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Energy research Centre of the Netherlands

Biomass co-firing
with the focus on the experience in the Netherlands

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ECN Biomass, Coal and Environmental research

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Presentation overview

- Brief introduction to ECN
- State-of-the-art biomass co-firing
  - Options
  - Co-firing activities in the Netherlands
  - Biomass co-firing vs total renewables in the Netherlands
- Biomass co-firing in high percentages
  - Technical bottlenecks
  - R&D needs and exemplified results
- Conclusions

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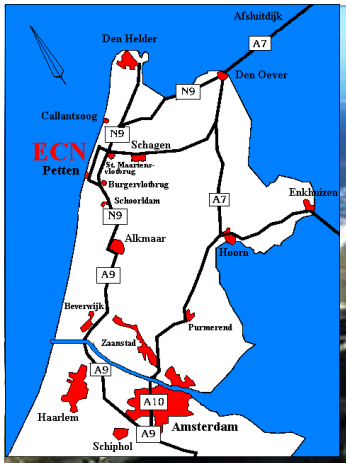


ECN develops high level knowledge and technology for a sustainable energy system and transfers it to the market

Independent (non-profit) research institute

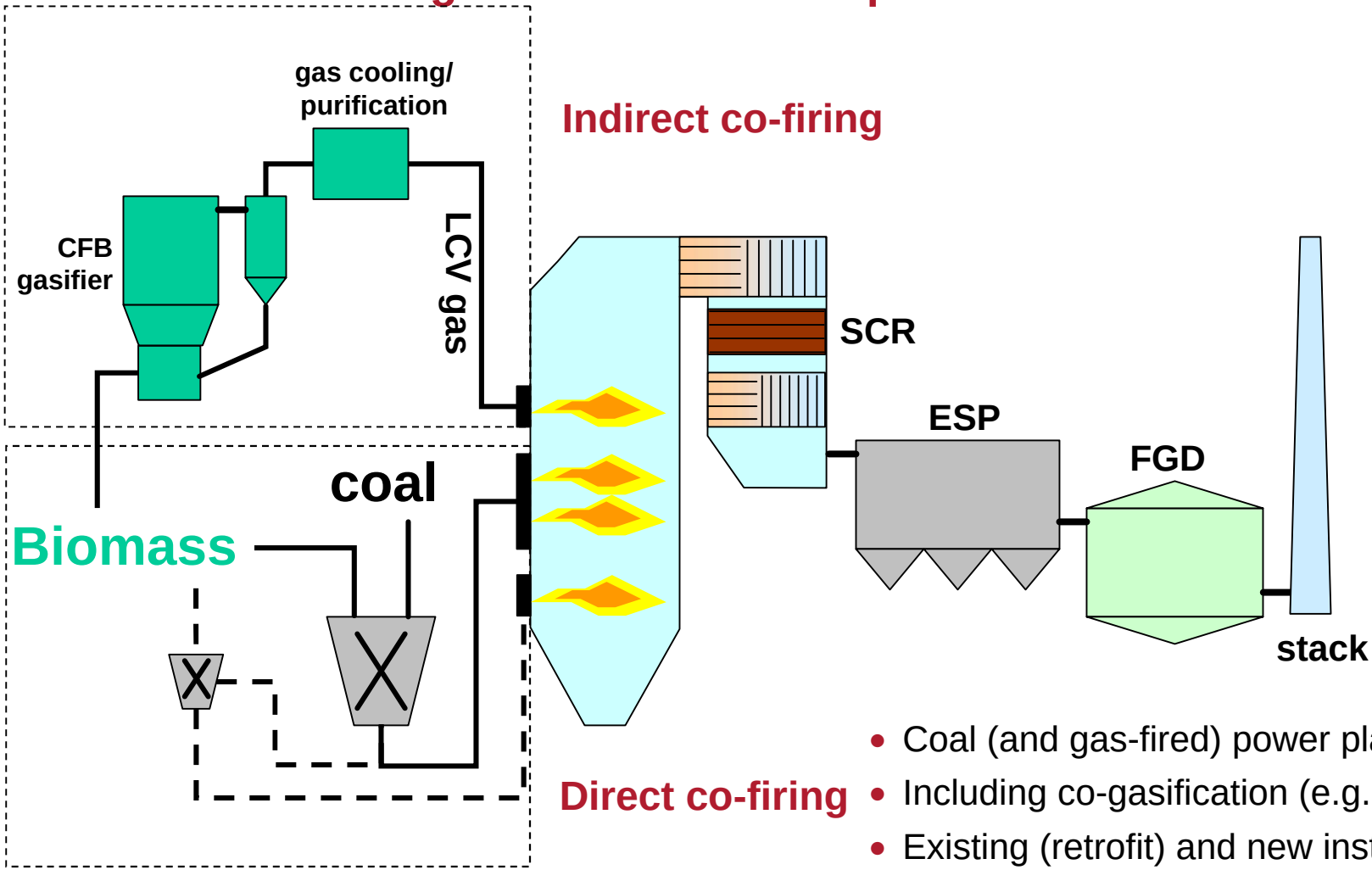
650 employees

Annual turn-over:
90 million Euro

Activities:

- Biomass, Solar, Wind
- Clean fossil fuels (CCS, fuel cells)
- Energy efficiency
- Policy studies

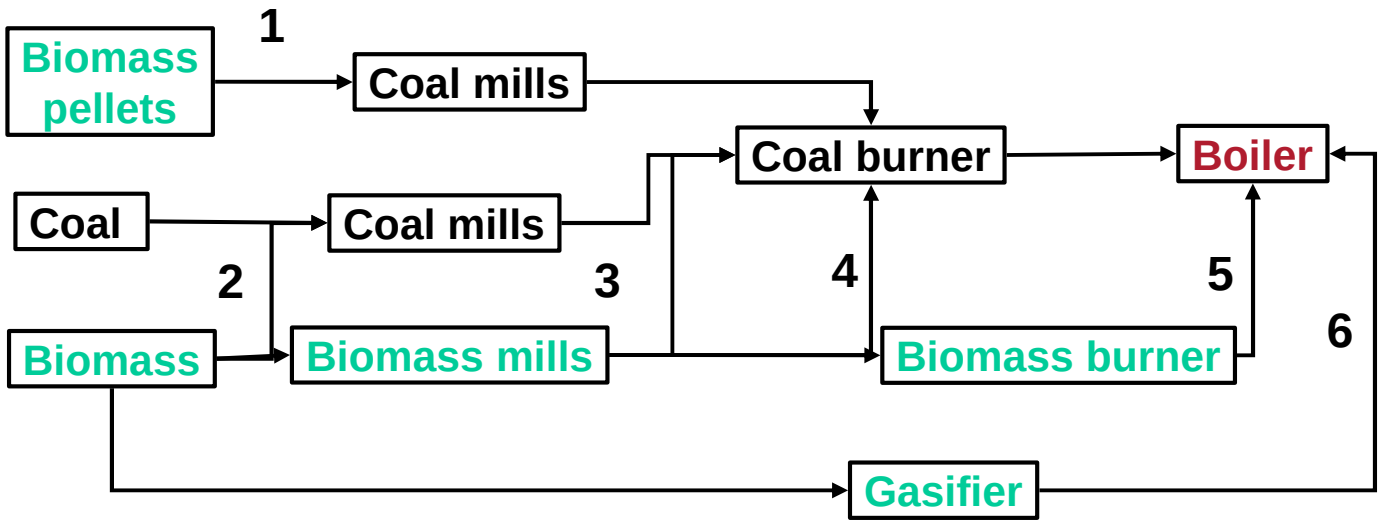
Biomass Co-firing – state-of-the-art options



