database of fuel properties
  - Database of characteristic thermogravimetric properties and fingerprints established and material types defined
- Method to determine composition of waste mixtures
  - Calculation of composition of mixtures appears to be possible
    - ➢ Determination of biogenic fraction
- Future needs
  - ➢ Methods and standards for sampling very important

Laboratory Fuel Characterisation

⇒ **Fuels Composed of a few major components**

TGA-Characteristic



Material Types

Class T_{peak}	Organics ≈300°C	Cellulosic 350-380ºC	Plastics >440ºC	Other
Base compound(s)	**Starch**	**Hemicellulose, cellulose, lignin**	**-**	**-**
Component	Banana Dry bread Palm pit	All wood types All paper types All cardboard types Cotton Hemp Laminate, plywood Miscanthus Olive husk Paper sludge Straw Sunflower	ABS PA PBT PC PE PET PP PS	Cacao residue Carpet Leather Lemon pellet Milk carton PVC Tire Wool

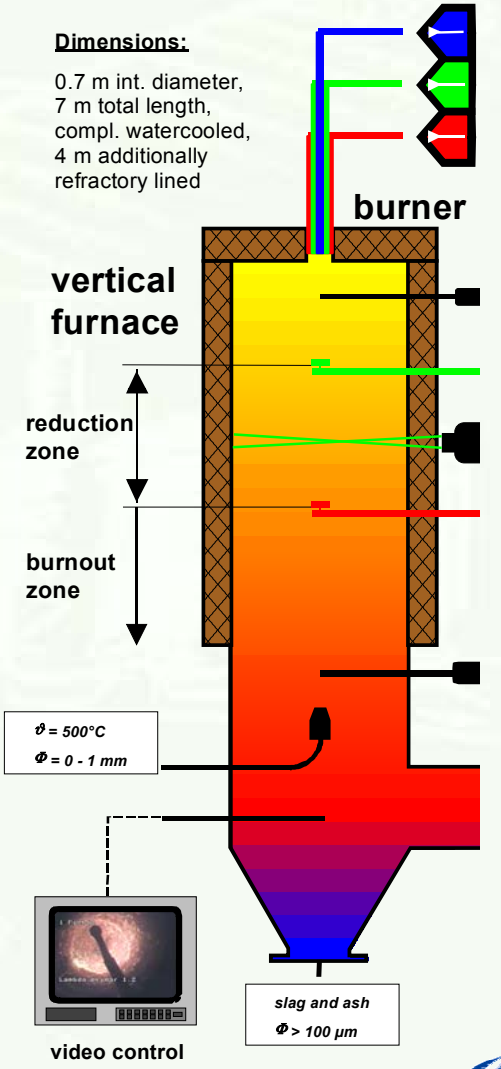
Fuel Preparation and Handling

- Cutting Mill
  - \+ Low energy consumption
  - \- Compact particle form
  - -- Sensible to fuel impurities
- Hammer Mill
  - -- High energy consumption
  - \+ More robust
  - \+ Fibrous particle form
  - \+ Drying
- Handling
  - \- Dust formation
  - \- Strong bridging due to fibrous particle form

➢ Adjusted handling system and fuel preparation for individual fuel and respective firing system

Combustion Tests

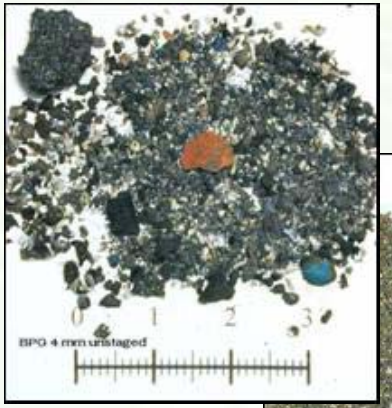
- Combustion
  - Particle ignition retarded
  - Flame shape altered
  - Formation of char particles
- Emissions
  - SO_2 (fuel input, ash capture)
  - NO_X (fuel input, primary measures)
  - Trace elements behave basically according to input; impact of fuel type, sorbent injection and operational conditions of the filter



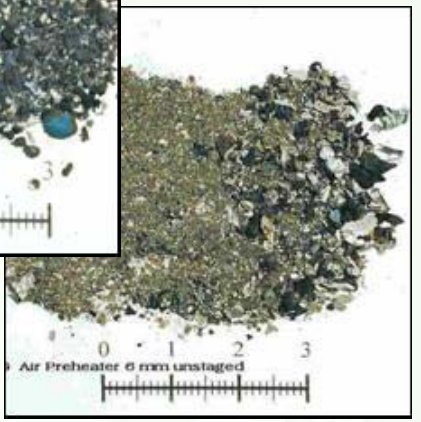
Combustion Tests

- **Ash/ Deposits**
  - Increase of LOI in ash and changed ash distribution and composition
  - Altered slagging and fouling tendencies (alkali, sulphur and metal input)

Bottom Hopper



Air Preheater



Dissemination
Technology Implementation

- Several presentations/papers published
- Databases of fuel properties
- Databases of characteristic thermogravimetric properties
- Report of the project results beginning 2004

Dissemination Technology Implementation

- Consulting / support by the partners
  - Determination of bio-degradable (TU-Delft)
  - Implementation of technology (IVD)
    - Evaluation of fuels (composition, particle size)
    - Evaluation of process (handling, burner configuration)
    - Measurements/sampling before and during start up
  - Implementation of technology (ENEL)
    - Data on dry sorbent injection for trace element capture will be used for decisions for technical solutions and during authorisation
- CEN-TC 343 Standardisation of Secondary Fuels
- Demonstration project in contract phase

ACKNOWLEDGEMENT

The work performed was funded by the European Community within the 5th framework with the contract number ERK5-1999-00021.

The partners

University Stuttgart / IVD

ENEL Produzione – Ricerca

Technical University Delft – Thermal Power Engineering

gratefully acknowledge this funding!

J. Maier, K.R.G. Hein

University Stuttgart

Institute for Process Engineering and Power Plant Technology

Pfaffenwaldring 23, 70569 Stuttgart, Germany

Phone: ++49 711 685 3396 Fax: ++49 711 685 3491

http://www.ivd.uni-stuttgart.de/

Universität Stuttgart