Workshop on

Fuel Flexibility in Biomass Combustion
The Key to Low Bioenergy Costs?

Arranged by:

Claes Tullin, SP, Sweden
Jaap Koppejan, TNO Science and Industry, Netherlands

World Bioenergy 2006 Conference
Jönköping, Sweden
May 31, 2006

IEA Bioenergy

Task 32: Biomass Combustion and Cofiring

IEA Bioenergy Task 32
Fuel Flexibility in Biomass Combustion
May 31, 2006, Jönköping, Sweden

Table of contents

Annexes

Programme

31 May 2006, 14:00-18:00
World Bioenergy 2006 Conference, ELMIA conference centre, Jönköping, Sweden

From	Topic
14:00	Opening Sjaak van Loo, IEA Bioenergy Task 32
Part A: Market issues	
14:10	"Future Supply of Biomass for Fuel; Sources, Quantities and Costs" Bo Hektor, Talloil
14:30	"Availability of biomass and biomass supply systems for co-firing purposes" Martin Junginger, Utrecht University
Part B: Fuel characterisation and standardisation	
14:50	"Is representative and relevant composition data for heterogeneous solid recovered fuels possible to accomplish?" Evalena Wikström , SP
15:10	"BioNorm – A project to support the ongoing standardisation process" Jan Burvall , SLU
Part C: Fuel preparation	
15:30	"Preparation of fuels based on waste material" Sture Mattsson, IQR
15.50	Coffee Break/Refreshments
Part D: Fuel quality and deposit formation/emissions	
16:20	"Deposit formation during combustion of different waste wood qualities and co-combustion of waste wood and sewage sludge" David Eskilsson, SP
16:40	"Experience from waste co-combustion in Vattenfalls fluidized bed boilers" Matts Almark, Vattenfall
Part E: Boiler design	
17.00	"Fuel flexibility through (co-)firing biomass in Belgian pulverised coal power plants" Yves Ryckmans, Electrabel
17.20	"Wet bio-fuels-Aspects on furnace design and boiler operation" Niklas Berge, TPS
17.40	Discussion and conclusions Claes Tullin, SP
18:00	Closing

Report of the workshop

The use of biomass for energy generation is predicted to increase very much supported by both economical, ecological and political drivers. This development will cause changes in the fuel structure which in turn will put demand on combustion technology to cope with new and “difficult” fuels. The present range of fuels consists mainly of residues from the forest and agriculture sectors and from waste. As long as the supply of biomass has been in abundance the cheapest and least problematic fuels have been utilized. In the future, more of residues and wastes will be in demand, but the principal increase will probably be in form of biomass from dedicated plantations, e.g. energy crops and fast growing tree plantations. The biomass potential has been estimated (IEA Task 40) to between 250 and 500 EJ (90 000 - 180 000 TWh) with very large potentials in tropical regions, thus indicating an opportunity for development of poorer regions. However, in the development of large scale bioenergy plantations utmost care must be taken in considering social structures as well as ecological problems.

Global trading of biomass fuels is quite possible provided that ocean ships can be used for the longer distances. As an example, at a cost of 20 € per ton, the number of transport kilometers by ship is about 10 000 km. This can be compared with 200 km by lorry or 600 km by railway. With transportation not being a barrier, tropical countries can be major suppliers of biomass fuels on the global market within 15-25 years time. As transportation is a major factor influencing fuel cost and the fuel energy balance, it is often advantageous to upgrade the fuel to obtain a higher energy density. There are a large number of possible biotrade chains depending on available biomass fuels, different degree of refining and upgrading, means of transportation and conversion and end use. Development of sustainability criteria for biomass (likely including CO_2/energy balance, food security and nature& biodiversity criteria) requires new efficient biomass supply chains.

With an increased availability of waste fuels as well as new energy crops on the market, proper fuel analysis are needed as correct fuel composition data has a large impact on the accessibility, emissions and maintenance cost of a boiler. In order to meet the requirements of relevant standards the EU-project BioNorm was initiated. In the project, the limitations of existing analysis procedures have been highlighted and improved sampling and testing procedures has been developed. The work has been closely linked to the work in CEN C 335 “Solid Biofuels”. A major problem that needs further work is how to obtain representative samples of heterogeneous fuels without the need to handle large sample quantities.

Cheaper fuels often means increased costs for operation and maintenance, often due to increased deposit formation and corrosion on boiler walls and superheaters. Waste wood, for instance, contains higher amounts of the deposit related compounds such as zinc, lead and chlorine. By choosing optimal fuel combinations, it is possible to reduce the problems of deposit formation radically. By co-combustion of sludge and waste wood, the deposit formation has been shown to decrease dramatically. Secondary measures to reduce problems include the ChlorOut process where the alkali chlorides are measured on line and controlling the amount of a sulphur containing compound that is introduced into the boiler. The sulphur reacts with the metal chlorides forming more stable, and non-sticky- sulphates. As a spin-off, the sulphur addition can also result in lower CO and NOx emissions. Similar effects can be obtained by co-firing a sulphur containing fuel such as coal or peat. Other issues of importance when combusting biomass fuels with waste fuels in BFBC´s is to arrange a proper fuel feeding and removal of non-combustibles in the bottom bed. To achieve good fuel flexibility in biomass fired grate boilers it is necessary to have good control of the temperature in both primary and secondary combustion zones and control of the aerodynamics of the freeboard combustion. Key parameters are for instance air supply, flue gas recirculation, ash burn out. Co-firing (i.e. co-combustion of, generally smaller, fractions of biomass with coal), has been shown to be an interesting way to develop bioenergy markets and to introduce bioenergy in large scale at high efficiencies. A number of installations are now in operation based on different technologies. A general problem with biomass (compared to coal) is that the volumes that must be handled are very large. This puts special requirements on logistics and organisation. Finally, for all combustion technologies, proper fuel pre-treatment is a prerequisite to obtain optimal combustion performance.

In conclusion, the present global introduction of bioenergy as one of the major renewable sources results in steadily increasing prices of biomass. The large variety of fuels and changes in availability with time results in large price differences. Thus, increased fuel flexibility is a possibility to reduce the fuel costs though care must be taken to control the operating and maintenance costs for instance caused by super heater corrosion. Recent developments in dedicated biomass combustion give insight as how to minimise these types of problems. An extensive experience regarding combustion of all sorts of biomass fuels is accumulating in biomass boiler applications as well as in co-firing applications. However, research is still needed to increase fuel flexibility and reduce the operating and maintenance costs. Not least important here are tools for fuel characterisation.

In order to cope with the new fuels that will be introduced on the market, a dialogue between the different stake holders in the biomass chain (from biomass and fuel production to final heat and power production and utilization of the residues) is needed. Activities that bring different stake holders together should be encouraged to develop integrated and flexible energy systems. A general problem that remains includes the development of an economically and ecologically sustainable large-scale bioenergy market.

Annex 1. Opening
Sjaak van Loo

Fuel Flexibility in Biomass Combustion

The Key to Low Bioenergy Costs?

Biomass Combustion and Cofiring
IEA Task 32

Sjaak van Loo
Claes Tullin

World Bioenergy Conference Workshop
Jönköping, Sweden, 31 May 2006

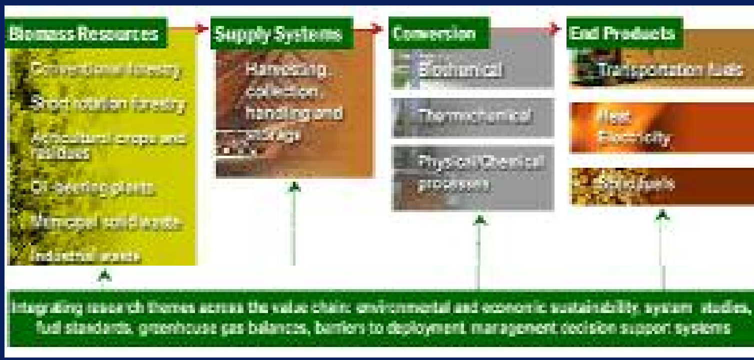
Introduction to IEA Bioenergy (1)

- The IEA was founded to implement an international energy programme in response to the oil shocks.
- Activities are directed towards collective energy policy objectives of energy security, economic and social development, and environmental protection.
- Activities are set up under Implementing Agreements. There are 40 active Implementing Agreements.

IEA Bioenergy

Introduction to IEA Bioenergy (2)

- **IEA Bioenergy** provides an umbrella organization where experts from research, government and industry work together



www.ieabioenergy.com

IEA Bioenergy Task 32: Biomass Combustion and Co-firing (1)

Objectives:

- To stimulate further expansion of the production of energy from biomass combustion
- Generating and disseminating information on technical and non-technical barriers and anticipated solutions for:
  - dedicated biomass combustion systems, and;
  - biomass co-firing in existing coal fired power plants.

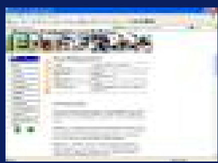
IEA Bioenergy Task 32: Biomass Combustion and Co-firing (2)

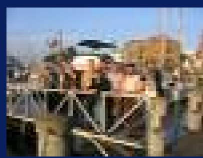
- Experts from 12 countries:

Australia	Austria	Belgium
Canada	Denmark	European Commission
Germany	Netherlands	Norway
Sweden	Switzerland	United Kingdom

- Working together in:
  - Cooperative projects
  - Meetings, Workshops, Conferences, Excursions
  - Cooperation with other Networks

www.ieabcc.nl





Fuel Flexibility: The key to low bioenergy costs?

- The desire to cut costs leads to the use of "uncommon" and "low spec" biomass fuels
- Determining factors for optimal fuel-technology combination:
  - market issues
  - fuel characterisation and standardisation
  - fuel preparation
  - fuel quality and deposit formation/emissions
  - boiler design
- We wish you a pleasant and informative Workshop!!

Annex 2. Future Supply of Biomass for Fuel; Sources, Quantities and Costs

Bo Hektor

Future Supply of Biomass for Energy:

Sources, Quantities and Costs

Bo Hektor, TallOil AB, Sweden

May 31, 2006

Global biomass potentials are large - but need to be developed

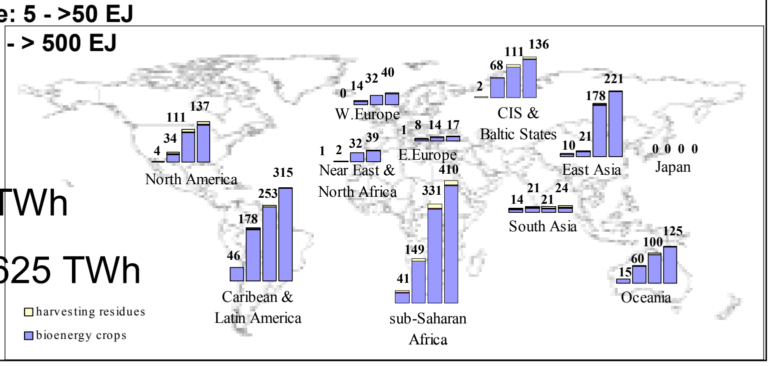
Agricultural land: <100- >300 EJ
Marginal lands: <60- 150 EJ
Agri residues: 15-70 EJ
Forest residues: <30-150 EJ
Dung: 5-55 EJ
Organic waste: 5 - >50 EJ
TOTAL: < 250 - > 500 EJ

From IEA Bioenergy Task 40

500 EJ ~

180 000 TWh

Sweden 625 TWh



Agricultural land (1)

- Dedicated Energy Plantations
  - Single Purpose Plantations
    - Eucalyptus
    - Acacia (N-fixing species)
    - Salix
  - Multiple Purposes
    - Sugar cane
    - Sweet sorghum
    - Jatropa

Agricultural Land (2)

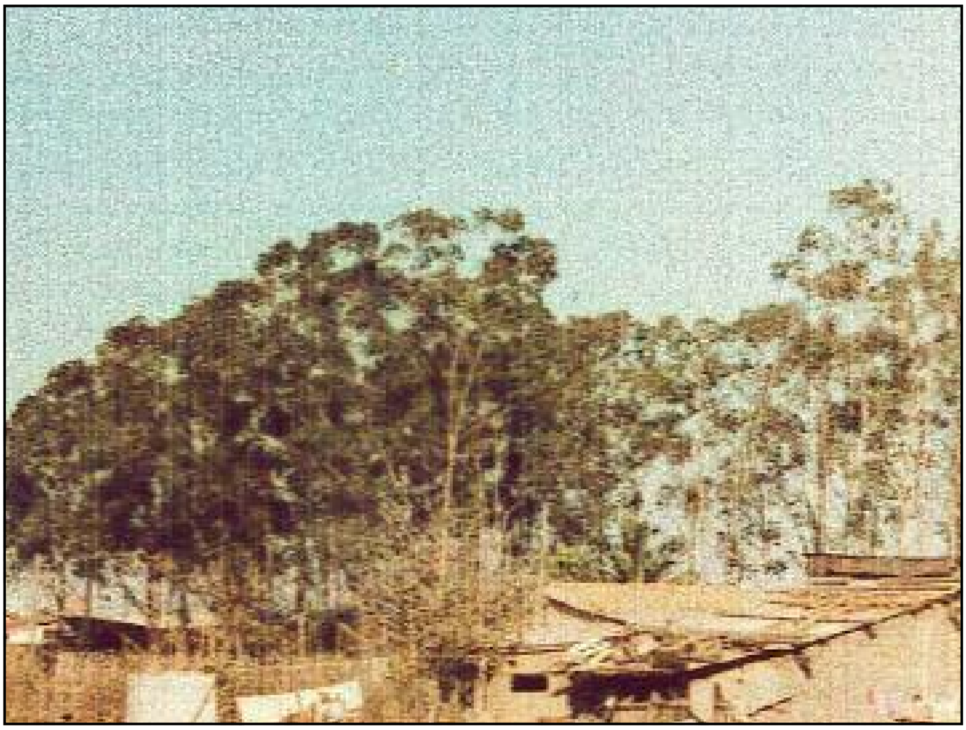
- Agroforestry
  - Shifting fallow
  - Shelter belts
  - Shelter trees

TallOil

Marginal Lands

- Former forest land
- Depleted agricultural land
- Arid land

Can produce biomass + environmental values e.g. soil conservation/improvement, erosion control, flood control



Agricultural residues

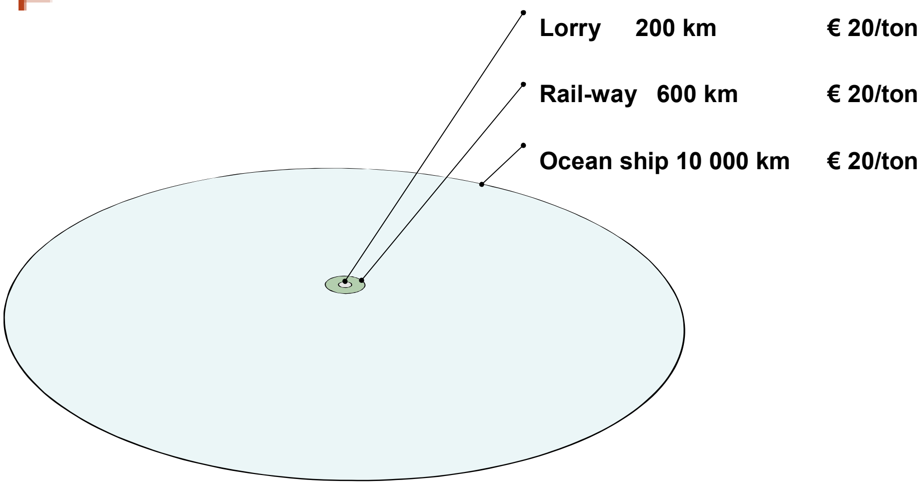
- Straw
- Palm oil kernels, etc
- Olive kernels, etc.
- Rice husks, etc.
- Oil seed shells, etc.
- Pruning residues
- and a wide range of others

Organic waste and Dung

- (not covered in this presentation)

Transport Costs

(general example)



Prediction

- Therefore,
  - Biomass fuels will be traded in a global market
  - Tropical countries will (within 15-25 years time) be the dominant large scale suppliers of biomass fuels in the markets; also local markets will co-exist where conditions permit
  - A wide range of biomass fuels will become available in the market.

Winners

- Those, who can integrate efficient combustion technology with acquisition of cheap, reliable fuels.
- Those, who can master system analyses and implementation of integrated solutions (business/technology)

Wood versus Oil Principal Calculation

- 1 barrel oil (70 $) 6,12 GJ
- 1 ton wood substance (odt) 17 GJ
- 0,47 ton wood(+bark)substance = 1 m3s
- 1 m3s(+bark) 8 GJ
- 1 m3s/1 barrel oil 1.3
- Energy value of 1m3s 91$
- **Price of pulp wood 1m3s 34 $**

Thanks for your Attention!