- Coal (and gas-fired) power plants
- Including co-gasification (e.g. IGCC)
- Existing (retrofit) and new installations

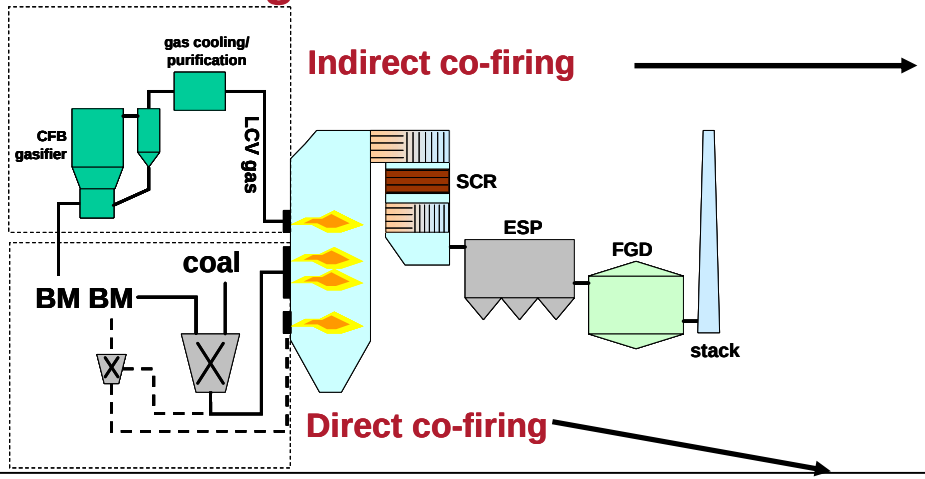
Biomass Co-firing – details of the state-of-the-art options

after W. Livingston, Doosan-Babcock / IEA Task 32 Hamburg 2009 workshop



1. The milling of biomass pellets through modified coal mills
2. The pre-mixing of the biomass with the coal and the milling and firing of the premixed fuel through the existing coal firing system
3. The direct injection of pre-milled biomass into the pulverised coal pipework
4. The direct injection of pre-milled biomass into modified coal burners
5. The direct injection of the pre-milled biomass through dedicated biomass burners or directly into the furnace
6. The gasification of the biomass, with combustion of the producer gas in the boiler

Co-firing activities in the Netherlands



Essent Amer wood gasifier

Essent Amer

EPZ Borssele 12

E.On BeNeLux Maasvlakte

Electrabel Gelderland

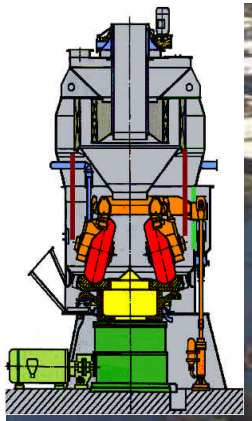
NUON Buggenum (IGCC)

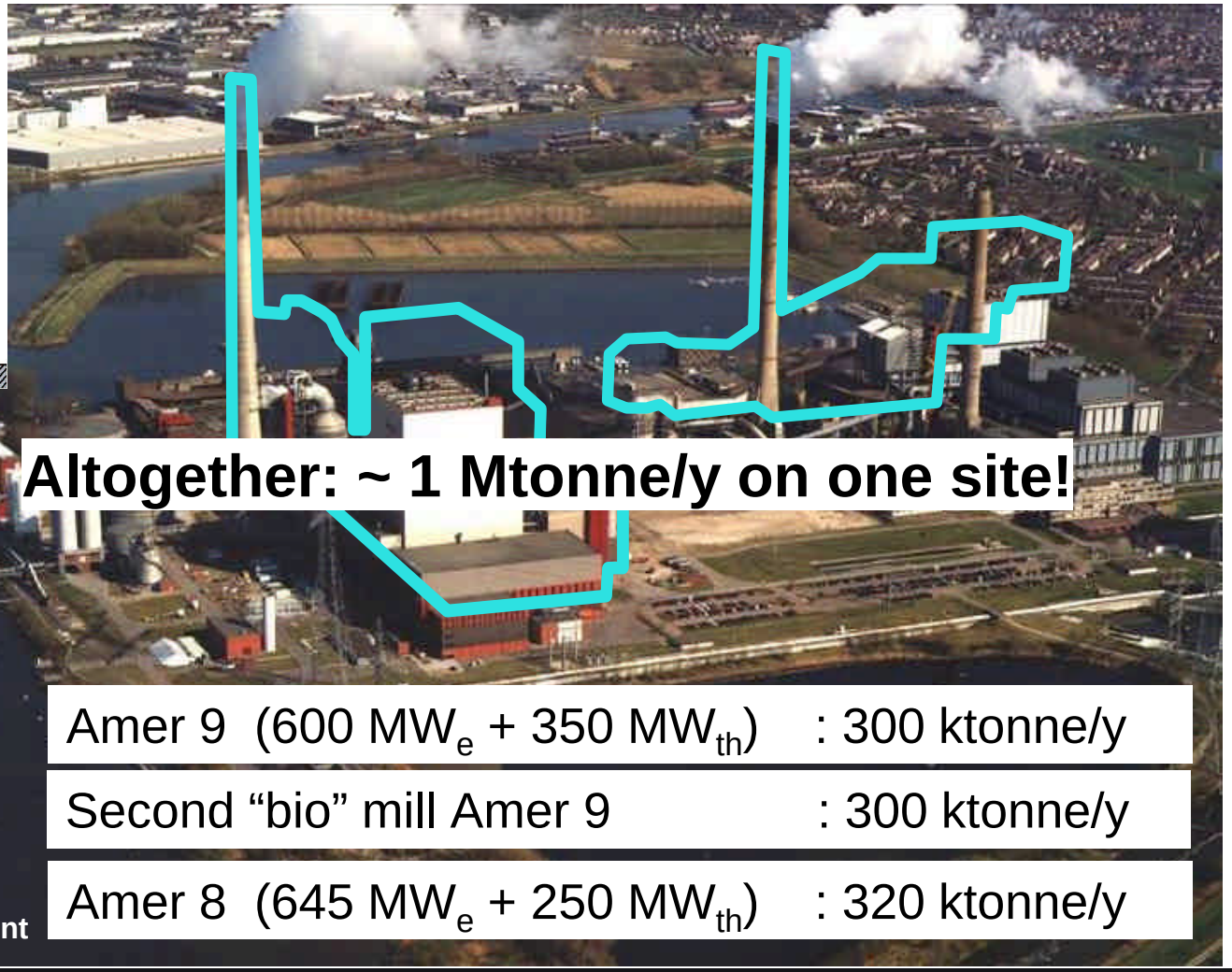
Co-firing activities in the Netherlands

Current co-firing status:

- **All co-firing options in use, but each producer has clear preferences**
- **Co-firing % ~20 % w/w, but many trials at ~30-40 % w/w**
- **Even > 50 % w/w tests scheduled (600+ MWe scale)**
- **Most producers aim at 20-25 % e/e**
- **Popular fuels:**
  - **All producers: clean wood**
  - **Essent Amer: certified, sustainable food-processing industry residues (i.e. coffee-husks in co-operation with Solidaridad fair trade)**
  - **E.On Maasvlakte: MBM and SRS animal fat, “biomass pellets”**
  - **EPZ Borssele: cocoa residue, palm kernel (PKS), citrus pulp**
  - **Electrabel Gelderland: agro- and food-processing residues**
  - **Nuon Buggenum (IGCC): clean wood**
- **Niche fuels:**
  - **E.On Maasvlakte and Nuon Buggenum (IGCC): sewage sludge**
  - **Essent: demolition wood (via gasification) and bark pellets**

Direct biomass co-firing at Essent Amer power station





Altogether: ~ 1 Mtonne/y on one site!

Amer 9 (600 MW_e + 350 MW_{th})	: 300 ktonne/y
Second “bio” mill Amer 9	: 300 ktonne/y
Amer 8 (645 MW_e + 250 MW_{th})	: 320 ktonne/y