Bo Hektor bo.hektor@talloil.se

Annex 3. Availability of biomass and biomass supply systems for co-firing purposes

Martin Junginger

Universiteit Utrecht

Availability of biomass and biomass supply systems for co-firing purposes

FUEL FLEXIBILITY IN BIOMASS COMBUSTION - THE KEY TO LOW BIO-ENERGY COSTS? Workshop organised by International Energy Agency (IEA) Bioenergy Task 32: Biomass Combustion and Co-firing,
Jönköping, 31.5.2006

Martin Junginger & André Faaij

Copernicus Institute - Utrecht University

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Overview

1. Current developments of biomass co-firing in the Netherlands.
2. Future supply chains – resources and pretreatment technologies (for biomass co-firing)
3. Some work of IEA bioenergy Task 40

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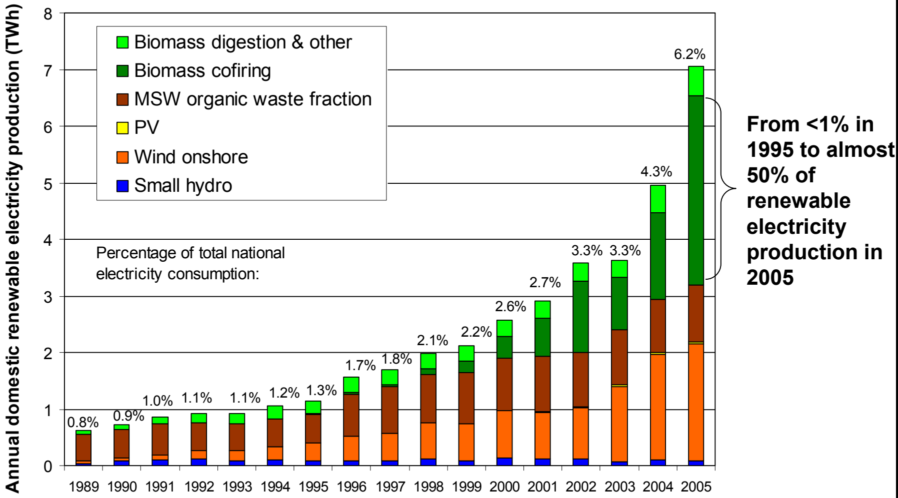
Domestic renewable electricity production in the Netherlands



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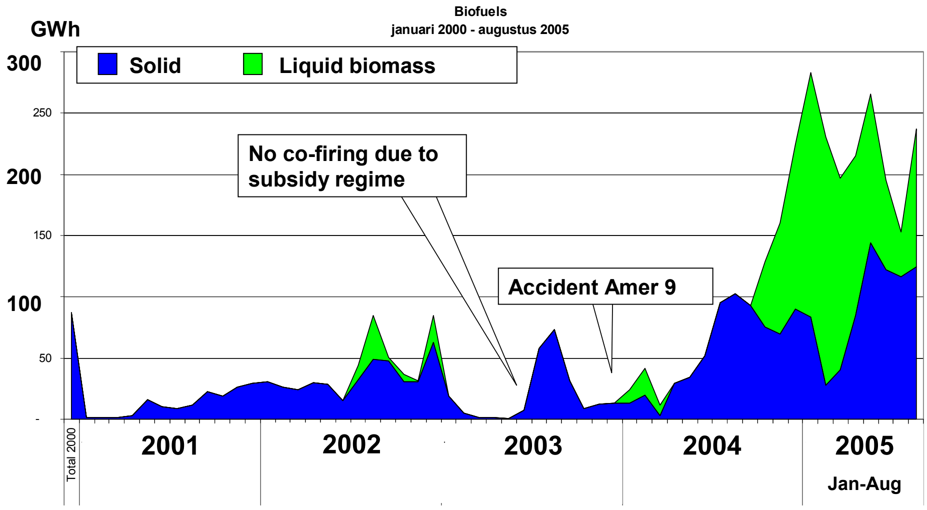
Co-firing of solid and liquid biomass in Essent power plants



Source: P.P. Schouwenberg, Essent Sustainable Energy

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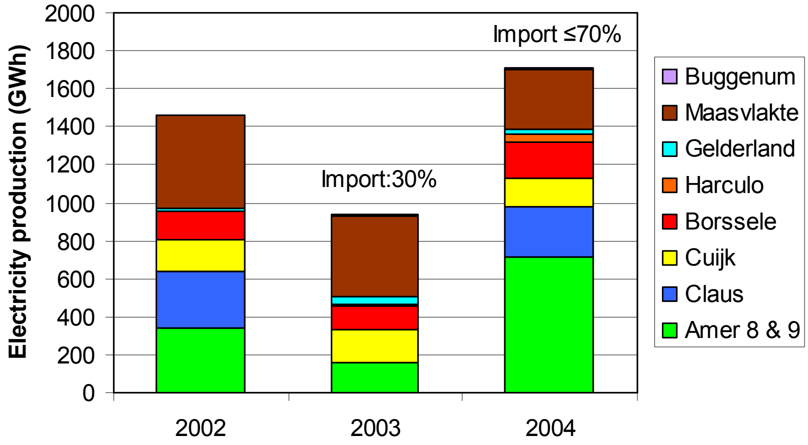
Electricity production from biomass co-firing in power plants



Imported fuels used:

- Wood pellets (mainly from Canada)
- Agro-residues (palm kernel shells, olive nuts, nut shells, cocoa husks, soy and sun flower residues)
- Palm Oil (Malaysia and Indonesia)
- Bone Meal and other waste streams

Current (policy) trends

- Palm oil deemed unsustainable, feed-in tariff cut from 7 €ct/kWh to <3 €ct/kWh
- Pellet market very volatile, present shortage of pellets
- Development of sustainability criteria for biomass, likely including CO2/energy balance, food security and nature& biodiversity criteria

=> New efficient & sustainable biomass supply chains needed

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Global potentials are large…; but need to be developed

Agricultural land: <100- >300 EJ
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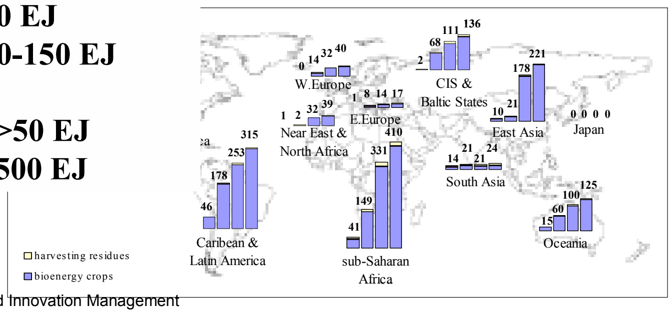

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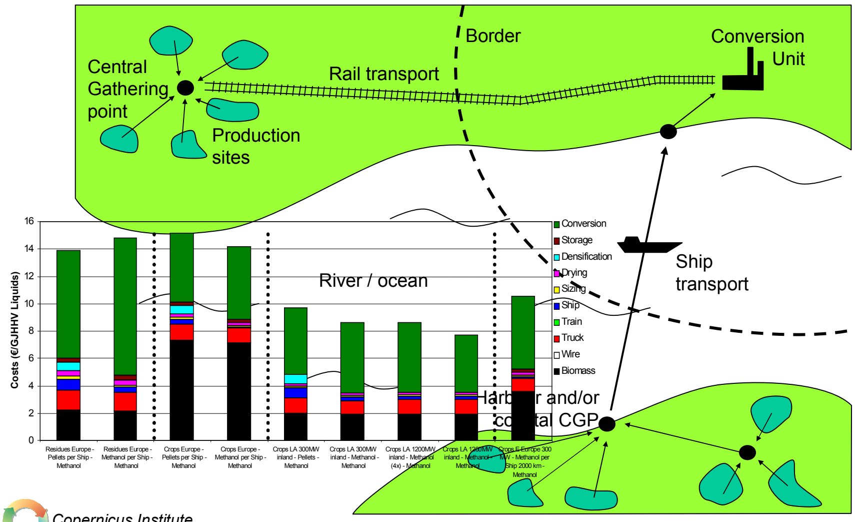
International bio-energy logistics
not a showstopper *when organized rightly*



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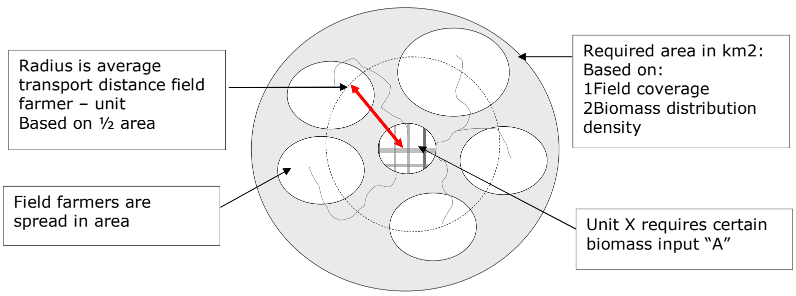
Logistic concept for production regions



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Many possible 'biotrade chains'

Exporter	Transport/transfer/storage	Importer
Biomass production	'raw' biomass	Full conversion
Biomass production & pre-treatment	Pre-treated (pellets, bales, bio-oil) biomass	(partial) conversion
Biomass production & conversion	Fuels (H2, MeOH, EtOH, HC's)	End-use
Production and conversion	Electricity transport	End-use
Biomass production	'conversion along the way'	End-use

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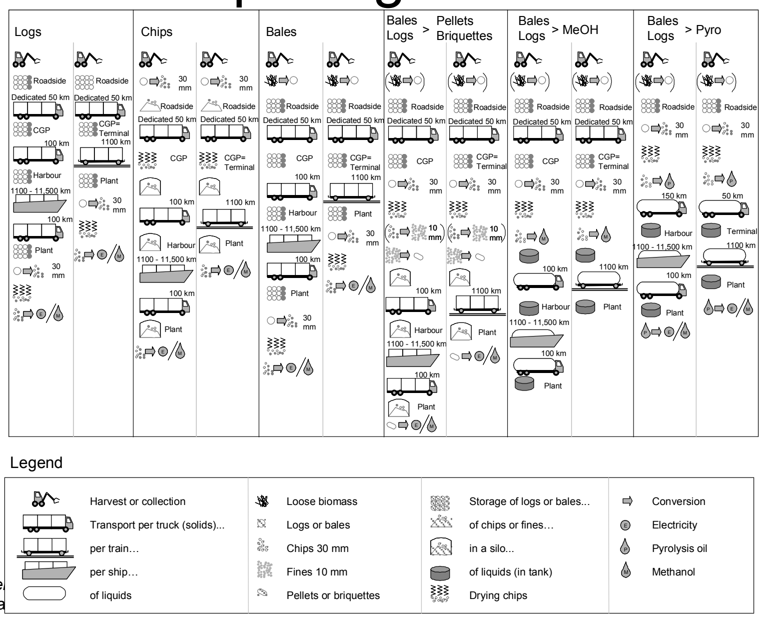
Composing chains…



Source: Hamelinck, Faaij, 2003

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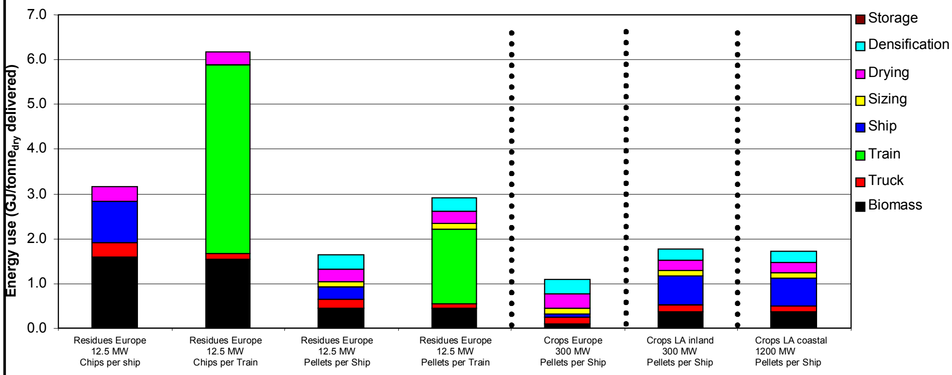
Primary energy use of biomass supply chains to a Dutch power plant



Source: Hamelinck, Faaij, 2003

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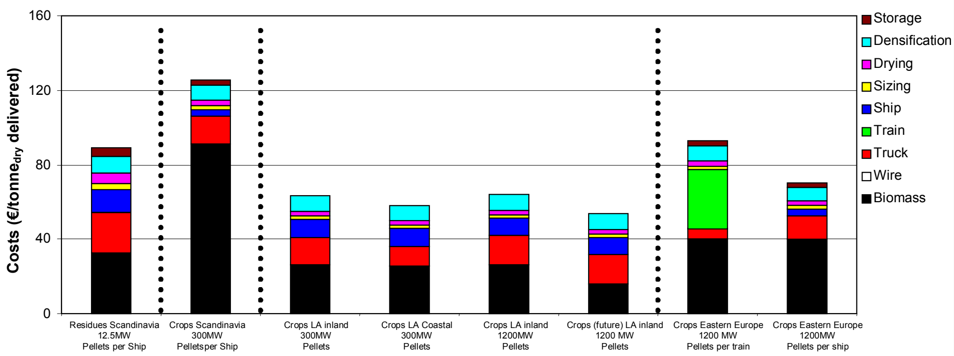
Cost breakdown of solid biomass delivered to the Netherlands



Source: Hamelinck, Faaij, 2003

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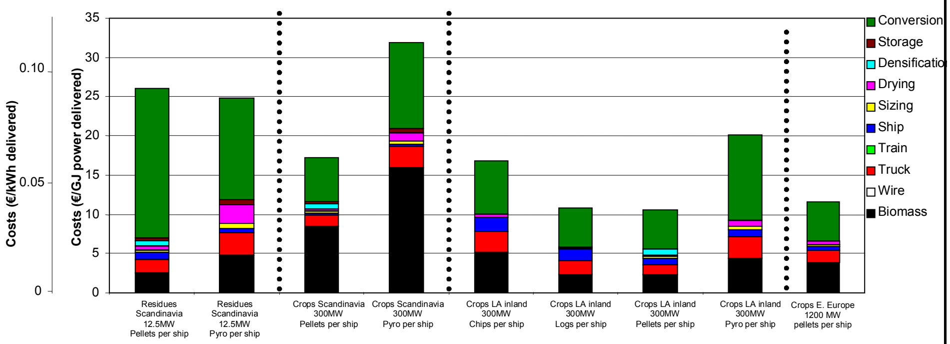
Cost breakdown of electricity delivered to the Dutch grid



Source: Hamelinck, Faaij, 2003

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Some key findings…

- Reference systems importing & exporting country crucial for net GHG impact.
- Economies of scale are crucial.
- Pre-treated biomass or secondary energy carriers preferred for international transport.
- Sea transport limited impact; road transport significant.
- Region specific (biomass distribution density, transport parameters, etc.).

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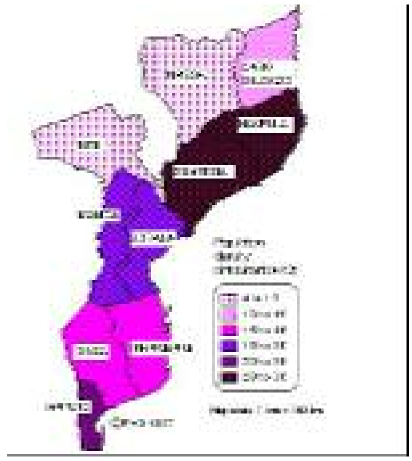
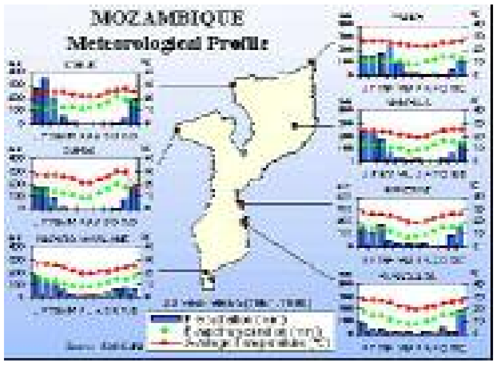
Mozambique…





Batidzirai & Faaij, 2005

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Level of advancement of agricultural technology

Level of agricultural technology	Water supply	Description
Low	rain-fed	No use of fertilizers, pesticides or improved seeds or breeds, specialised health care for animals and calf rearing activities, equivalent to subsistence farming as in rural parts of e.g. Africa and Asia.
Intermediate	rain-fed	Some use of fertilizers, pesticides, improved seeds or breeds, animal health care and mechanical tools.
High	rain-fed	Full use of all required inputs and management practices as in advanced commercial farming presently found in the USA and EU.
Very high	rain-fed	Use of a high level of technology on very suitable and suitable soils, medium level of technology on moderately suitable areas and low level on moderately and marginally suitable areas.
Very high	rain-fed/ irrigated	Same as a very high input system, but including the impact on irrigation on yields and areas suitable for crop production.

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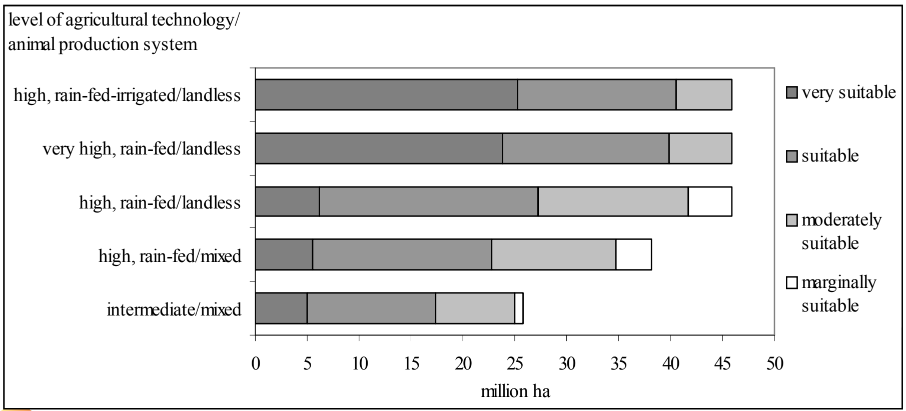
Potential surplus agricultural land in 2015 in Mozambique, dependent on the level of advancement of agricultural technology



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Batidzirai & Faaij, 2005

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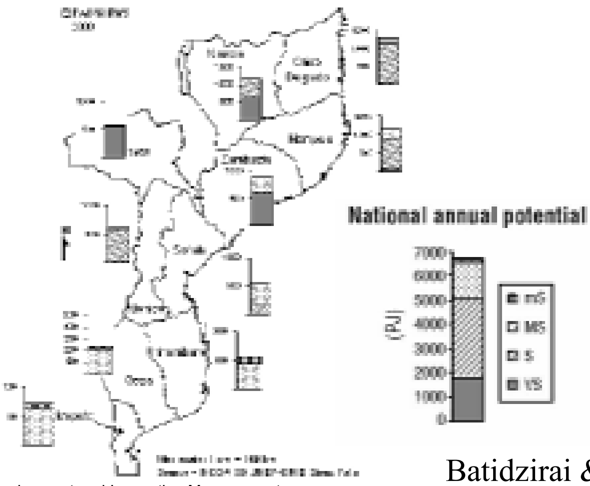
Regional biomass annual production potential in Mozambique/PJ_{HHV} (2015)



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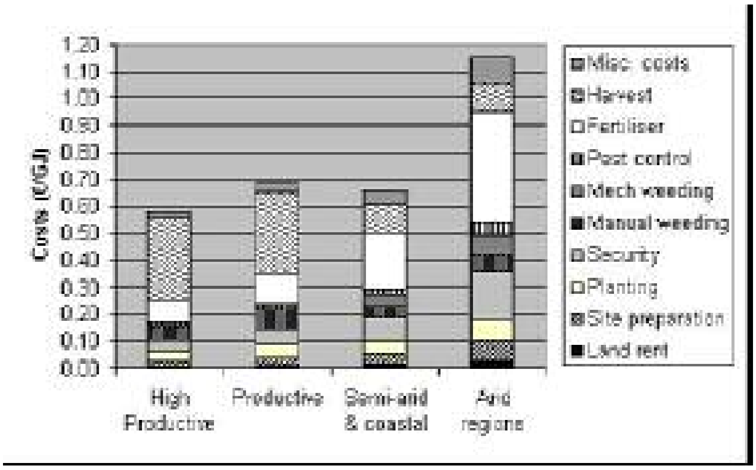
Comparison of bioenergy growing costs by region type (€/GJ)



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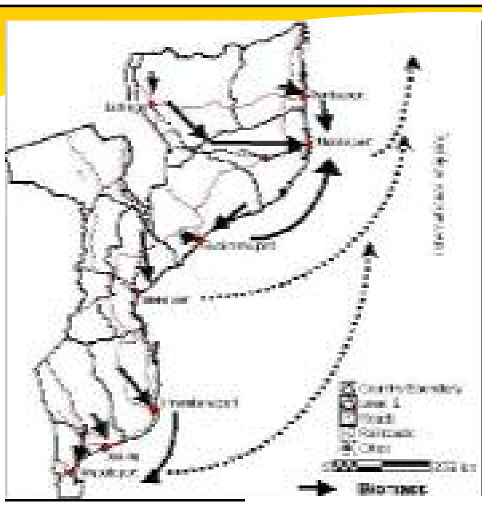
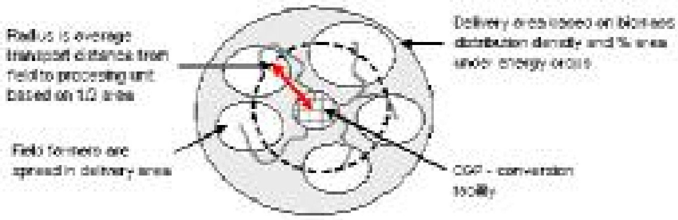


Logistics for export….