Source: Essent

Wood pellets

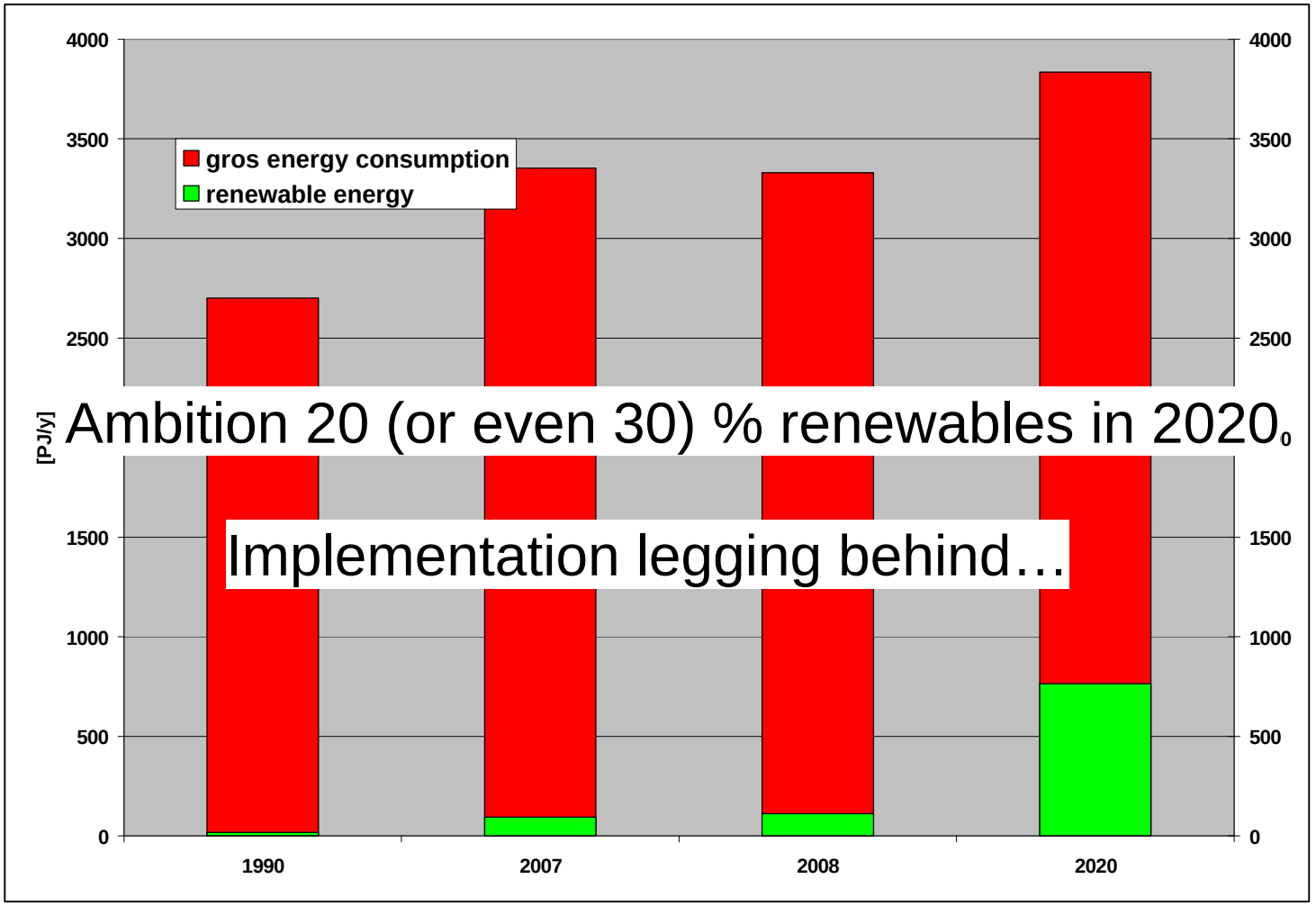
Citrus pellets

Palm kernel chips

Olive residu

Indirect biomass co-firing at Essent Amer power station

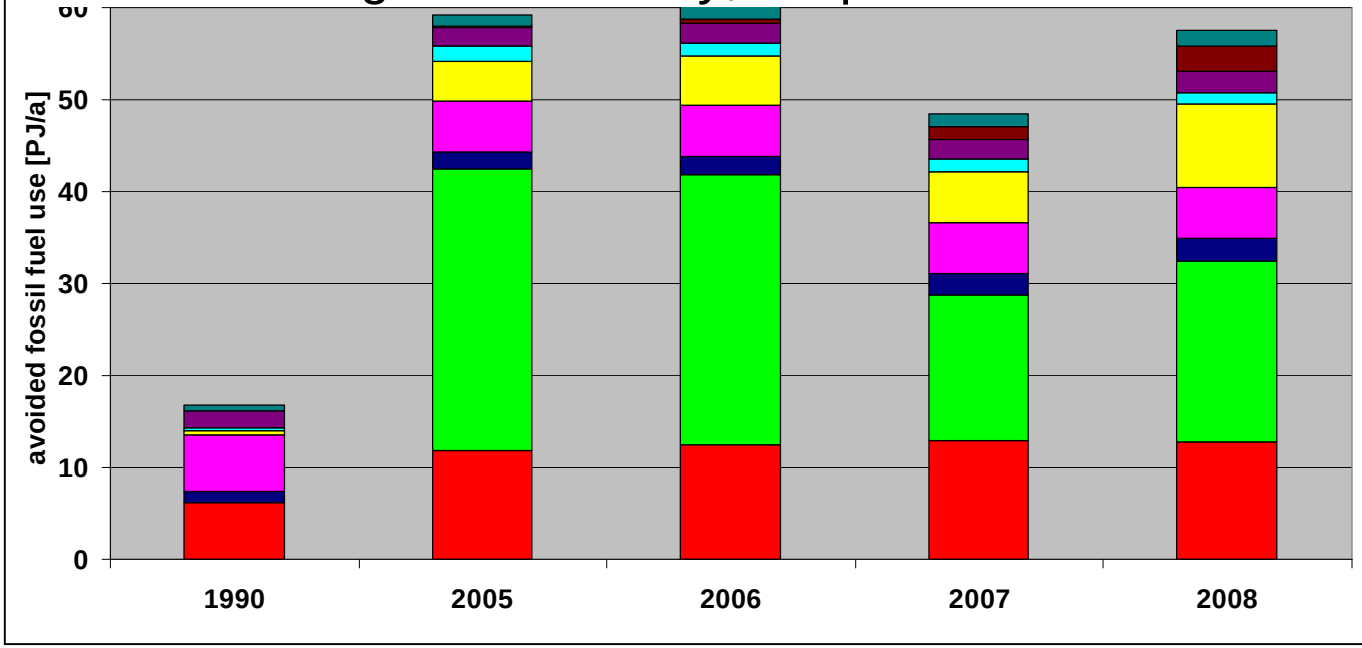
Renewables in the Netherlands – current data vs ambitions



Renewables in the Netherlands – biomass contribution

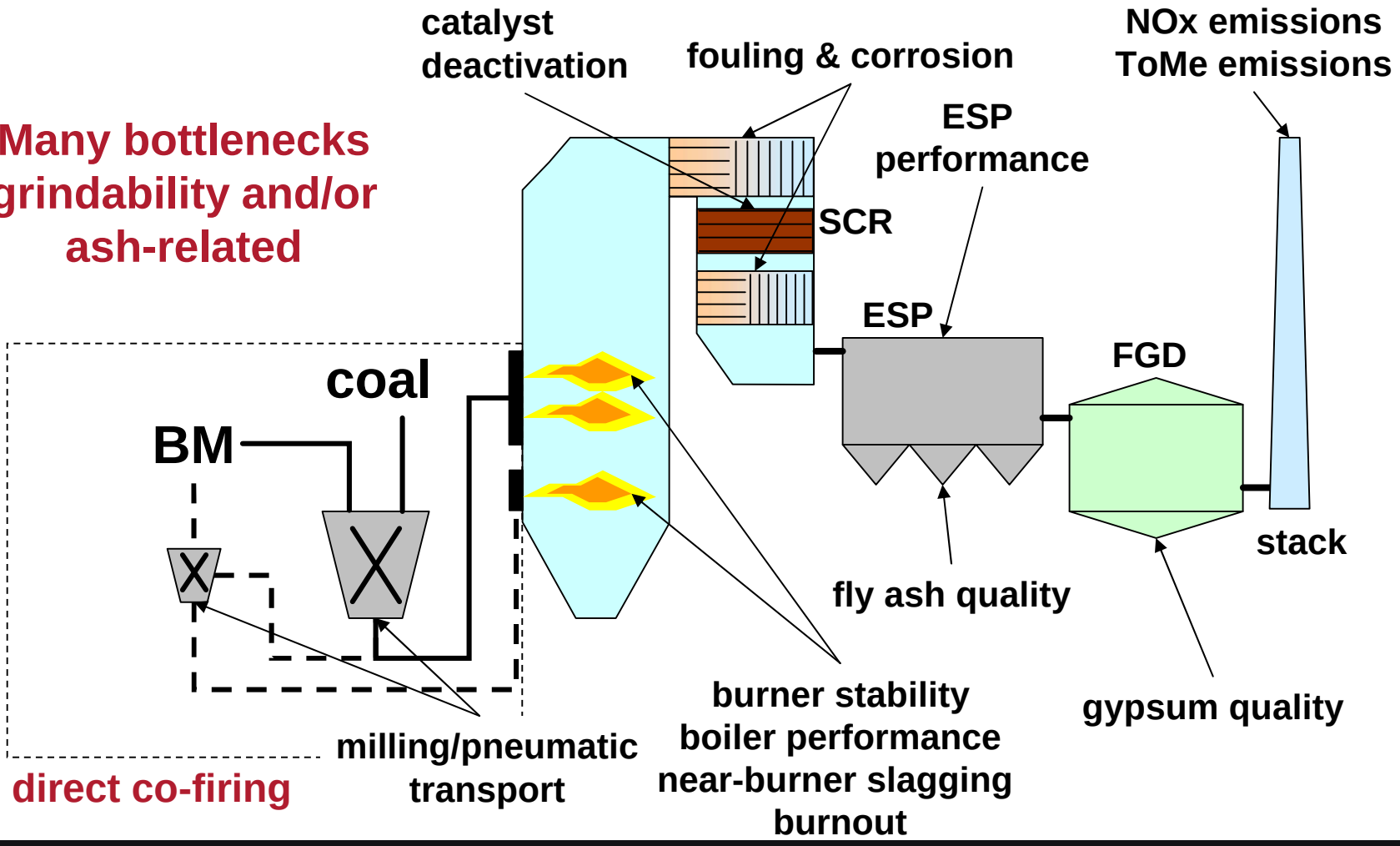
Approximately 60 % total renewable from biomass!

- Large decrease in co-firing in 2007:
  - cancelled feed-in tariffs for (palm) oil
  - tight clean wood pellets market
  - delay in development of new subsidy system
- 2008: clear signs of recovery, despite lowered subsidies