Batidzirai & Faaij, 2005



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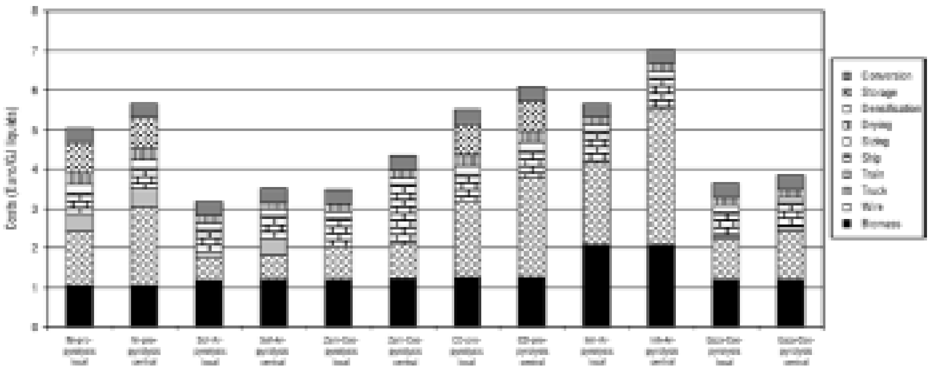
Chains supplying pyrolysis oil from Mozambique to Rotterdam



Batidzirai & Faaij, 2005

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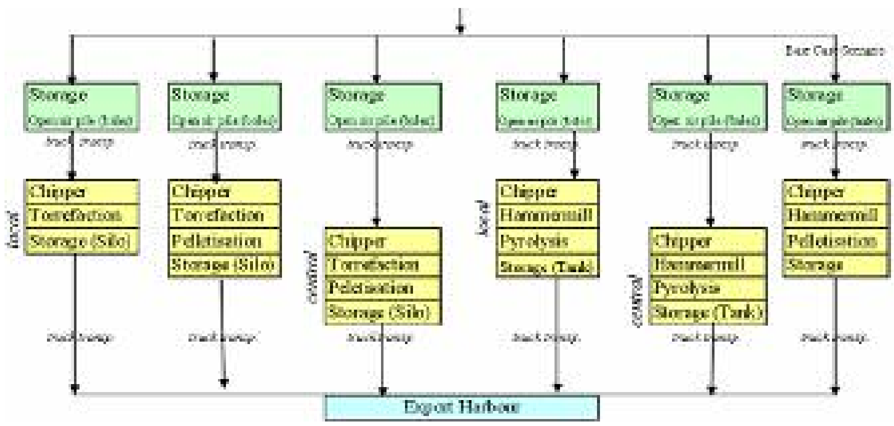
Comparison of Torrefaction, pellets and Pyrolysis pretreatment



Uslu & Faaij, 2006

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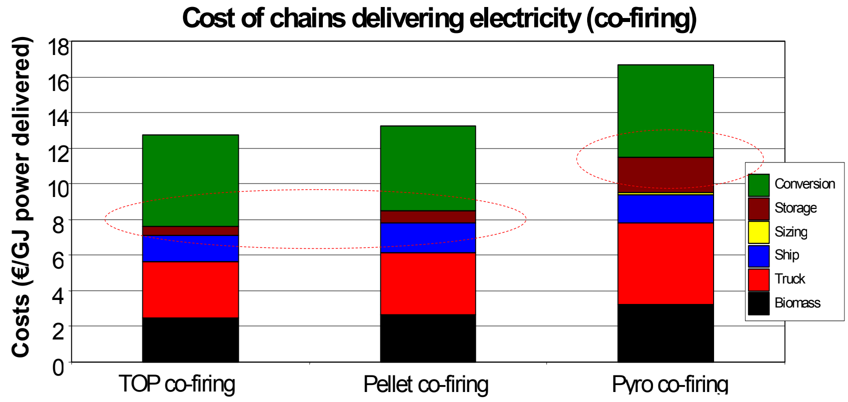
Comparison of co-firing wood pellets, torrefied pellets (TOP) and Pyrolysis oil



Energy use (GJ/GJ)	8.5%	11%	8%

Uslu & Faaij, 2006

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Relevant work of IEA bioenergy Task 40

Country reports

- on Brasil, Finland, the Netherlands, Norway…
- Updated country reports and synthesis report to be published in autumn 2006

Market studies:

- on ethanol (published)
- on global wood pellet markets and resources (to be published end of 2006)
- On pyrolysis oil (to be published end of 2006)

=> Keep an eye on www.bioenergytrade.org

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Thank you for your attention!

Refs to the studies presented:

Carlo Hamelinck, (C.N.), Outlook for advanced biofuels, Ph.D. thesis, University of Utrecht, 2004, 232 pp. (NWS-E-2004-25)

Batidzirai, Faaij and Smeets, Biomass and bioenergy supply from Mozambique, Energy for Sustainable Development, Volume X (1), March 2006.

Faaij and Uslu, Pretreatment technologies and their effects on international bioenergy supply chain logistics, Techno-economic evaluation of torrefaction, fast pyrolysis and pelletisation. Forthcoming.

Available at www.chem.uu.nl/nws -> publications

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Annex 4. Is representative and relevant composition data for heterogeneous solid recovered fuels possible to accomplish?

Evalena Wikström

Sampling and preparation of heterogeneous waste fuels?

Is it possible to accomplish a representative and relevant composition data?

Evalena Wikström, Lennart Gustavsson and Jolanta Franke

Aim of the project

To suggest a method for sampling and mass-reduction valid for heterogeneous waste fuels

Consisting of:

✓a minimal sample size that accomplish representative data
✓a mass-reduction technique at site
✓a routine for the first grinding step
✓a sample reduction method at the lab

SP Swedish National Testing and Research Institute

Background

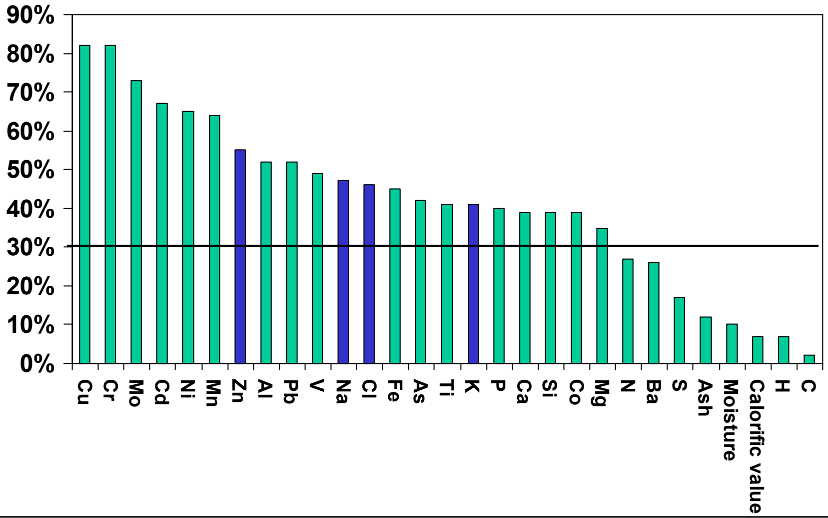
SP Swedish National Testing and Research Institute

- Two new standards " methods for sampling" and "laboratory preparation" for Solid Recovered Fuels (SRF) valid from ´06
- Heterogeneous waste fuels are about the most difficult to sample correct
- The composition varies a lot
- Correct fuel composition data has a large impact on the accessibility, emissions and maintenance cost of a boiler
- The future market of waste fuels will demand accurate composition data of a mixture

Example variation in data N=6

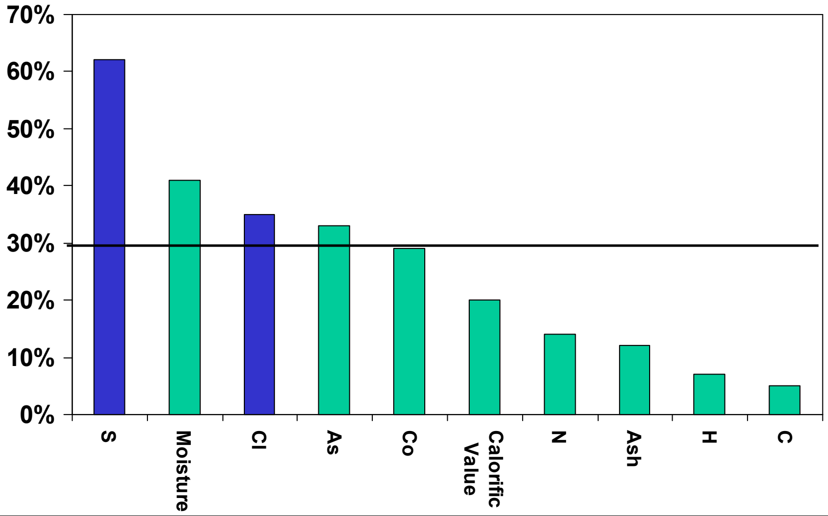
SP Swedish National Testing and Research Institute

A 20 W Waste incinerator
Pre-treated, grinded waste



Example variation in data N=14

A 20 W Waste incinerator
Non-treated waste



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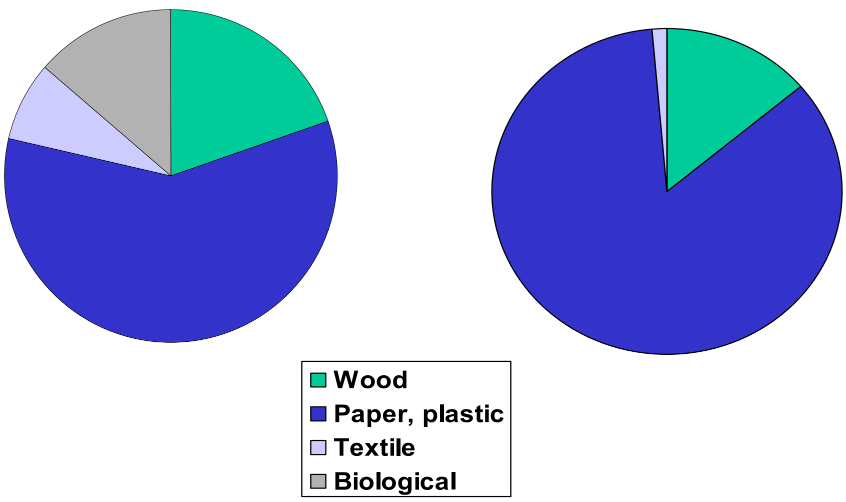
Variation in sorting analyses



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Element and risks

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- Sampling
  - Method
  - Volume/mass
  - Duration time
- Sample reduction
  - Method
  - Volume/mass
- Preparation at the lab
  - Sample reduction
  - Size reduction
- Analyses
  - Method
  - Technique

Two new standards for Solid Recovered Fuels

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Solid Recovered Fuels – Methods for sampling **CEN 15442** (Jan 2006)

Solid Recovered Fuels – Methods for laboratory sample preparation **CEN 15443** (Jan 2006)

What is required to work according to theses standards

Two new standards for Solid Recovered Fuels

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Necessary elements for developing a sampling plan

1. Define overall objectives
2. Define lot and determine lot size
3. Define sampling procedures
4. Define minimum number of increments
5. Define minimum sample size
6. Define effective increments and sample size
7. Define methods for reducing the sample size
8. Define analytical methods

Quantity waste produced during a consecutive period

Size of each portion

Size of the total sample

Actual total sample size

Solid Recovered Fuels – Methods for sampling

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Determination of minimum sample size

Input/information required:

- The nominal top size of a particle d_{95} = ?
- The maximum volume of a particle V_{95} = ?
- The shape factor $s=V_{95}/(d_{95})^3$ = ? or 1
- The particle density = 1
- The bulk density = ?
- The distribution factor = 0,25
- The factor p = 0,01
- The coefficient of variation CV = 0,01

=> minimum sample size

Solid Recovered Fuels – Methods for sampling

Determination of minimum increment size

Mechanical sampling

- The nominal top size of a particle d_{95}
- Drop speed

or

Manual sampling

- Drop speed
- Sampling time

=> minimum increment size

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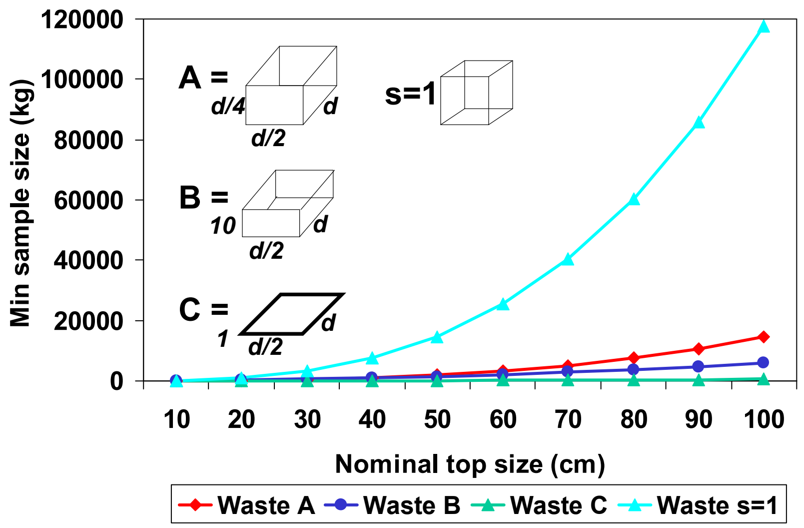
Minimum sample size



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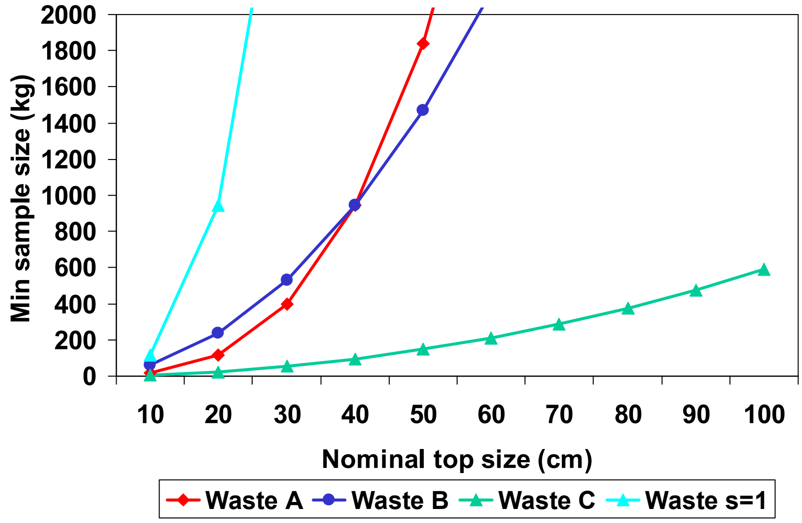
Minimum sample size (reduced scale)



Solid Recovered Fuels – Methods for sampling

- Effective increment size=Min sample size / #increments

⇒ **Effective increment size > Min increment size**

- Effective sample size=Eff. Increment * #increments

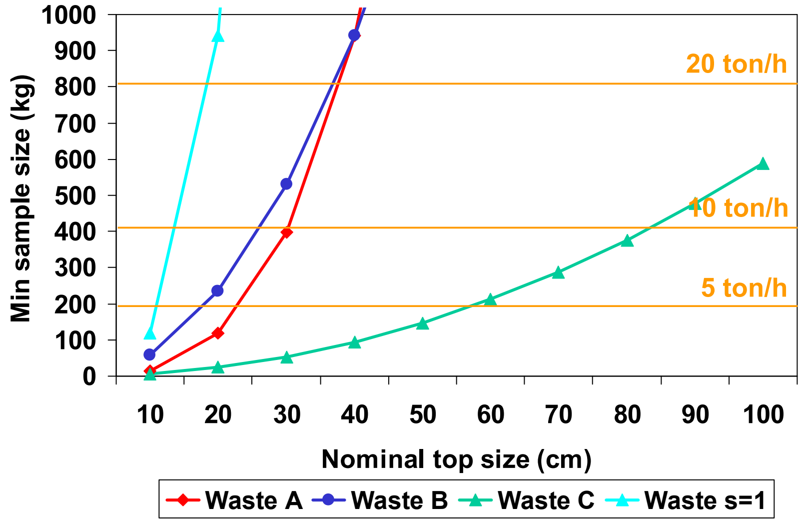
⇒ **Effective sample size > Min sample size**

#increments ≥ 24

Example:

When d95 is smaller than 30 cm the effective increment size and sample size is controlled by the waste flow to the incinerator.

Minimum sample size vs effective sample size



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Sample reduction – reduce the size with unchanged sample composition

At the site: Coning, Strip mixing, Long pile, Manual increment division

At the lab: Riffle boxes, Rotary sample dividers, grinding

The **third-power law** controls the mass-reduction

Reduction factor d_{95}	Reduction factor of the sample size
2	8
5	125
10	1 000
30	27 000

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Test plan of the project

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- **Overall objectives:** To determine the possibilities to simplify the sampling methods and still accomplish a representative sample from a MSW incineration plant with non-treated waste
- **Define the lot**: 24 hours
- **Sampling procedure:** Manual, drop flow
- **Minimum number of increments:** 24
- **Minimum sample size:** d_{95}=30 => 400 kg
- **Minimum increment size:** 37 kg *(based on 22 ton/h)*
- **Effective increment size:** 17 kg (400 kg/24)
- Effective increment size > minimum increment size
- **Effective sample size:** 880 kg (37*24)

Test plan

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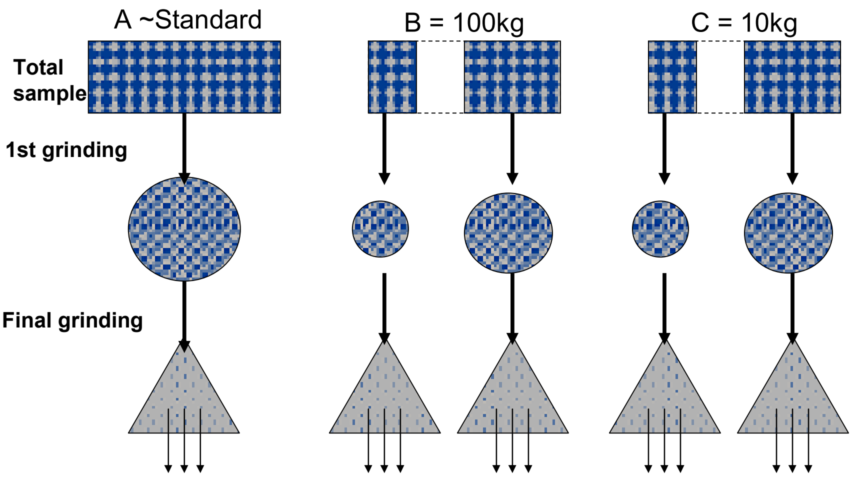
- Sample A ~ to standard
- Sample B = 100 kg
- Sample C = 10 kg
- Test of 25 and 50 % of the sample volume

- How well does sample B and C imitate sample A?
- What simplifications can be made without influence the quality?
- Which sample size is recommended?
- How much dose the initial preparation sample volume affects the quality of the data?

Test plan of the project



A simplified sampling and preparation method

- Suggest a minimal sample size that accomplish representative composition data
- Suggest a mass-reduction technique at site
- Suggest a routine for the first grinding step
- Suggest a sample reduction method at the lab
- Based on experimental data and the two standards

…all valid and suitable for heterogeneous waste fuels

Annex 5. Bionorm – A project to support the ongoing European standardisation process of solid biofuels

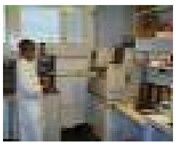
Jan Burvall

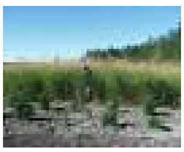
Unit of Biomass Technology and Chemistry, Umeå

Jan Burvall

Unit of Biomass Technology and Chemistry Umeå





- **Bioenergy, the whole chain from energycrop – heat water production**
- **Research on pellet production**
- **Characterisation of biomass focused on On-line technology e.g. NIR**

BioNorm – A project to support the ongoing standardisation process

"Pre-normative work on sampling and testing of solid biofuels for the development of quality assurance systems"

EU Political Targets

- Reduction of green house gases emissions by 8 %
- White paper on Renewable Sources of Energy
- Renewable Electricity Directive
- European Biofuel Directive

Measures to achieve targets

- Definition of acceptable standards for classification, sampling and testing of solid biofuels
- Development and implementation of QM systems for solid biofuels
- Elimination of trade barriers by harmonisation of the existing rules within Europe
- Development of a European market for solid biofuels

Aim of Bionorm

To carry out pre-normative work on solid biofuels in cooperation with CEN TC 335 “Solid Biofuels” in the field of:

- Sampling and sample reduction
- Physical and mechanical test methods
- Chemical tests
- QA systems
- Integration of new EU-member States (NMS) and newly Associated States (NAS)., respectively, in the standardisation process

Examples why BioNorm was needed for European standards

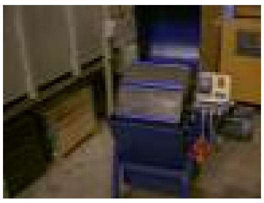
- CEN TC 335 Solid biofuels started in 1997
- Different methods for testing of solid biofuels were used within the European countries in many cases built on coal standards
- Round round robin tests showed a significant bias between some of them e.g the ash content and durability for pellets

Ash content

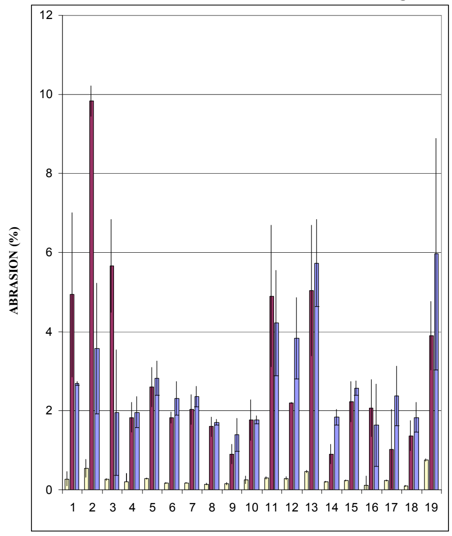
Temperature at 550 ˚C or 815 ˚C

Durability -pellets

ASTM SS ÖNorm

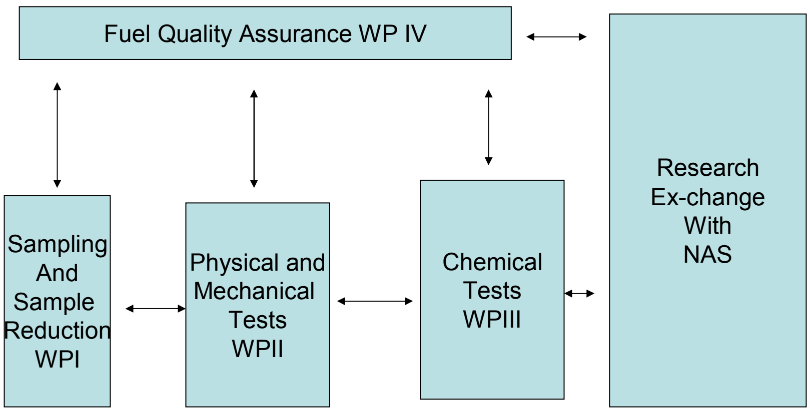


Durability - pellets



Yellow lines = SS 18 71 80 Increasing diameter
Red lines = Lignotester O60
Blue lines = ASAE 269.4

Bionorm Structure



Bionorm

Project co-ordination

IE Institute for Energy and Environmental GmbH, Leipzig, Germany

Prof. Dr.Ing. Martin Kaltschmitt

Overview Data

- Project runs from Jan 2002 to Dec 2004
- 33 partners from 14 European Countries and 16 sub contractors involved
- 6 partners from NMS/NAS are active in WP VI

(Bulgaria, Czech Republic, Latvia, Lithuania, Poland, Hungary)

- Total Budget: 5.7 Mio €
- EC contribution: 3.3 Mio €
- The project has been designed to support the of CEN TC 335 “Solid Biofuels”

European standards for Solid Biofuels CEN TC335

- Terminology
- Quality assurance
- Fuel specification and classes
- Sampling and sample reduction
- Physical methods
- Chemical methods

Today totally 28 Technical Specifications are published

Technical Specification and Standard – What is the difference ?

WP I
Sampling and Sample reduction

- Task I.1 Investigation of methods for sampling biofuels
- Task I.2 Investigation of methods for sample reduction of biofuels

WP II
Physical and Mechanical tests

- Task II.1 Moisture content and bulk density
- Task II.2 Ash melting behaviour
- Task II.3 Particle size distribution
- Task 11.4 Durability and raw density of pellets and briquettes

WP III

- Task III.1. Determination of sulphur, chlorine and nitrogen
- Task III.2 Determination of major and minor elements

Sampling -Biofuels

- Sampling
- Sampling from lorries
- Sampling plan and certificates

Biofuels – Sample preparation








Moisture content

- Reference method
- Simplified procedure
- General analysis sample



Fig 9. Picture of the drying equipment in the "GC-MS"-method.

Fig 10. The flow meter, the water trap and the cotamination trap together with the heating mantle.

Fig 11. The sample container and the pre-heating cupper tubing inside the oven.

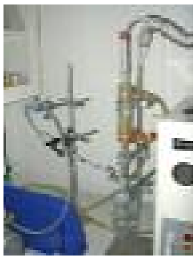


Fig 12. The collection system with cooler, glass flask, carbon tubes and water trap.

Fig 13. The GC-MS instrument

Losses of VOC when drying at 105 °C

Calorific value for VOC in biomass

	kJ/g
α – pinene	45.2
β – pinene	45.0
Carene	39.0

Biomass material	VOC as % of dry matter
Birch bark	0,30
Birch chips	0,04
Cork	0,05
Eucalyptus	0,03
Hard wood	0,004
Logging residues	0,08
Milled peat	0,20
Miscantus	0,20
Olive stones	0,06
Pine bark	0,15
Pine chips	0,06
Pitchy wood	1,74
Rape cakes	0,04
Salix	0,02
Sawdust	0,05
Spruce bark	0,28
Spruce chips	0,04
Triticale	0,01
Wood pellets	0,09
Wood pellets II	0,10

BioNorm II obtained 26 of 30 points in the evaluation and is on a special list with other promising proposals which will be preferred when further resources are available.

- Instrumental methods for rapid tests and On-line measurements
- Developing of methods for Bridging properties, impurities and particle size distribution
- Validation of the classification system of biofuels by handling and combustion tests
- Sampling and sample reduction of biomass from southern Europe

Summary

- BioNorm has developed improved sampling and testing procedures and assessed the limitations of existing procedures in detail.
- The quality assurance system developed in BioNorm allows for biofuel provision of quality according to customer demands
- The integration of the NMS/NAS into the work of BioNorm ensures that the standardisation requirements of these countries are considered.
- Due to the close link to the work of CEN TC 335 “Solid Biofuels”, an excellent exploitation of the results is guaranteed.
- BioNorm has contributed significantly to the development of highly sophisticated standards.

Thanks for your attention !

Annex 6. Preparation of fuels based on waste material

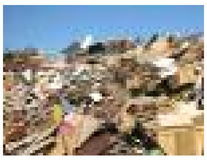
Sture Mattsson

SWEDEN´S UNIQUE SITUATION

OIL NO

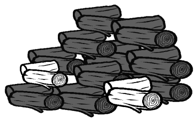
GAS NO

COAL NO

WOOD  YES!

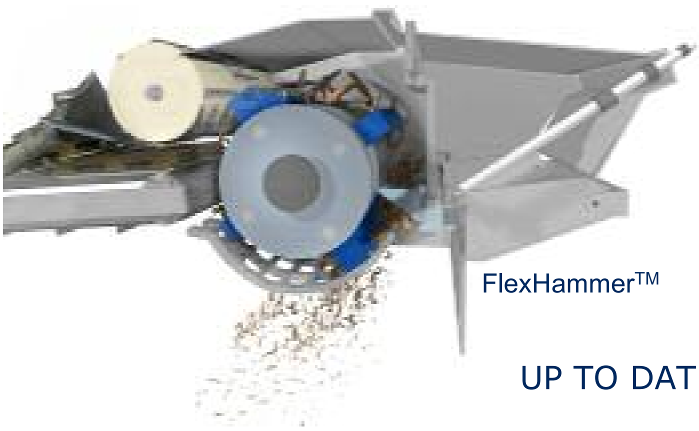
WASTE YES!

FUEL PREPARATION



TRADITIONAL

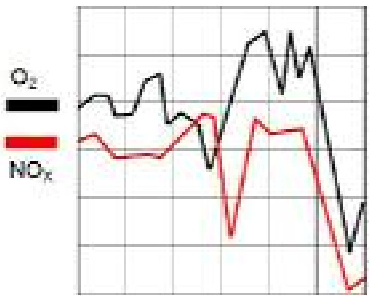
FUEL PREPARATION



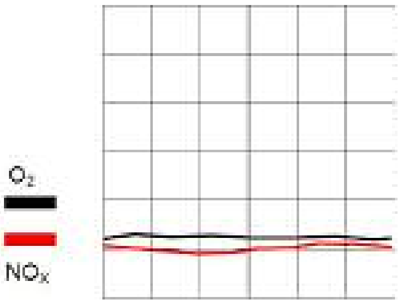
FlexHammer™

UP TO DATE

Emissions from not prepared fuel.



Emissions from prepared fuel.



Fuel Based on Waste Materials

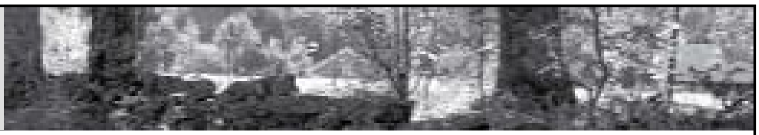
FACTORS of influence to the incineration control

1.COMPOSITION
- Type of community
- Structure of industry
- Communication community-industry-waste company

2.HOMOGENEITY
- Collection
- Feeding
- Design of storage, in – out order
- All steps through

3.HUMIDITY
- Preparation order
- Storage volume
- Design of storage, in – out order

4.PARTICLE SIZE
- Preparation equipment
- Equipments´ flexibility



High Quality fuel for BFB & CFB boilers

Means Improved incineration

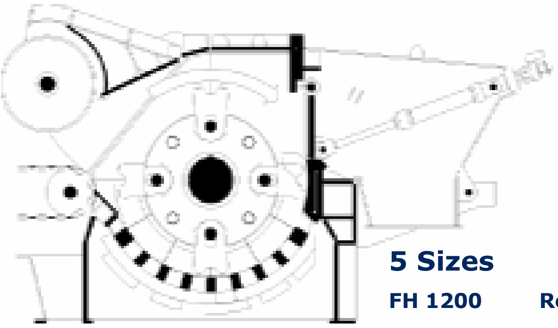
- No organics in ashes
- Simple gas cleaning
- Less NOX
- Less emissions
- Increased temperature
- Increased pressure

Saying 1:
- Grate boilers need no fuel preparation…..but
- Grate boilers have high demand on AVAILABILITY
  Zero acceptance regarding production breakdowns is very demanding
- A breakdown means no energy delivery out and no waste delivery in and millions/day in lost money

Saying 2:
- ”Design-fuel” doesn´t exist

Saying 3:
- Guaranteed ”clean” material never arrives

FlexHammer™



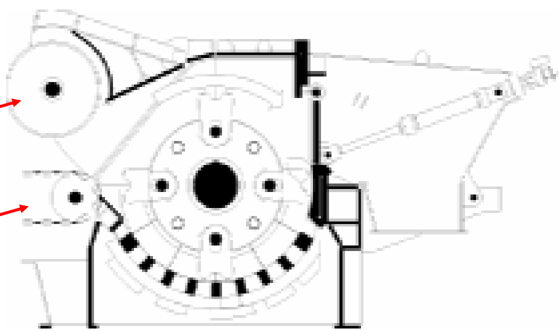
5 Sizes

FH 1200	**Rotor diam. 1200**	**130-315 kW**
FH 1500	**-- ” --**	**130-315 kW**
FH 1800	**-- ” --**	**160-400 kW**
FH 2000	**Rotor diam. 1600**	**500-800 kW**
FH 2400	**-- ” --**	**615-1000 kW**

FlexHammer™ Flexibility

Feed Roller
alt.
Force Feeder

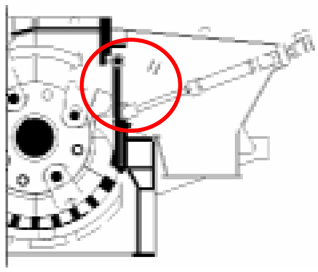
and Apron Feeder



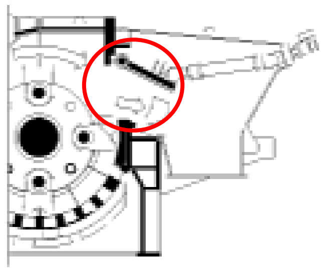
Variable speed makes it possible to take full advantage of installed motor power by variations in feed materials´analyzis or supply.

FlexHammer™ Flexibility

Closed Door



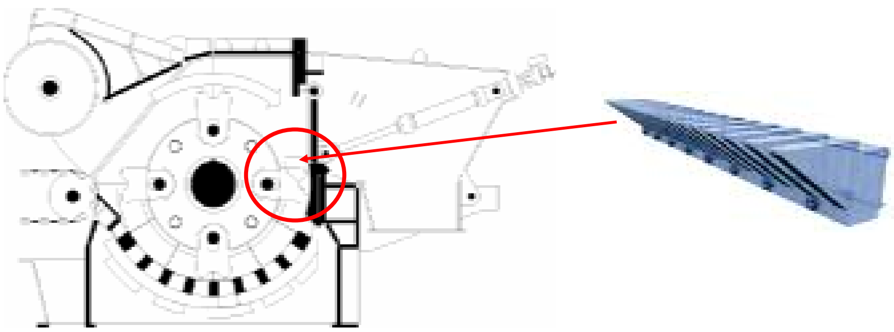
Open Door



Closed Door – Processing over bottom grate, fine fractions

Open Door – Precrushing, bypassing the grate, coarse fractions e.g. processing railway sleepers with steel

FlexHammer™ Flexibility

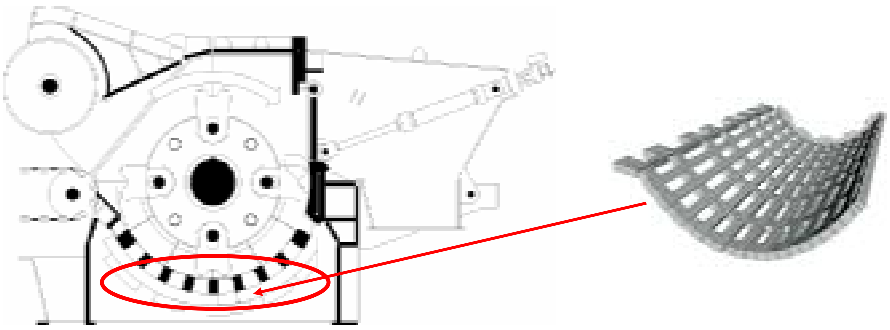


”Knives” Comb/Anvils

An item, very important, specifically when processing elastic obejcts such as plastic folios and textiles.

Necessary in the ”uncrushable objects” release system, the reject door function.

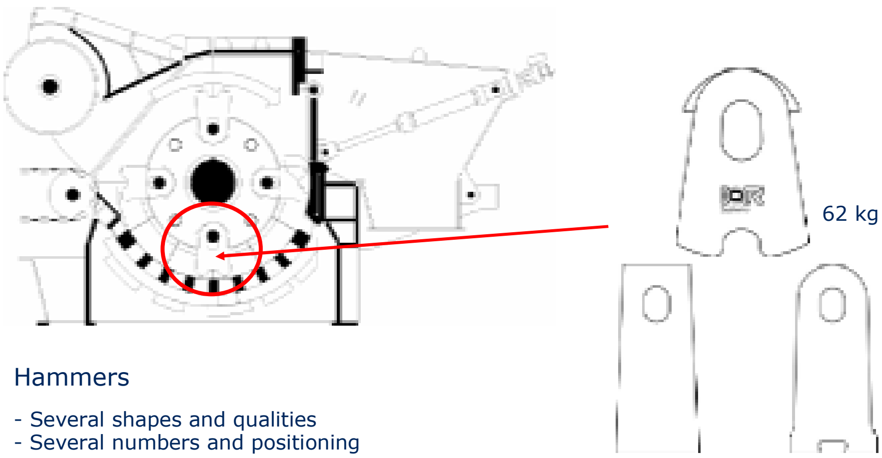
FlexHammer™ Flexibility



Grate

- Installed / Not installed / Partly installed
- Several opening dimensions
- Several opening combinations
- Steel bars- alt. Steel plate design

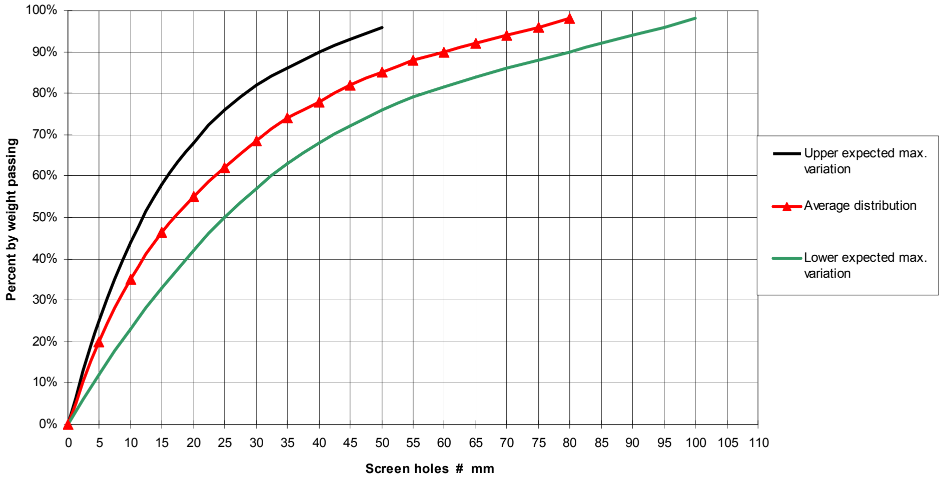
FlexHammer™ Flexibility



Hammers

- Several shapes and qualities
- Several numbers and positioning patterns
- Several sizes

Size Distribution Diagram for mixed Swedish household-
and industrialk waste, processed over 120mm grate



IQR™ Systems

Annex 7. Deposit formation during combustion of different waste wood qualities and co-combustion of waste wood and sewage sludge

David Eskilsson

Deposit formation during combustion of different waste wood qualities and co-combustion of waste wood and sewage sludge

David Eskilsson
SP Swedish National Testing and Research Institute

Lars-Erik Åmand
Chalmers, Department of Energy technology

SP Swedish National Testing and Research Institute

Agenda

- Introduction
- Chemical content of different waste wood qualities
- Deposit formation during combustion of waste wood in a grate furnace
- Deposit formation during combustion of different waste wood qualities in a CFB
- Deposit formation during co-combustion of waste wood and sewage sludge in a CFB
- Conclusions

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Introduction

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Demolition wood = Waste wood

Waste wood: Sorted demolition wood from old buildings and wood packing material. These materials are crushed to a suitable fuel size.