Technical bottlenecks in biomass co-firing

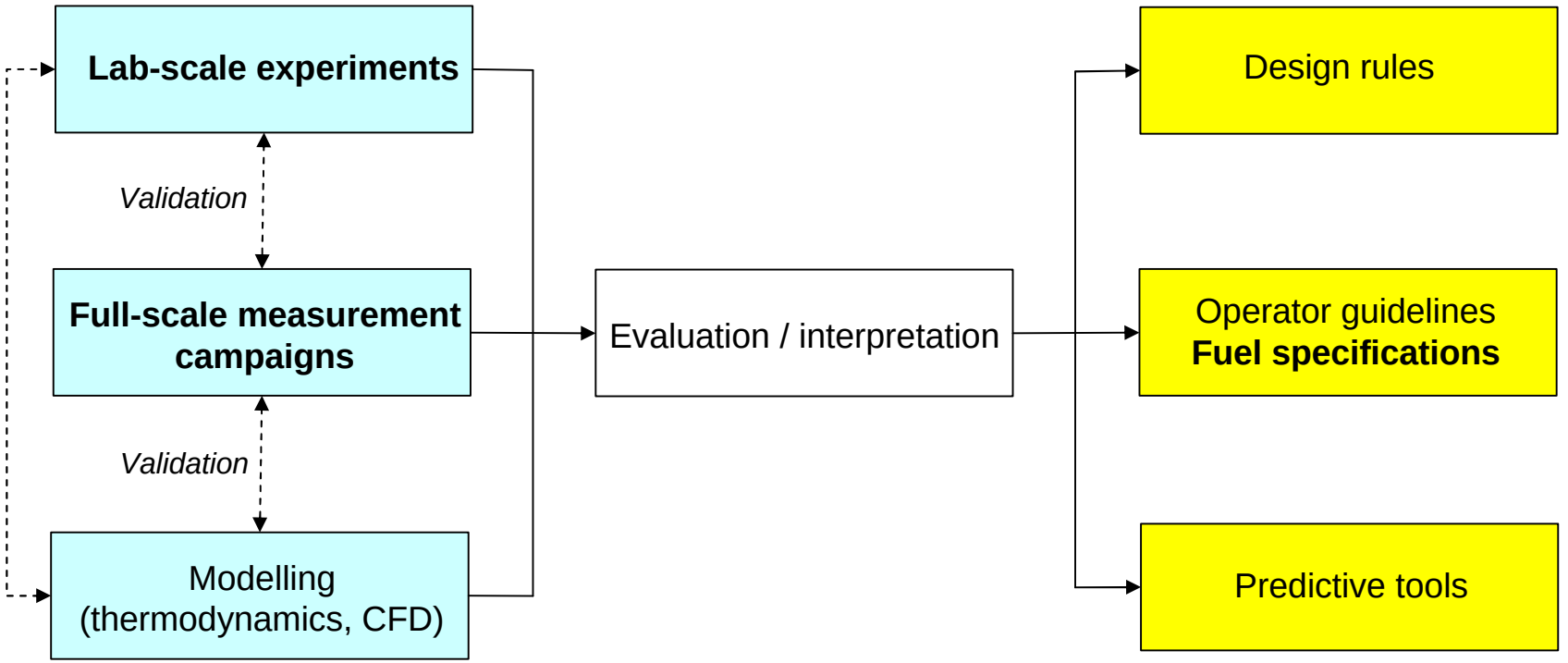
Many bottlenecks grindability and/or ash-related



R&D needs - biomass co-firing in high percentages

- Biomass upgrading technology to reduce the cost of biomass logistics and improve the compatibility of biomass as a fuel
- Better mechanistic understanding of combustion/gasification-related technical bottlenecks and translation into fuel mixing recipes, design specifications and operating guidelines
- Predictive tools for assessing the co-firing potential of biomass streams and optimising boiler design and operation for co-firing (low-cost screening, modelling)
- Biomass co-firing and future boiler designs (i.e. USC)
- Advanced techniques for (on-line) process monitoring and control
- (Ash recycling strategies and) utilisation options

De-bottlenecking – R&D approach



Lab-scale experiments and modelling allow investigations beyond current full-scale practice (higher co-firing percentages, higher steam conditions, oxy-fuel combustion)

De-bottlenecking – torrefaction for improved fuel specs

Woody biomass **Agricultural residues**

Friable and less fibrous
19 - 22 MJ/kg (LHV, ar)
Hydrophobic
Preserved
Homogeneous

Superior fuel properties:
- Transport, handling, storage
- Milling, feeding
- Gasification, combustion
- Feedstock range
- Standardisation

Torrefaction

tonne-scale batches of materials available from the ECN torrefaction pilot-scale plant

Mixed waste

Tenacious and fibrous
10 - 17 MJ/kg (LHV, ar)
Hydrophilic
Vulnerable to biodegradation
Heterogeneous