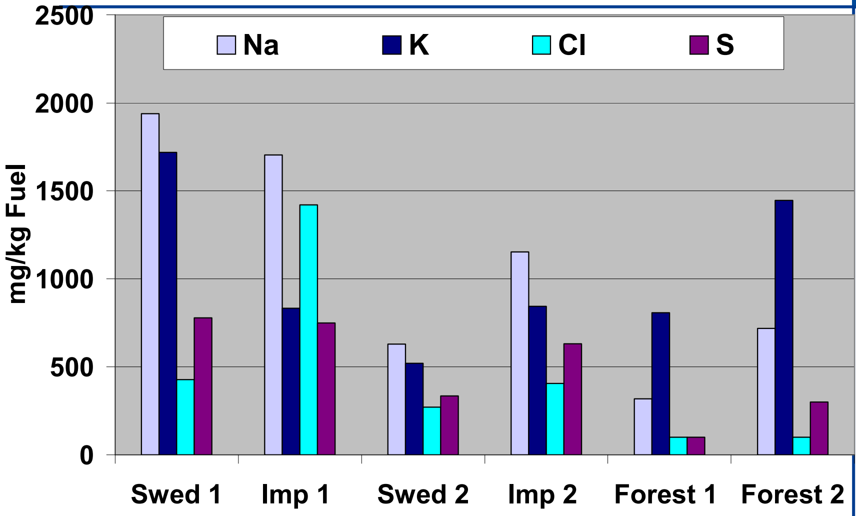
Waste wood can contain different amounts of:
Metals (nails and fittings), creosote, plastic, gypsum, board

In some countries different classes of waste wood exists.

Waste wood often contains higher amounts of Zn, Pb, Cl and S compared to virgin wood. Causes problems with increased deposit formation and corrosion on super heaters.

ZnO and PbO were used as a pigment in old paint

Chemical content of some different waste wood qualities – Na, K, Cl and S



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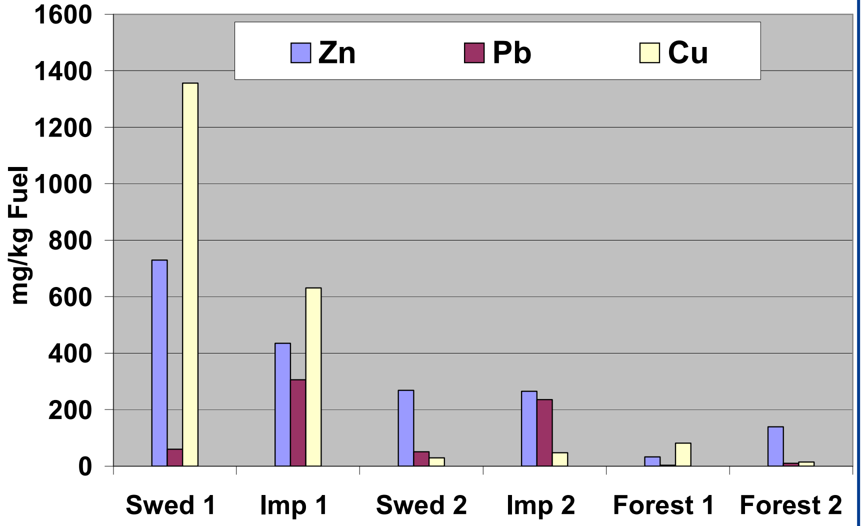
Swed: Swedish waste wood qualities

Imp: Imported waste wood qualities

Chemical content of some different waste wood qualities – Zn, Pb and Cu



Swed: Swedish waste wood qualities

Imp: Imported waste wood qualities

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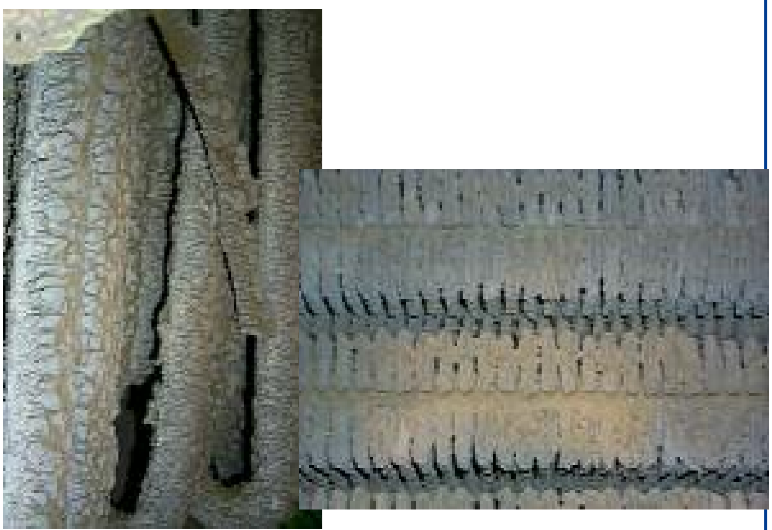
Example of deposit formation during waste wood combustion



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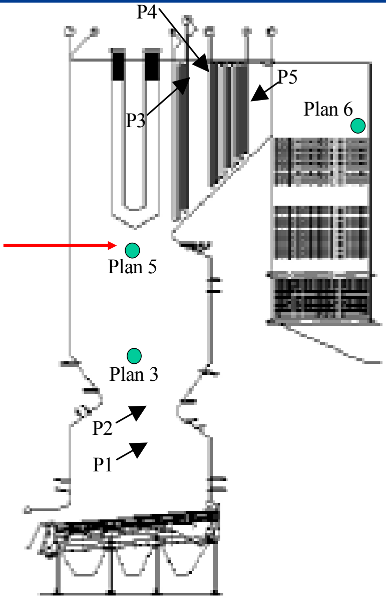
Deposit formation during waste wood combustion Händelö P11 – Vibrating grate



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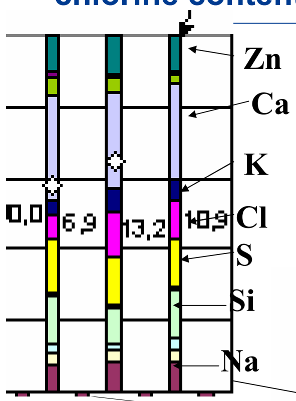
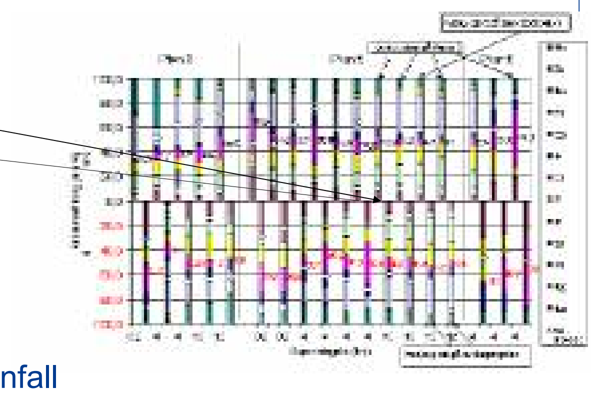
Combustion of imported waste wood with high chlorine content (0,14 w%) – Deposit content



Flue gas temperature: 900 °C

Metal temperature: 500 °C

Melting point of deposit: 400 °C



Measured by Vattenfall

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Combustion of Swedish waste wood with low chlorine content (0,04 w%) – Deposit content

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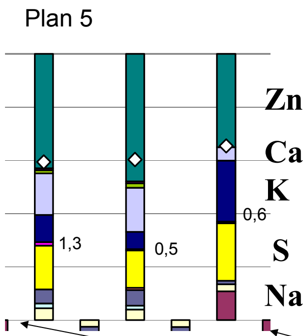
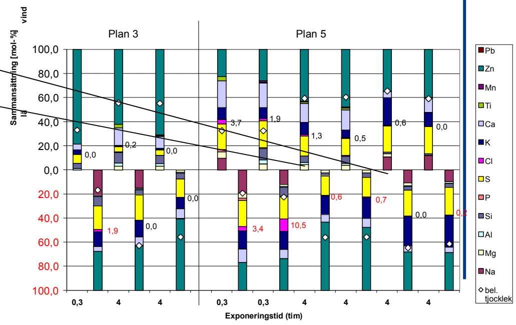


Flue gas temperature: 900 oC
Metal temperature: 500 oC



Measured by Vattenfall

Combustion of different waste wood qualities and co-combustion of waste wood and sewage sludge in a CFB

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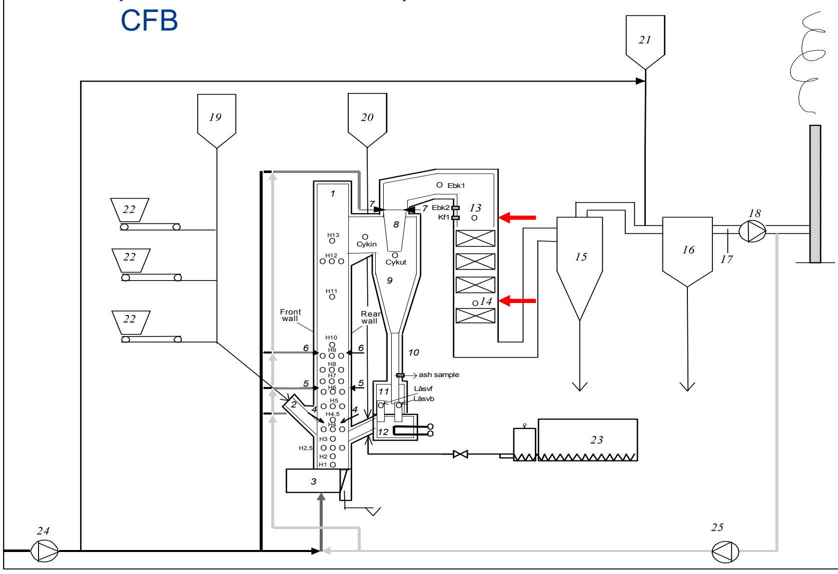
Experiments have been performed in Chalmers 12 MW CFB



Experimental - Fuels

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Almost equal amounts of wood pellets and demolition wood were fired.

In some cases sewage sludge was added.

Three different demolition wood qualities were simulated in a reproducible way:

1) "Clean" demolition wood
2) Painted demolition wood: Added ZnO (pigment in old paint)
3) Painted demolition wood with high chlorine content: Added ZnO and HCl

Experimental – Test program

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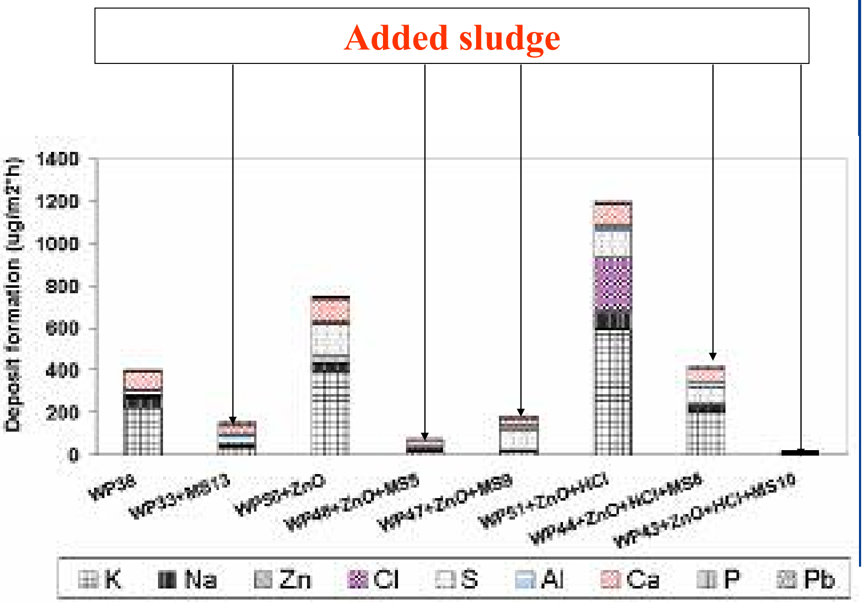
WP: Wood Pellets

MS: Municipal Sewage sludge

Number: mass dry fuel / mass total dry fuel

Runs	Molar ratio Cl/Zn	S/Zn	Cl / (K+Na)	2S / (K+Na)	2S/Cl
WP38	4.4	6.0	0.11	0.3	2.7
WP33+MS13	3.0	18	0.08	1.02	12.8
WP56+ZnO	0.91	0.64	0.27	0.4	1.5
WP48+ZnO+MS5	0.88	3.2	0.16	1.2	7.5
WP47+ZnO+MS9	0.97	5.9	0.16	1.9	11.9
WP51+ZnO+HCl	4.0	0.63	1.9	0.6	0.3
WP44+ZnO+HCl+MS6	3.9	3.8	0.80	1.6	2.0
WP43+ZnO+HCl+MS10	3.5	5.9	0.51	1.7	3.4

Results – Deposit formation



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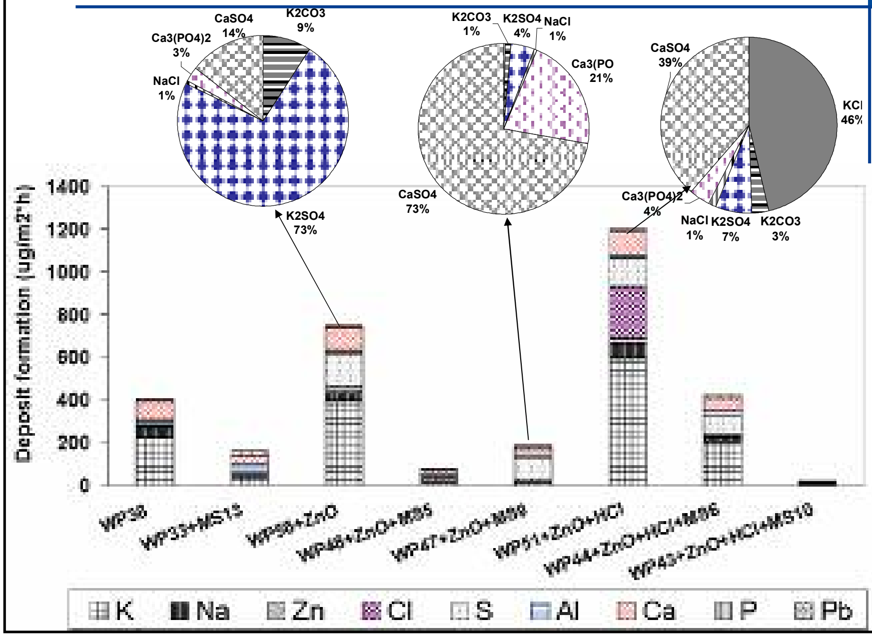
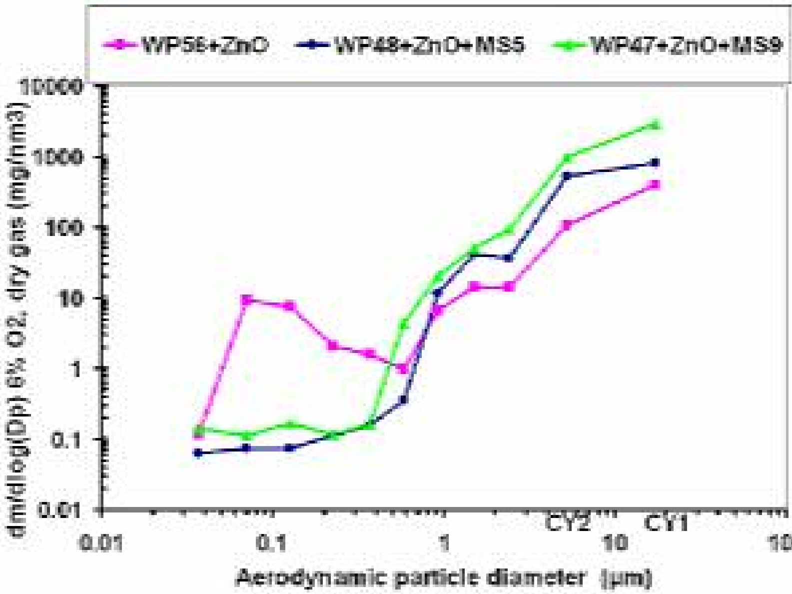
Results – Chemical analysis of the deposits



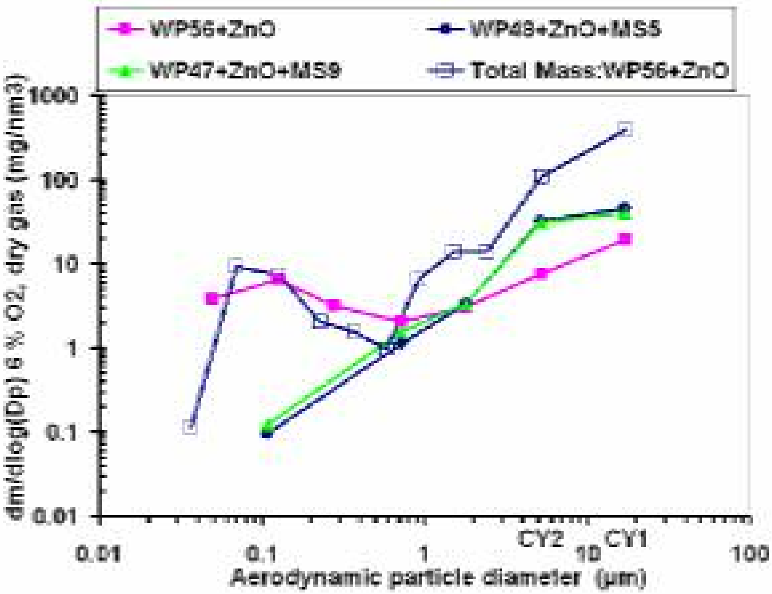
SP Swedish National Testing and Research Institute

Results – Mass size distribution of the fly ash measured by a DLPI



SP Swedish National Testing and Research Institute

Results - Sum of elements related to fouling in fly ash particles (K, Na, Zn, Cl and S)



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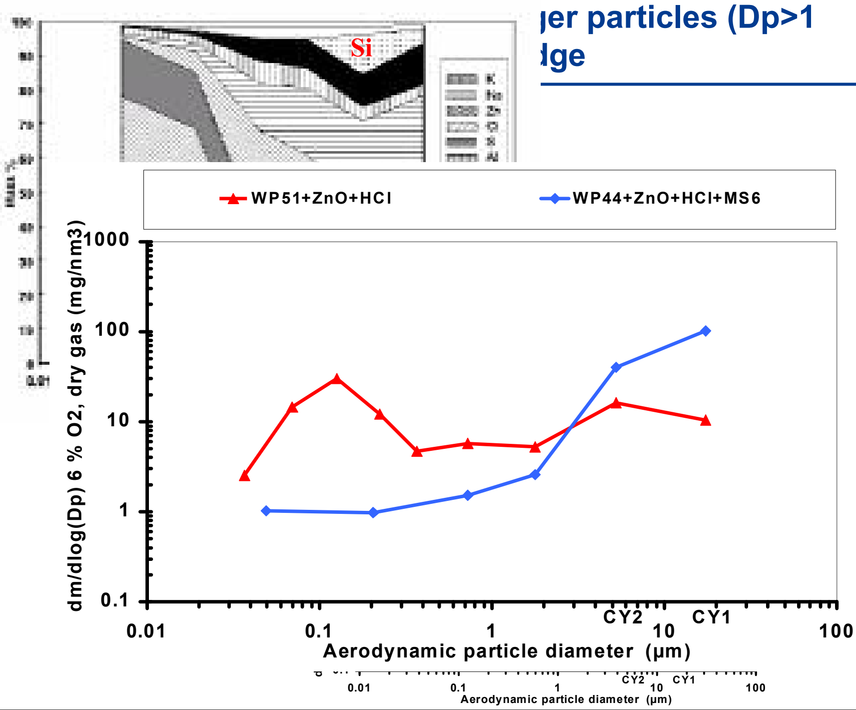
ge



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Conclusions - waste wood combustion

•Waste wood often has a higher content of chlorine, sulphur, zinc, lead and copper compared to virgin biomass.

•High amount of chlorine in the fuel increases the deposit formation and give a deposit with higher chlorine content.

•Zinc can in some cases evaporate from the combustion chamber and form deposits. In these studied furnaces the zinc evaporation was high during grate fired conditions.

•Zinc can lower the melting point of the deposit and increase the corrosion rate.

The results from the combustion tests at Chalmers CFB have been reported in: Lars-Erik Åmand, Bo Leckner, David Eskilsson, and Claes Tullin , "Ash Deposition on Heat Transfer Tubes during Combustion of Demolition Wood" , Energy & Fuels, 20 (3), Pages 1001 -1007, 2006,

SP Swedish National Testing and Research Institute

Conclusions - Co-combustion of waste wood and sewage sludge

- **The deposit formation decreases radically when sludge is added to the combustion**
- **The fouling related elements (mainly KCl) in the submicron particles is transported to the bigger particles (Dp>1 µm) during sludge combustion**
- **During high S/Cl ratios, the potassium is sulphated**
- **Looking at the results from the elemental concentration of the bigger particles during sludge combustion indicates that a major part of the potassium could have reacted with aluminum-silica compounds**
- **Sludge contain high amounts (10 % dry basis) of zeolites (aluminum-silica compound) which derive from phosphate free washing detergent.**

Lars-Erik Åmand, Bo Leckner, David Eskilsson and Claes Tullin, "Deposits on heat transfer tubes during co-combustion of biofuels and sewage sludge", Fuel Volume 85, July-August 2006, Pages 1313-1322

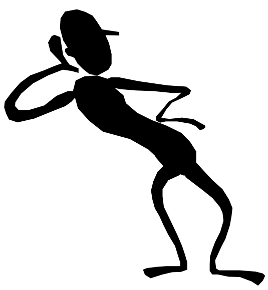
SP Swedish National Testing and Research Institute

Acknowledgement

Energimyndigheten

Financial support from the Swedish Energy Agency and from Värmeforsk AB

Thank you for your attention!



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Annex 8. Experience from waste co-combustion in Vattenfalls fluidized bed boilers

Matts Almark

Experience from waste co-combustion in Vattenfall fluidized bed boilers

Matts Almark

VATTENFALL

Co-combustion, waste & biofuels

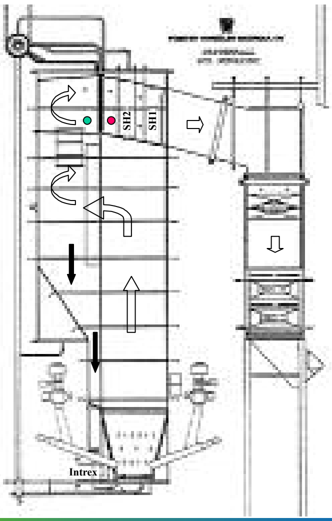
- Waste fractions containing unwanted elements
  - Chloride, alkali, heavy metals
- Increased fouling & corrosion compared to “clean” biofuels

- Some experiences and observations with different amounts of waste derived fuels in fuel mix
- Measurement of alkali chlorides in flue gas - monitoring fuel quality
- Additives and other solutions
- Myllykoski, Idbäcken, Munksund

VATTENFALL

Munksund

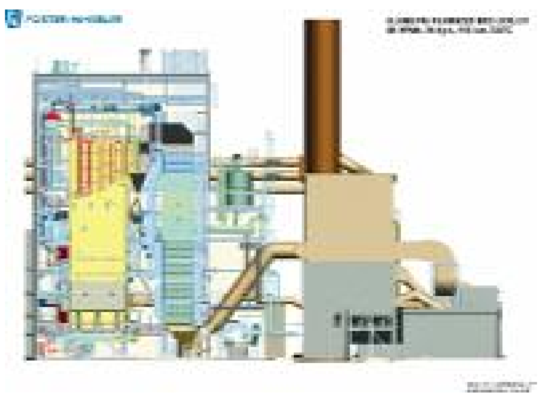
- CFB
- 96 MW_{th}
- Bark (> 80%)
- Sawdust, woodchips
- Cardboard reject (<6%)



VATTENFALL

Myllykoski

- BFB
- 88 MW_{th}
- Bark, peat, forest residues,sludge, recycled wood
- (Recycled Energy Fuels)



VATTENFALL

Idbäcken

- BFB
- 105 MW_{th}
- Biomix + Recycled wood (50%)

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5

VATTENFALL

Fuel chemistry derived problems - characterization

- Measurement of gaseous alkali chlorides – IACM
- Deposit probes
  - Fouling rates
  - Deposit chemistry – corrosion rates

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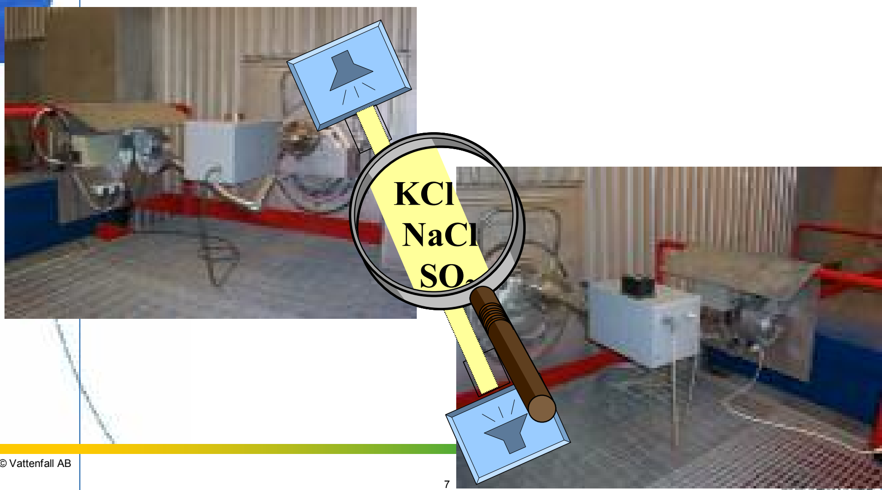
6

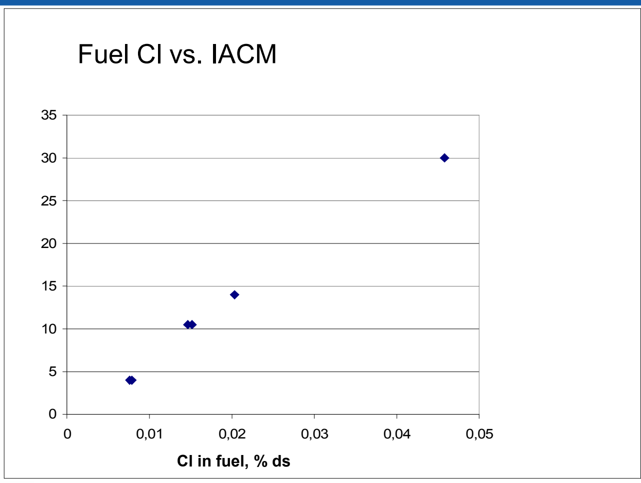
VATTENFALL

IACM – In situ Alkali Chloride Monitor

- UV lamp and detector



IACM as fuel quality monitor



(Biofuel boiler)

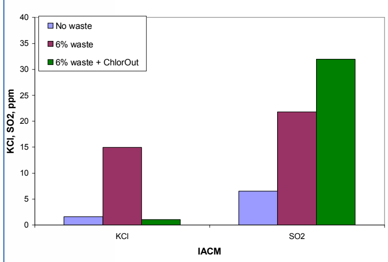
Reduction of alkali chlorides - ChlorOut

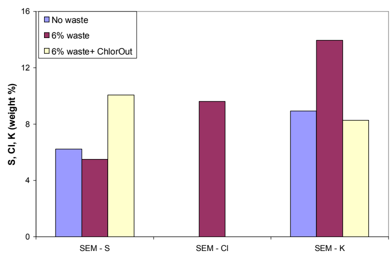
- $(NH4)_2SO_4 \rightarrow 2\ NH_3 + SO_3 + H_2O$
- $SO_3 + H_2O + 2KCl \rightarrow 2HCl + K_2SO_4$

- Also reduction of NO_x and CO emissions

Munksund

- No waste; waste addition; waste + ChlorOut
- Measured levels of KCl and deposit chlorine content





Normal & with ChlorOut addition

Without ChlorOut
Chloride conc. 12%
deposits 6 g/m^2/h

With ChlorOut
Chloride conc. <0.2%
deposits 2 g/m^2/h

VATTENFALL

Bio/recycled wood 50/50

Without ChlorOut
Chloride 25%
Fouling rate 21 g/m2/h

With ChlorOut;
Chloride <0.2%
Fouling rate 6 g/m2/h

VATTENFALL

Myllykoski K7

- Operating on a wide mix of fuels
- Peat, bark, forest residues, sludge
- Recycled wood, recycled energy fuels
- REF (~5%)

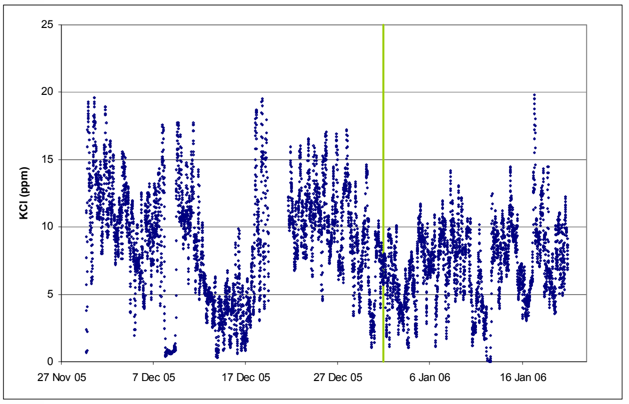
- High levels of S from peat and sludge

- S/Cl or S/alkali above what usually considered critical limits

VATTENFALL

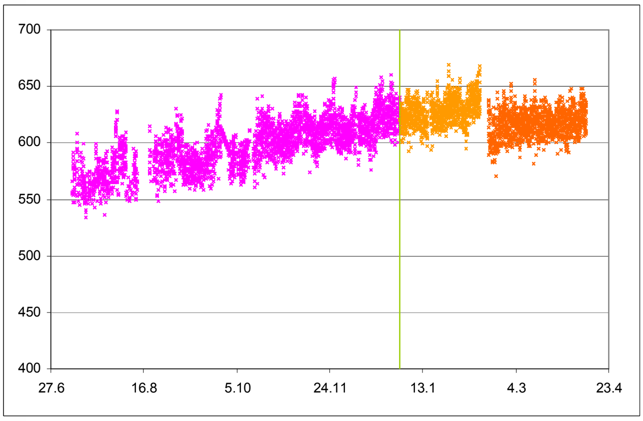
Myllykoski K7, IACM

- Removal of REF from fuel mix; week 50/2005 & 2006



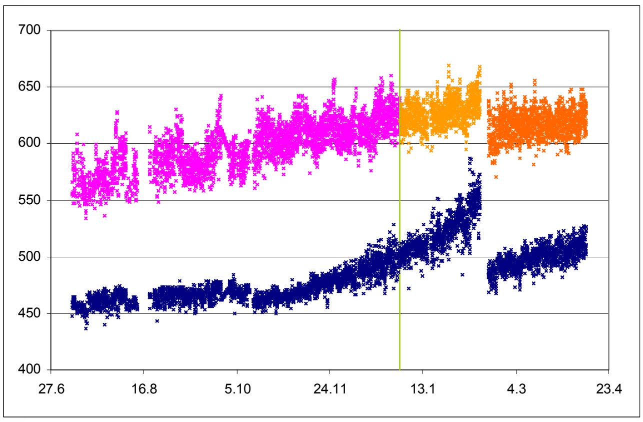
VATTENFALL

Flue gas temperature



VATTENFALL

Flue gas temperature & pressure loss



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Idbäcken

- Removal of coal from fuel mix
- Increasing fouling and corrosion
- ChlorOut as S-additive
- SH replaced to E1250

VATTENFALL

Idbäcken, fuel distribution over bed

- With increasing share of recycled wood problems with deposit formation over fuel feed points
- Uneven temperature in bed – problems reaching high loads
- Mixing in freeboard
- Improved fuel feeding system - reduced deposit formation
  - Reduced amounts of fines and rapidly volatilized burning immediately above fuel feed points
  - More even heat release in bed

VATTENFALL

Idbäcken, fuel distribution table

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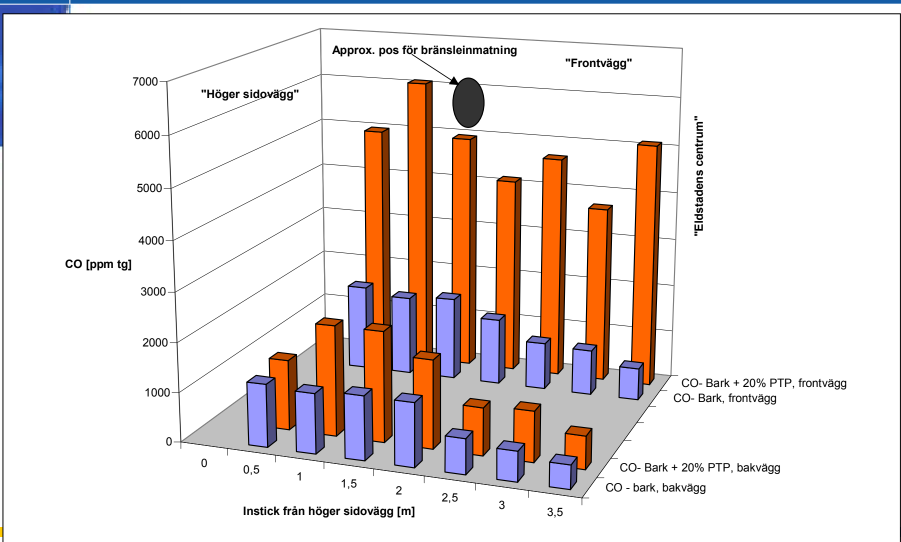
19

CO concentrations (Johannes BFB)



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20

Idbäcken, remaining issues

- Deposit formation in furnace wall
- Furnace wall corrosion

VATTENFALL

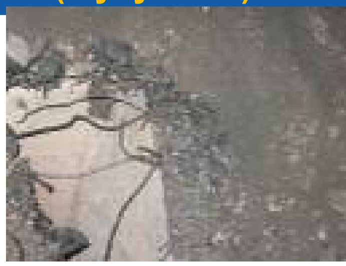
Bed fluidization issues –metal waste

- With recycled fuels in certain cases high amounts of incombustible matter, metal waste
- Nails in recycled wood
- Will not fluidize in the bed, decreased mixing
- Forming defluidized zones
- Difficulties removing metal waste with bed bottoms not designed for the task

VATTENFALL

Removal of metal waste (Myllykoski)

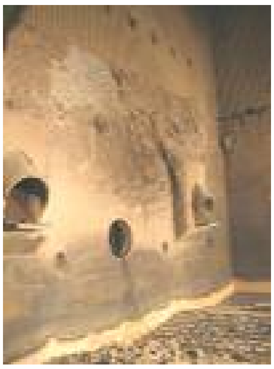
- Nails forming tangled lumps
- Manually removed

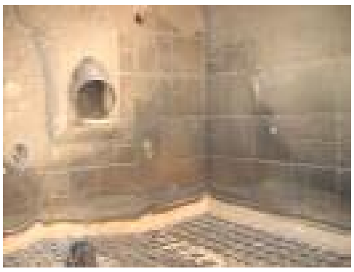


VATTENFALL

"Rassausaukko"

- Bed bottom manually cleaned without need for shut-down
- Reduced load on natural gas





VATTENFALL

Conclusions

- Waste fractions can be co-combusted with biofuels
- Feed arrangement must be looked over
- Spreading of fuel – especially in BFB:s

- Increased fouling & corrosion risk compared to "clean" fuels
- Increased amounts of chlorine, alkali, heavy metals

- Bed bottom capacity to deal with (metal) waste

VATTENFALL

Conclusions (2)

- Fuel quality can be monitored with IACM

- SH fouling rates correlating with measured alkali chloride levels

- Additives (ChlorOut) – reduction of alkali chlorides, fouling rate and corrosion risk

VATTENFALL

Annex 9. Fuel flexibility through (co-)firing biomass in Belgian pulverised coal power plants

Yves Ryckmans

LABORELEC

From R&D to operational assistance

Fuel flexibility
in coal power plants
with co-firing

Yves Ryckmans

Jönköping
31/5/2006

Electrabel

BELGIUM HAS GREEN CERTIFICATE SYSTEMS

- 3 systems (one per region)
- Compatibility is technically feasible but excluded by law except OK between Brussels and Wallonia
- Growing target calculated on the base of yearly electricity sales for each supplier
- Penalty between 75 and 125 €/certificate
  or 7,5 to 12,5 €c/kWh
  but only a part of the benefit according to energy balance
- Regulatory body in each region
- Market of green certificates : market value < penalty
- Today : stable market value

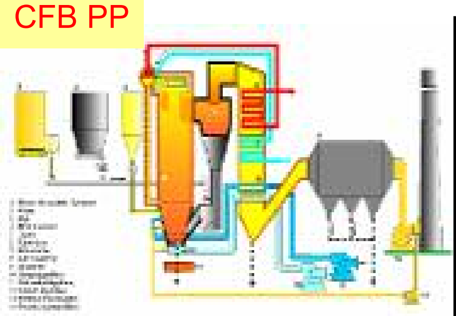
BIOMASS TECHNOLOGIES

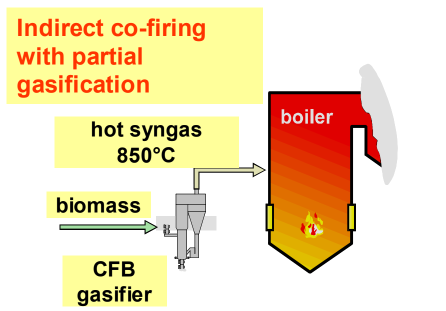
- Modern coal power plants can accommodate biomass
  ex. Avedore PF (Dk), Buggenum ICCG (NL)
- Firing biomass in dedicated plants equipped
  with grate boilers or Fluidised Beds
  (depending upon capacity 20..35 MW)
  with feedstock = cheap local biomass

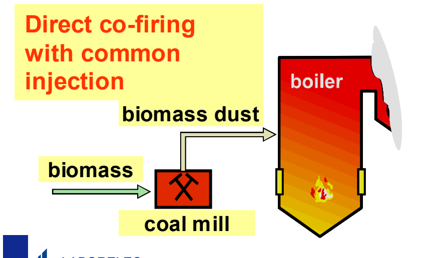
  INVESTMENT AT LEAST 3 X MORE EXPENSIVE
- Co-gasification of biomass (like Ruien) :
  (capacity depending upon dryness of feedstock)
  feedstock = cheap local biomass or waste
- Retrofit of existing coal power plant (like Awirs 4) :
  feedstock = expensive imported biomass
- Mixing bio-fuels with coal (with co-milling or separate injection)
  nearly no investment
  (cheap) waste or more expensive biomass

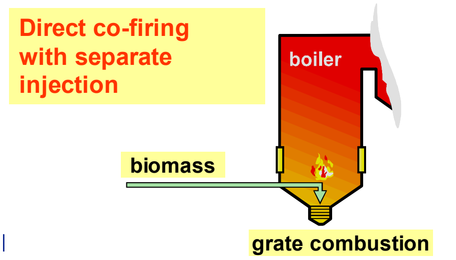
BIOMASS TECHNOLOGIES

CFB PP

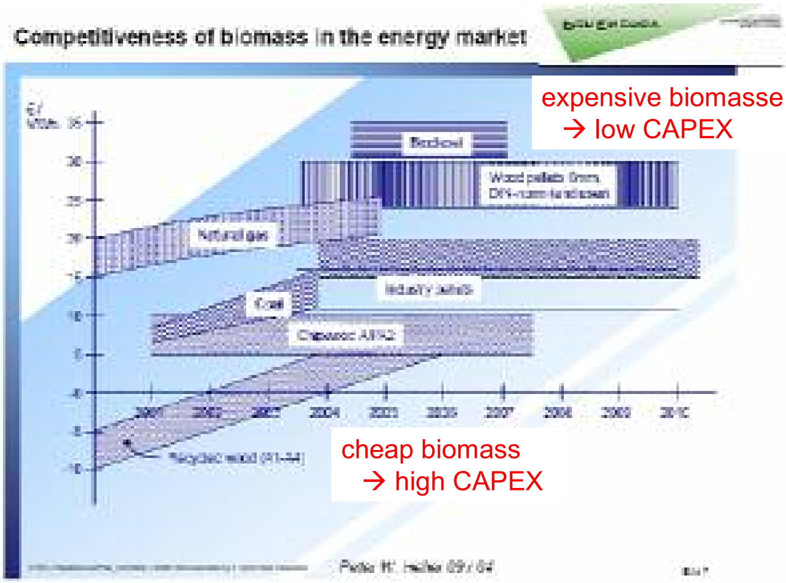




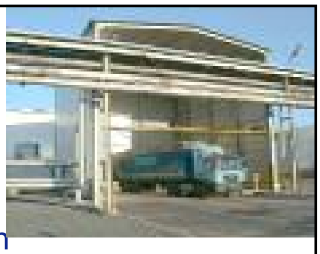




BIOMASS COST



Which kind of biomass ?
How is it used ?