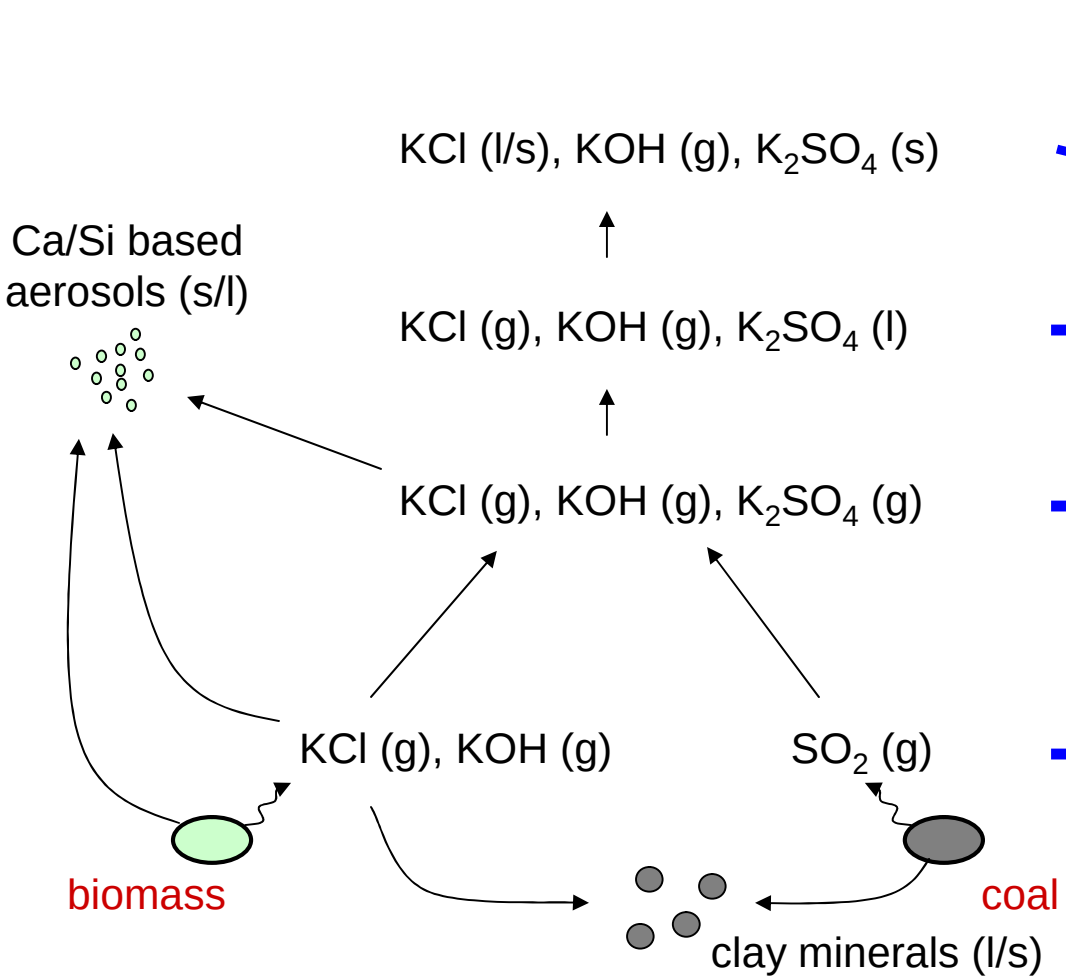
Fuel powder

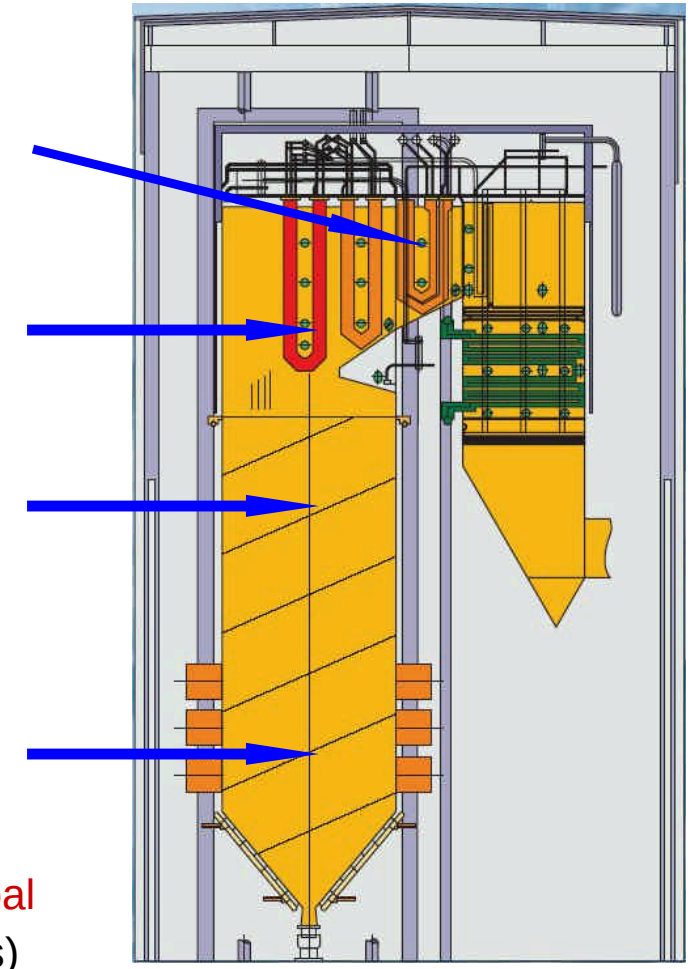
Pelletisation

Bulk density 700-800 kg/m^3
Bulk energy density 13-17 GJ/m^3

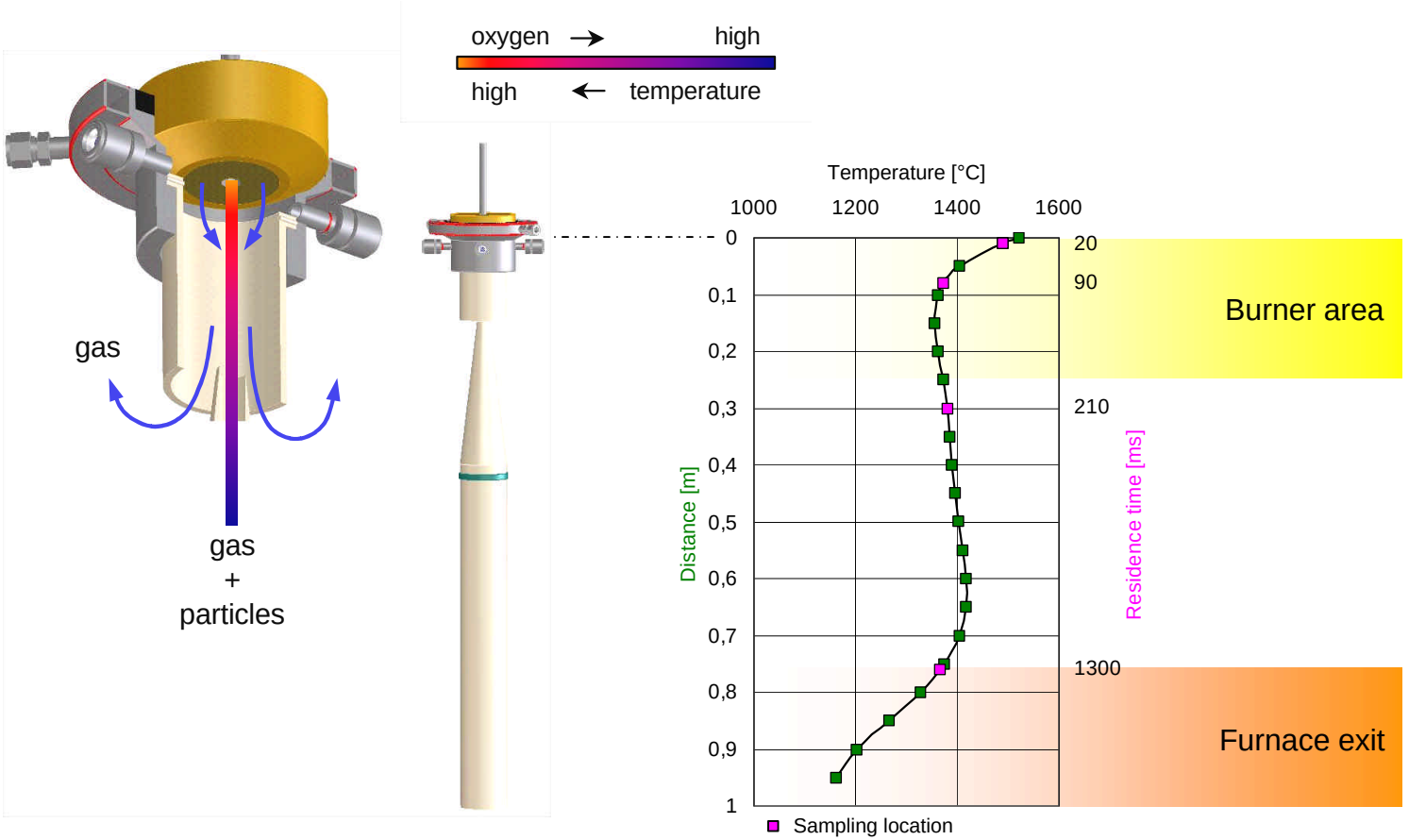
Fuel pellets

De-bottlenecking - example of fuel interactions



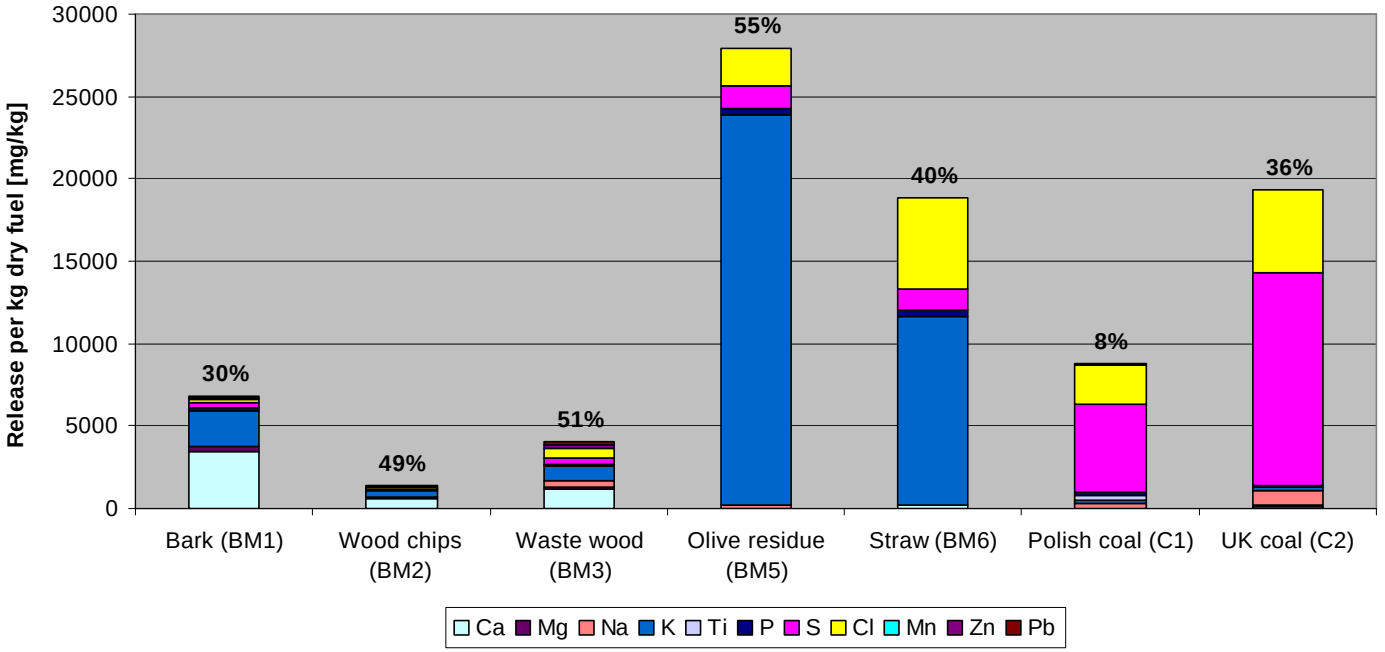


De-bottlenecking tools - Lab-scale Combustion Simulator



Realistic gas temperature and gas composition profiles, sampling 5-2500 ms