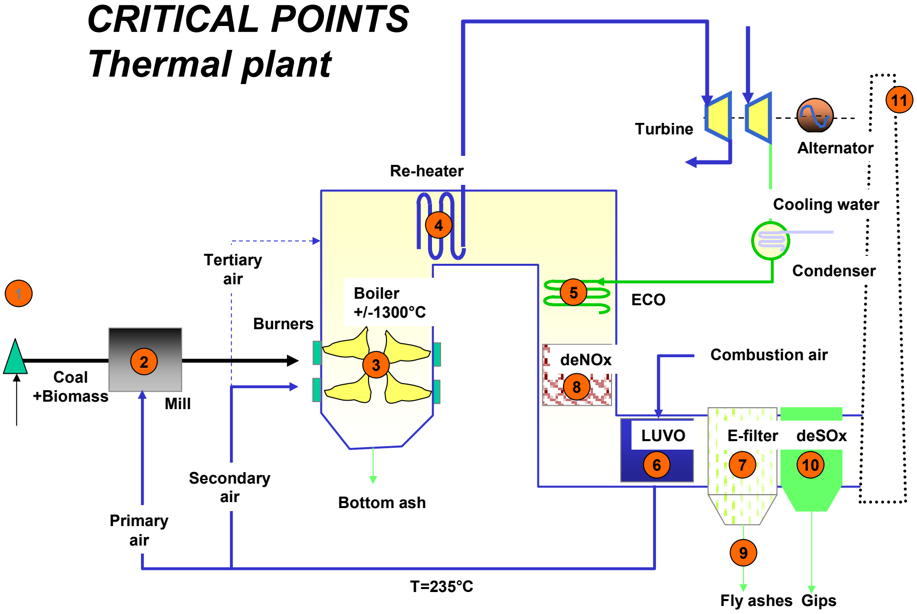
Reference:

With an electrical efficiency of 36 %,
1 ton hardcoal generates approx. 2,5 MWh

(Co-)firing bio-fuels today :

sewage sludge :	mixed with coal	1 kg → ~ 1,0 kWh
olive cake :	mixed with coal	1 kg → ~ 1,3 kWh
coffee ground :	mixed with coal	1 kg → ~ 1,6 kWh
wood dust :	injected after mills	1 kg → ~ 1,8 kWh
wood chips :	syngas injected	1 kg → ~ 0,8…1,5 kWh
wood "pellets" :	hammer mills	1 kg → ~ 1,8 kWh

CRITICAL POINTS
Thermal plant



Critical points of co-firing biomass with coal

1.	Storage	Health, fire, …
2.	Milling	Mechanical problems, fire, explosions (volatiles)
3.	Furnace	Slagging, corrosion (reducing atmosphere !)
4.	Super-heater	Fouling, HT-corrosion (Cl, K)
5.	Economizer	$CaSO_4$ deposits
6.	High-dust $DeNO_x$	Catalyst deactivation (K, P, As, Ca)
7.	Air heater	Blockage, LT-corrosion, …
8.	ESP	Efficiency (S)
9.	By-products	Valorization ash in cement & concrete (Ca, P)
10.	DeSOx	Waste water, gypsum quality
11.	Stack: emissions	Legal aspect: permits

Use of coal roller mills for biomass

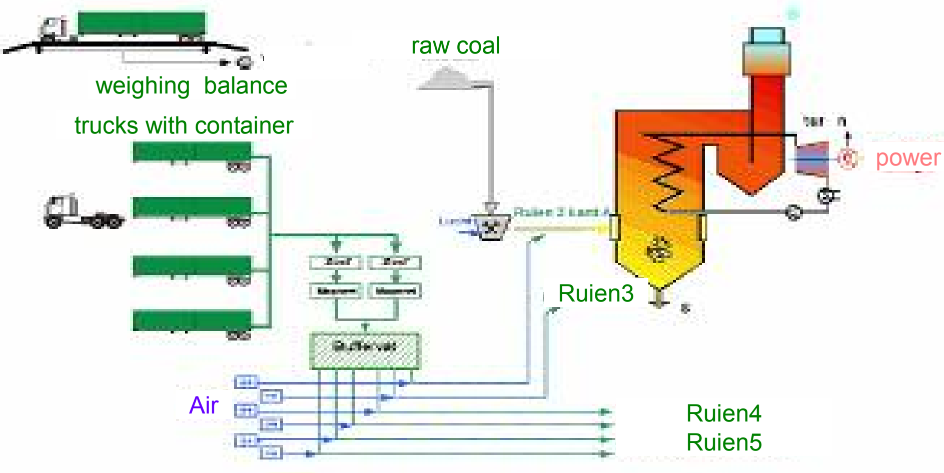
- Wear is caused by minerals which are both coarse and hard
- Power consumption is influenced by:
  - Particle size before grinding
  - Particle size needed after grinding
  - Type of coal or value of HGI
  - Moisture content
- With fibrous biomass risk of
  - agglomeration
  - vibrations and mechanical trouble
  - fires

RECENT DEVELOPMENTS

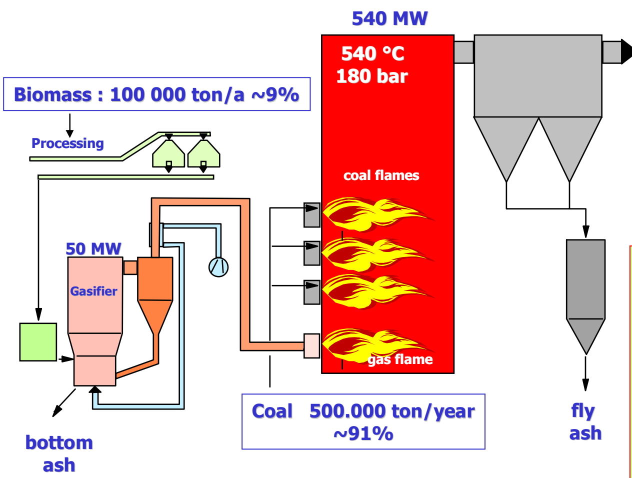
- 2005 :
  - Wood dust : Langerlo : + ~ 20 MW O.K.
  - Firing « wood pellets » :
    - Rodenhuize : co-combustion : ~ 65 MW test run
    - *Awirs (Liège) : 100% pellets : ~ 70 MW ~O.K.*
  - Olive cake :
    - + Mill efficiency enhancements : total + ~ 5 MW
  - Coffee Grounds : Mol
- 2007 :
  - Wood chips milling : Ruien : ~15 MW

Ruien Power Station

WOOD DUST IN RUIEN

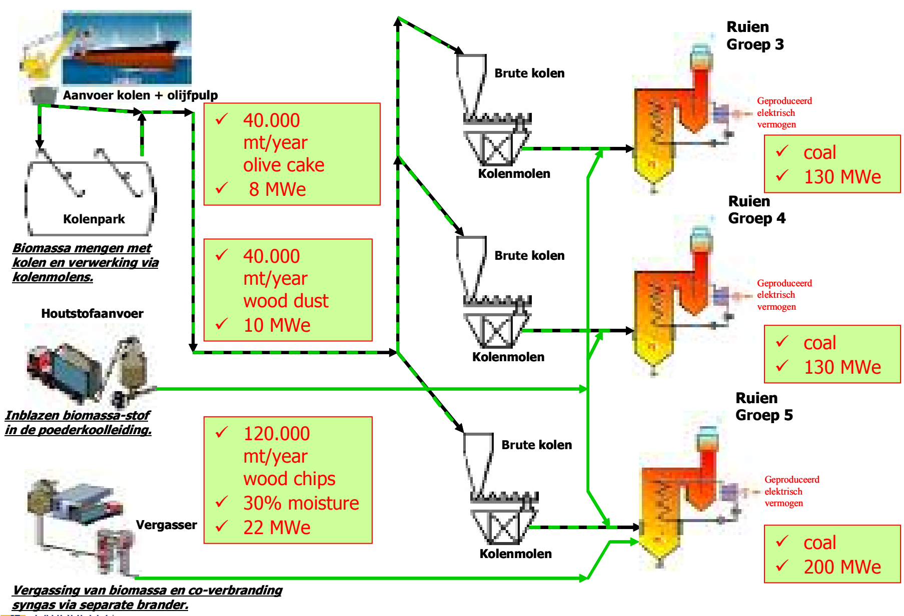


WOOD CHIPS CFB GASIFIER RUIEN

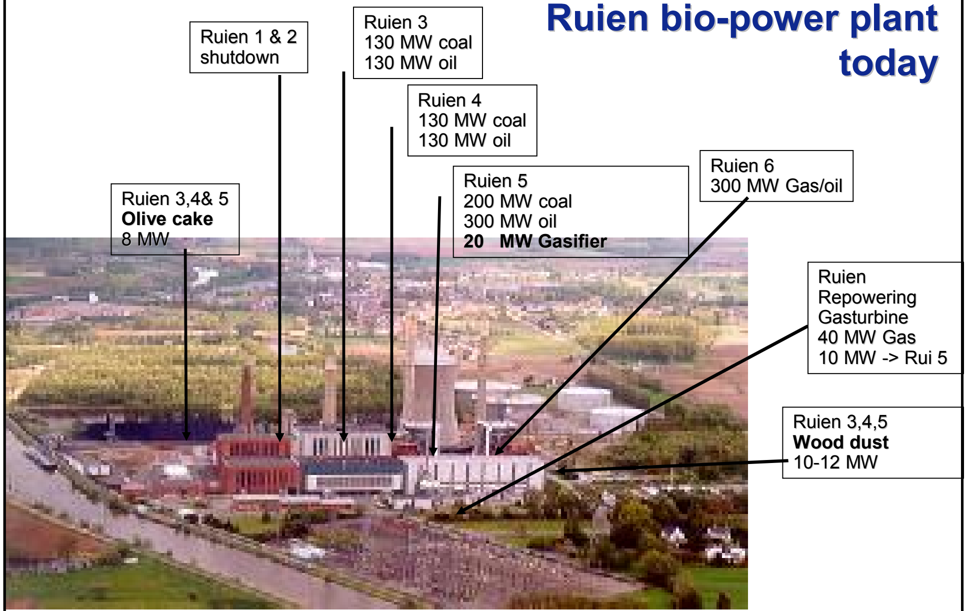


- ✓ 120.000 mt/year wood chips
- ✓ 17 – 28 MWe
- ✓ 30-50% d.m. moisture

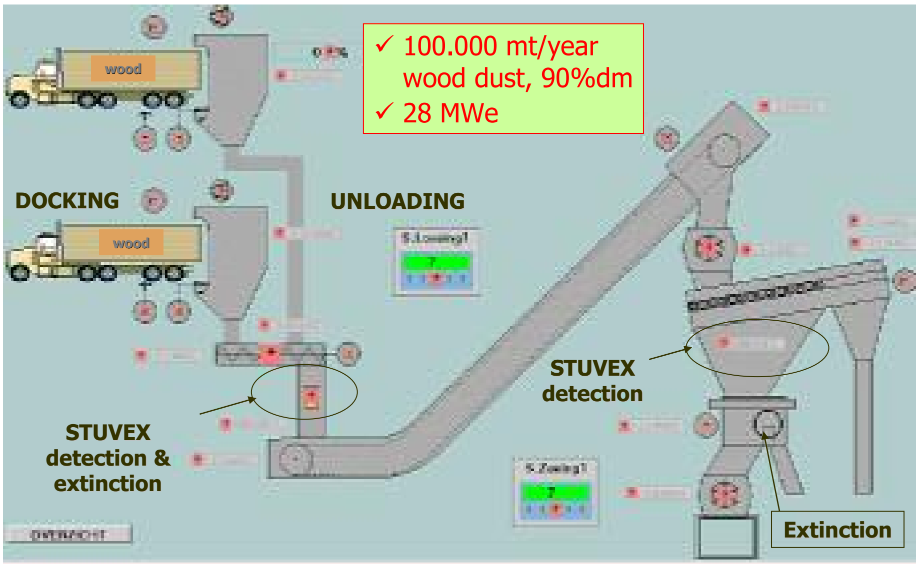
Concept of biomass co-firing in Ruien PP



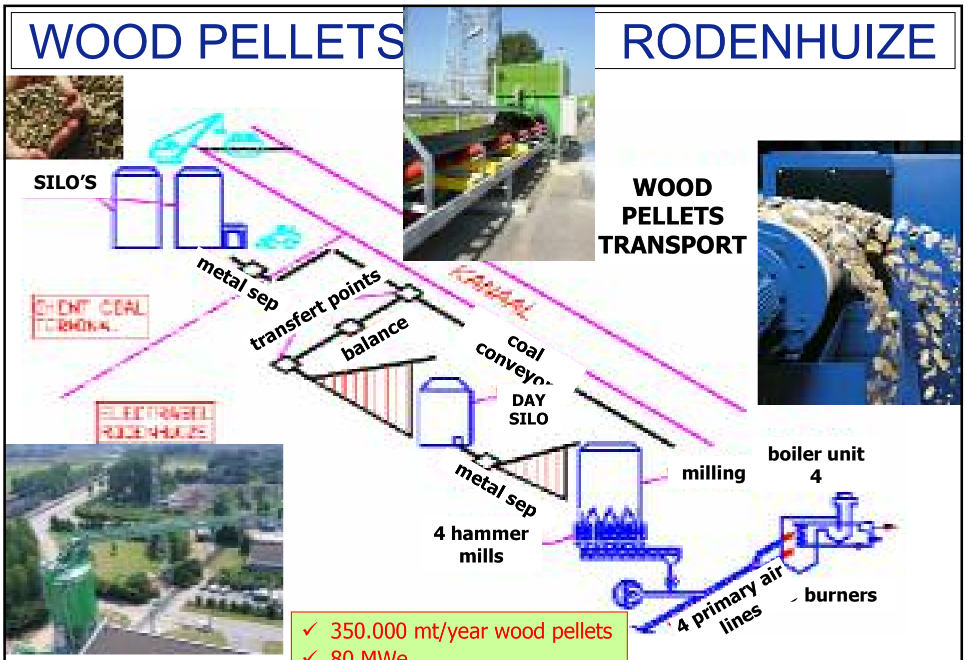
Ruien bio-power plant today



WOOD DUST IN LANGERLO

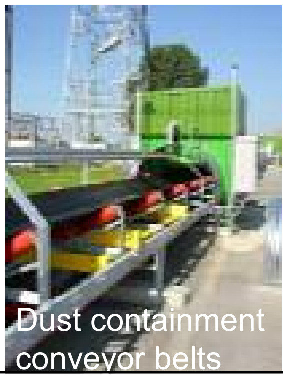


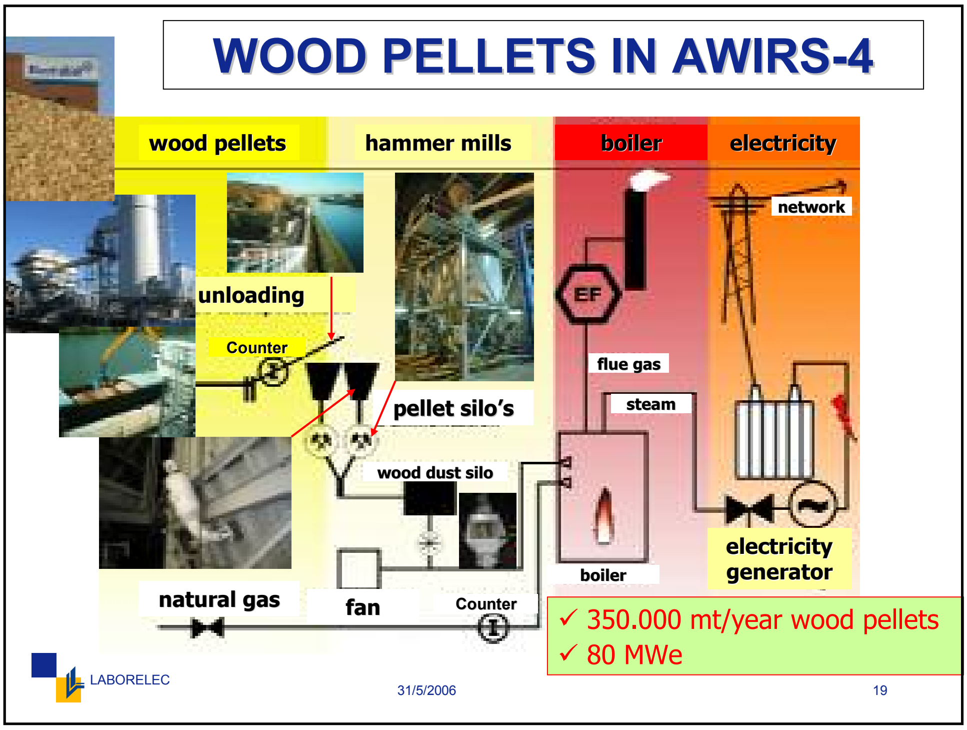
WOOD PELLETS RODENHUIZE



- ✓ 350.000 mt/year wood pellets
- ✓ 80 MWe

DESIGN RODENHUIZE 4





WOOD PELLETS IN AWIRS-4
wood pellets
hammer mills
boiler
electricity
network
unloading
Counter
EF
flue gas
steam
pellet silo's
wood dust silo
boiler
electricity generator
natural gas
fan
Counter
✓ 350.000 mt/year wood pellets
✓ 80 MWe
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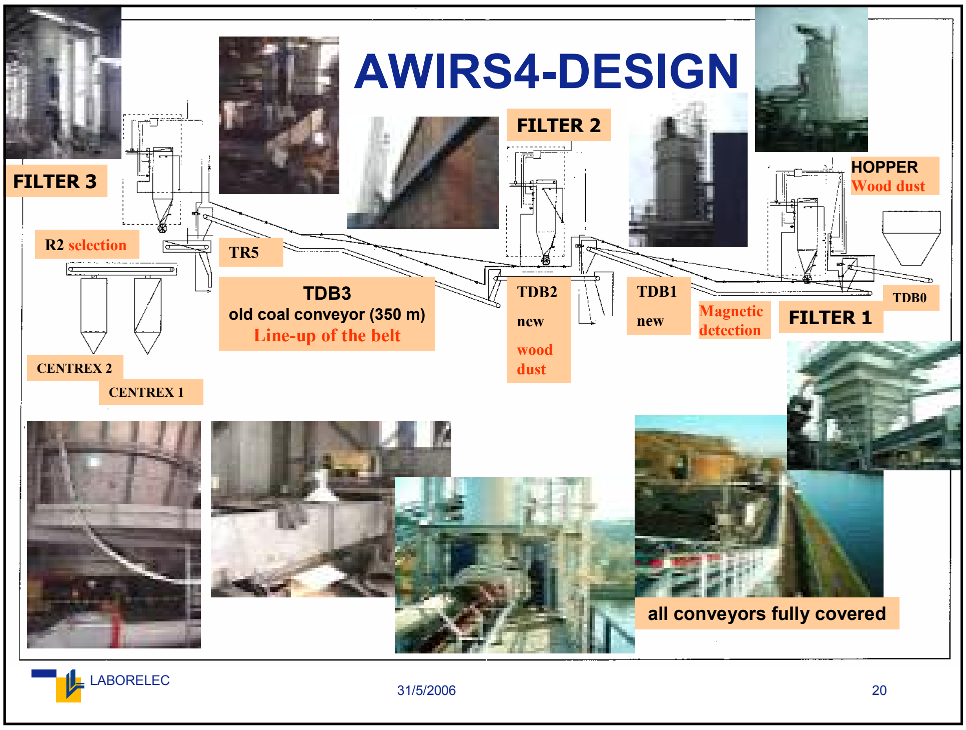