De-bottlenecking - ash/minerals release for various fuels



Release biomass very different from coal:

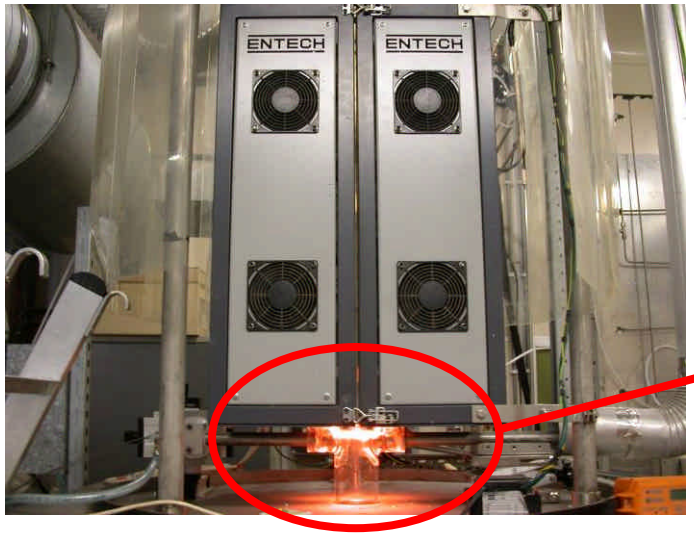
- total release biomass 30-55% (incl. S and Cl)
- total release coal 0.3-2.6% (excl. S and Cl) or 8-36% (incl. S and Cl)

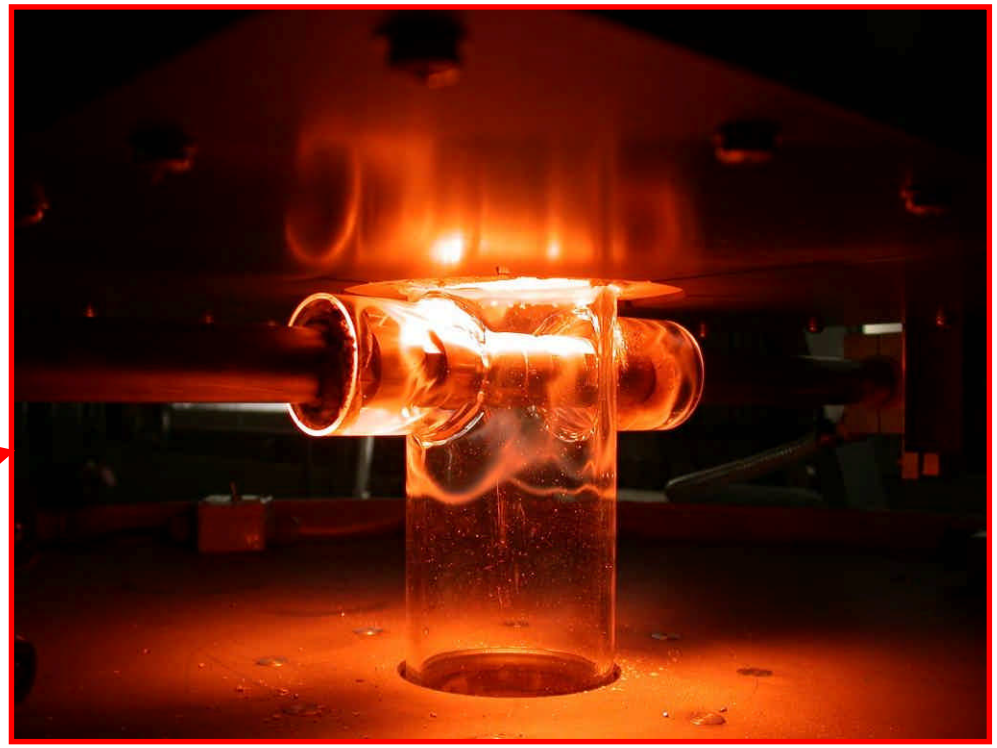
De-bottlenecking tools – lab-scale Horizontal Deposit Probe

Developed in co-operation with Hukseflux (subsidiary of Clyde Bergemann)