AWIRS4-DESIGN
FILTER 3
FILTER 2
HOPPER
Wood dust
R2 selection
TR5
TDB3
old coal conveyor (350 m)
Line-up of the belt
TDB2
new
wood
dust
TDB1
new
Magnetic
detection
FILTER 1
TDB0
CENTREX 2
CENTREX 1
all conveyors fully covered
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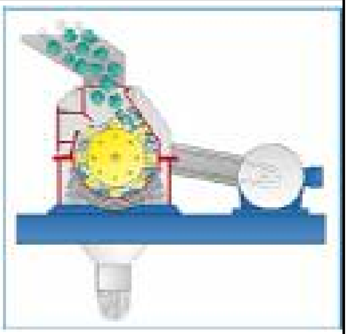
TECHNICAL ISSUES HAMMER MILLS



- Plugging of the sieves (holes of 2.5 mm)
- Wood dust bridging
- Hammer wearing
- Capacity linked to pellet quality
- Abrasion steel elements

Awirs 4

- 2 BVO mills
- 25 ton/h each
- 90% part. < 1.0 mm
- 1 mill ➔ 8 burners
- feed all burners

Rodenhuize 4

- 4 Sprout - Matador mills
- 10 ton/h each
- 99% part. < 1.5 mm
- 1 mill ➔ 2 burners
- feed middle burner row

Liquid bio-oils

Additional alternative liquid biofuels available :

- Palm oil
  - greatest potential available (Malaysia = 25 mil.ton/a)
  - not always produced on a sustainable base
  - cost 300 – 600 €/t
- Oils of coco, rapeseed, soya, sunflower
  - more expensive
- Recycled fry oil
  - cost 300 €/ton
  - potential limited
  - waste stream

INSTALLED CAPACITY WITH BIOMASS

2004 : 60 MW

- Ruien : wood dust ~ 8 MW
- Ruien : gasification of clean wood chips ~ 17 MW
- Langerlo, Rodenhuize, Ruien : olive cake ~ 31 MW
- Langerlo : sewage sludge ~ 4 MW

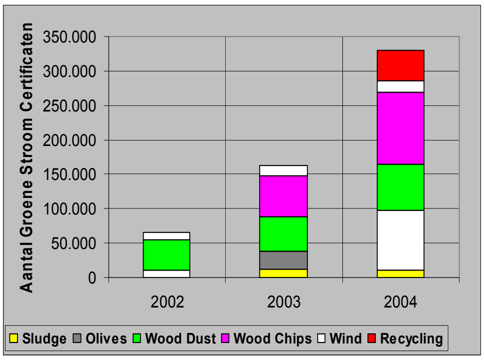
2005 : 246 MW

- Ruien wood dust ~ 10 MW
- Ruien : gasification of clean wood chips ~ 20 MW
- Langerlo : wood dust ~ 28 MW
- Langerlo, Rodenhuize, Ruien : olive cake ~ 34 MW
- Langerlo : sewage sludge ~ 4 MW
- Mol : coffee ground ~ 2 MW
- Awirs wood pellets ~ 80 MW
- Rodenhuize wood pellets ~ 66 MW

2007 : 261 MW

- Ruien wood pulverisation (Biostof) ~ 15 MW

EVOLUTION GREEN POWER ELECTRABEL



Biomass source	ton/a	Power plant	Capacity MW	GREEN Certificates	Avoided ton/y CO_2
2005	*402 000*	*biomass*	*246*	*610 000*	*611 000*
2006	*782 200*	*biomass*	*246*	*1 007 300*	*1 258 700*

MAIN DIFFICULTIES

- L : Logistics and organization (volume !)
- A : Administrative : stability of regulations ?
  - Operation license
  - Emissions regulations
  - Green Certification
- S : Supply : market growing, prices rise
- T : Technical : specific technical adaptations

➔ *Long delays = loss of opportunities…*

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Five reasons for you to choose Laborelec :

- You have one-stop shopping for your energy needs
- You get access to more than 40 years of experience
- You get rapid service with reliable solutions
- You increase the profitability of your installations
- You benefit from independent and confidential advice

LABORELEC

The technical Competence Center
in energy processes and energy use.
From R&D to operational assistance.

Annex 10. Wet bio-fuels - Aspects on furnace design and boiler operation

Niklas Berge

Wet biofuels –
aspects on furnace design and boiler operation

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Fuel properties

Moisture content 30 – 60 %
Ash content (dry base) 0,3 – 6
Lower calorific value (a.r.) 6 – 14 MJ/kg
Adiabatic temperature 1050 – 1450ºC
Volatile content (dry base) 70 – 85 %

National and EU emissions restrictions

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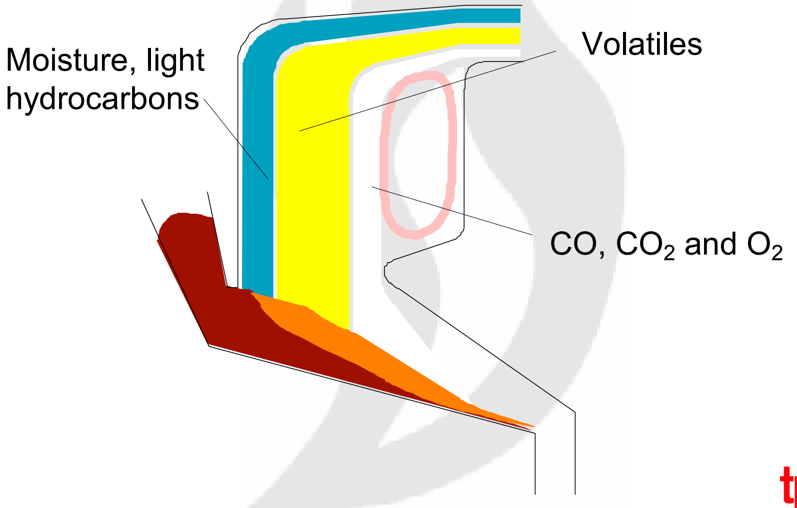
Fluid dynamics

Streams formed in a grate fired or FB boiler



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Actions

The topics has been under continues research and methods development in the “TPS Multi Client Research Programme for District Heating Utilities”

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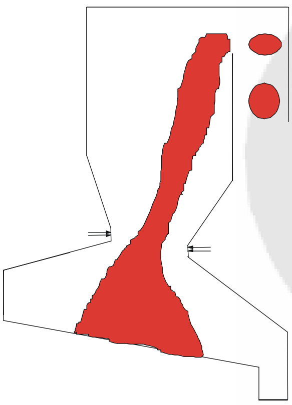
Research program organisation

Steering comity

- Gratefiring
- FB-combustors
- Burners
- Complementary R&D

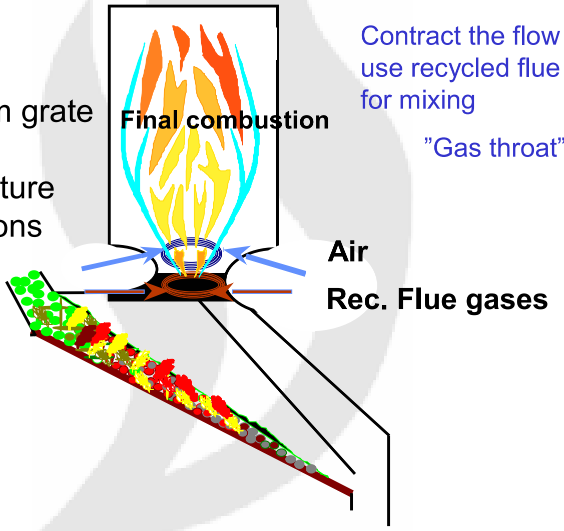


Bad penetration of secondary air

Uncontrolled recirculation zones

Freeboard of furnace

Mixing gases from grate
Even air supply
Maintain temperature
Control of emissions
Fuel flexibility
Low O_2



Contract the flow and use recycled flue gas for mixing

"Gas throat"

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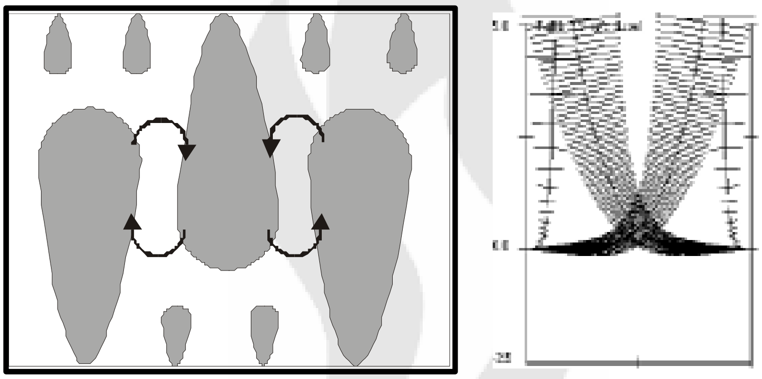
Freeboard of furnace



Staggered nozzles for secondary air and flue gas recirculation

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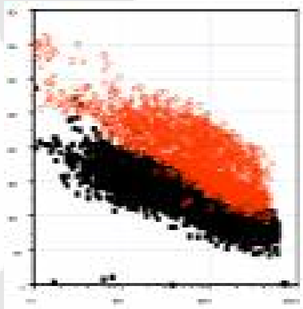
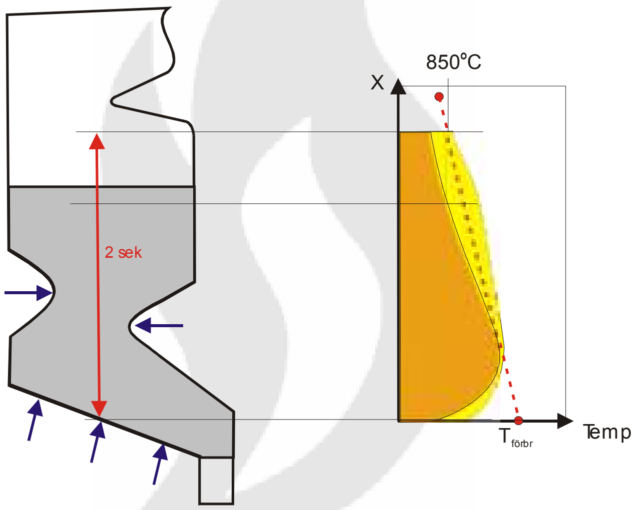
Staggered nozzles

Improved control of CO and NOx



Simple retrofit in existing boilers

Reducing heat transfer to improve fuel flexibility



Control off the primary combustion on the grate

- Optimise the drying of the biofuel
- Fast and stable ignition control of the fuel bed
- Controlled burn out of the bottom ash

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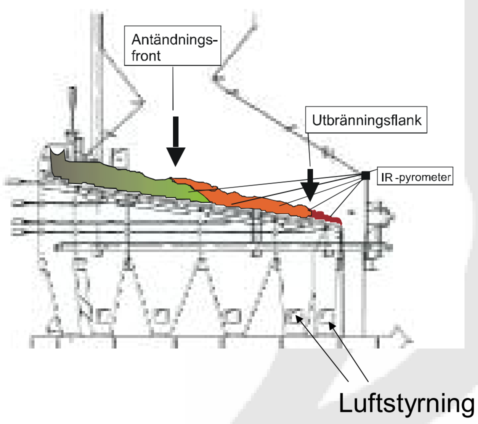
Control of burn-out with IR-detection



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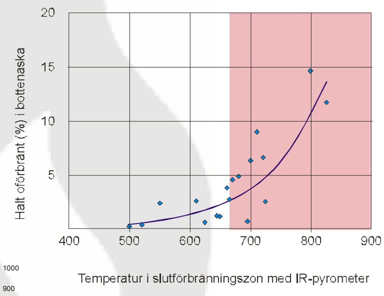
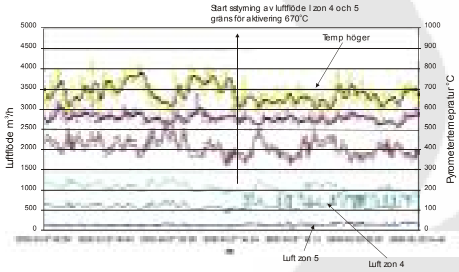
Control of burn-out with IR-detection

Content of unburnt in bottom ash vs. surface temperature





Burn-out controlled by primary air flow in late grate zone

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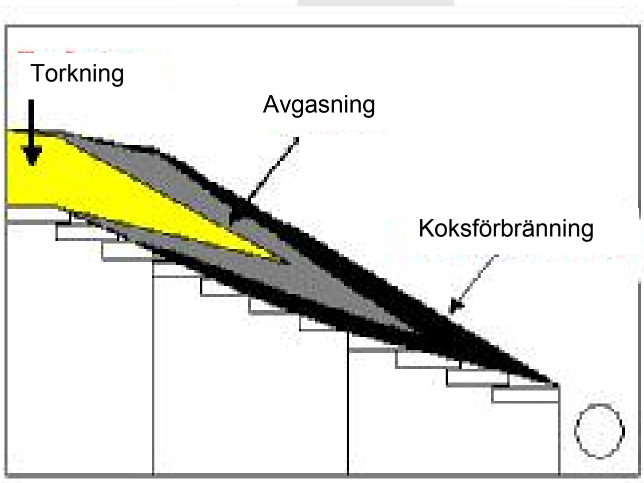
Two front combustion



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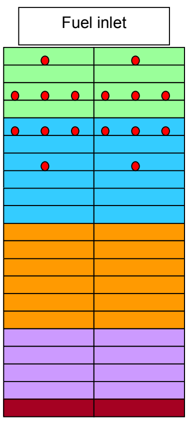
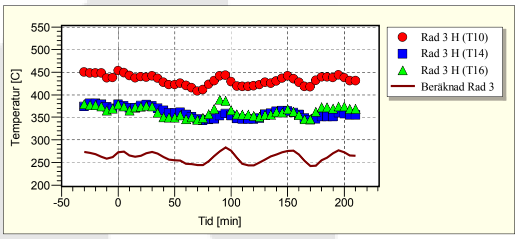
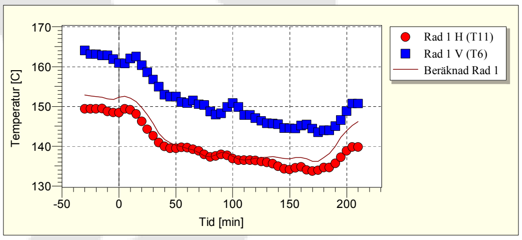
Measuring the grate rod temperature

Temperature measured with thermocouples close to the surface of the grate rod.

Measuring the grate rod temperature

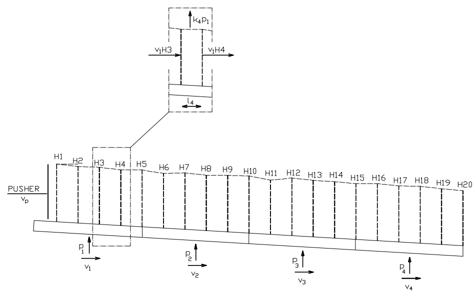






High temperatures already in the “drying zone”

TPS dynamic grate model



•The model predicts grate and bed temperature, height and oxygen concentration

•Heat transfer in the grate rods

•Dynamic of the bed at changes in the input conditions

•Simulates both top, bottom and mixed ignition of the bed

Conclusions bed model

- Combustion near the grate often starts already within 1 m from the fuel inlet
- Temperature indication and control can be used to control the distribution of primary air and early indication of changes in moisture content
- Grate rod temperature is affected by a complex relation of several parameters
- Model can be used to compute temperature variations

Conclusions

To achieve good fuel flexibility in a boiler it is necessary to have:

- Good measurements of temperature in both primary and secondary combustion zones
- Control of the aerodynamics of the freeboard combustion
- Good control of input parameters such as air and recycled flue gas distribution
- Heat transfer properties of boiler for worst possible case with recycled flue gas for controlling temperature
- Control of air supply to grate and temperature distribution
- Individual control of ash burn out
- Good understanding of effect of and interaction between control parameters

Annex 11. Summary and conclusions
Claes Tullin

Discussion & Conclusions

SP Swedish National Testing and Research Institute

- Market issues
- Fuel characterisation and standardisation
- Fuel preparation
- Fuel quality and deposit formation/emissions
- Boiler design

”Fuel Flexibility in Biomass Combustion - The Key to Low Bioenergy Costs?”

In summary ….

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Yes!

- Increased fuel flexibility gives advantages on the market

But…

- Higher costs for operation and maintenance

Requirements:

- Technology
- Competence (knowledge and/or experience)

Market Issues

"Fuel Flexibility in Biomass Combustion

- The Key to Low Bioenergy Costs?"

Yes!	But….
• Bioenergy market increases!! • Competition for fuels increase •"Conventional" fuels limited • Closed loops: Waste => Fuel (legislation important) • Energy crops/fast growing tree plantations • Many fuels attractive in co-firing	• Competence to use "difficult to burn"/new fuels limited" • Technical development necessary (small and large scale; dedicated combustion or co-firing) • Fuel quality very varying • Minor fractions • Unsecure availability • "Disturbances" (taxes, directives, …)

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Fuel characterisation and standardisation

"Fuel Flexibility in Biomass Combustion

- The Key to Low Bioenergy Costs?"

Yes!	But….
• Extensive on-going efforts in developing relevant biomass fuel characterisation methods for sampling and analysis	• Methods not yet available •Some fuel fractions very hard to characterise • Fuel fractions can be very heterogeneous

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Fuel Preparation

"Fuel Flexibility in Biomass Combustion
- The Key to Low Bioenergy Costs?"

Yes!	But….
• Market driven fuel development of the fuel preparation process • Good fuel preparation => better combustion performance • Increased sorting of waste => improved possibilities	• Some fuel fractions very difficult to handle • Costs can be high • Technical development required (on-line analysis, ..)

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Fuel Quality and Deposit Formation/emissions

"Fuel Flexibility in Biomass Combustion
- The Key to Low Bioenergy Costs?"

Yes!	But….
• Increasing competence on mechanisms, new materials etc • Technical solutions to reduce problems available • Significant experience avalilable from "learn by doing"	• Higher steam data => more problems! • Improved scientific knowledge on ash chemistry required

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Boiler Design

"Fuel Flexibility in Biomass Combustion
- The Key to Low Bioenergy Costs?"

Yes!	But….
• Extensive experience gathered from commercial scale operation – Dedicated biomass – Co-firing	• Design criteria has to be considered

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