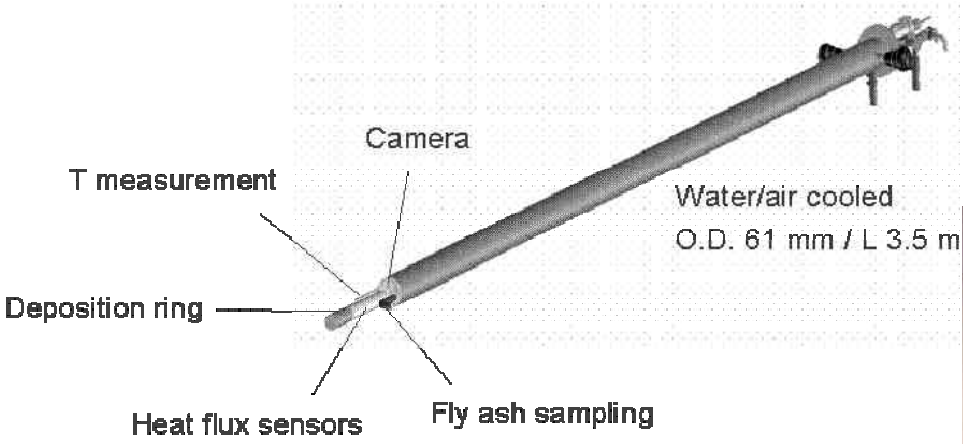
Functionalities:

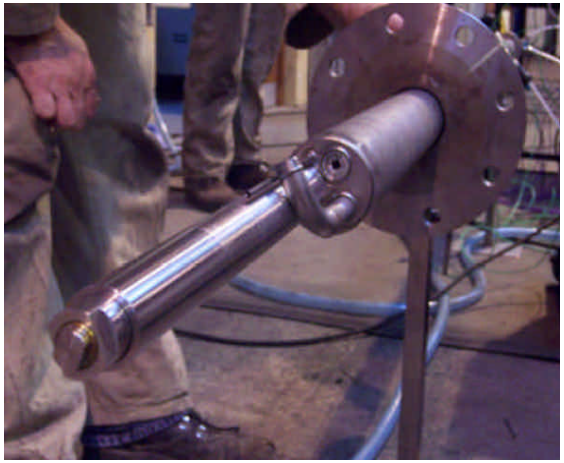
- Deposit composition
- Deposit influence on heat transfer
  - $700 < T_{gas} < 1300$ °C
  - $300 < T_{surface} < 750$ °C





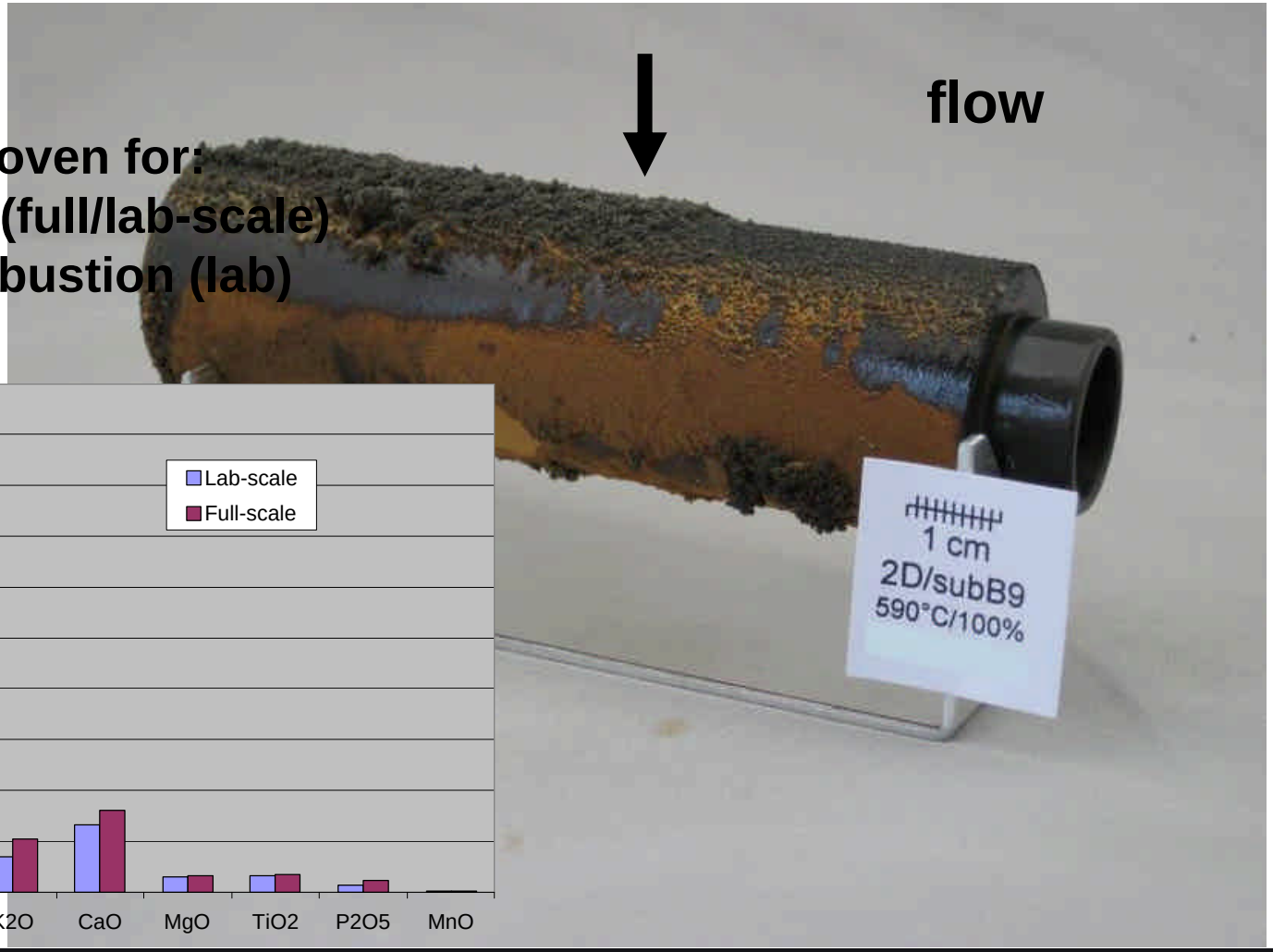
De-bottlenecking tools - full-scale mobile deposition probe





De-bottlenecking – Full/lab-scale slagging/fouling tests

Approach also proven for:
- USC conditions (full/lab-scale)
- oxyfuel BM combustion (lab)



Conclusions

- Biomass co-firing is an established technology for co-firing percentages up to 10-20% (e/e)
- Biomass co-firing at high percentages (30-50% e/e) is feasible, but needs/highly benefits from:
  - Innovative biomass upgrading technologies
  - Better mechanistic understanding of technical bottlenecks
  - Better predictive and diagnostic tools
  - On-line monitoring and control (e.g. fouling, corrosion)
- Torrefaction allows for a cost-effective, high-efficiency production of commodity biomass fuels with superior grindability and conversion properties.
- Many technical bottlenecks in biomass co-firing are ash related. Main mechanisms of ash formation and ash behaviour have been mapped. R&D focus now on quantification and incorporation of mechanistic knowledge in predictive tools.
- Combination of predictive tools and on-line monitoring is key to successful management of ash behaviour, particularly for new boiler designs.
- New challenges in biomass co-firing include sustainability, heat utilisation, lower quality ("salty") biomass, wet biomass.

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Thank you for your attention!

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