Challenges in biomass combustion and cofiring: the work of IEA Bioenergy Task 32

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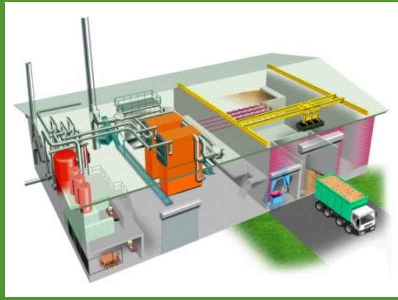
- Introduction
- Challenges and trends in combustion technologies
  - Residential heating
  - Industrial scale combustion
  - Co-firing
- Activities of Task 32

Introduction (2)

- **Biomass Combustion is the most widely spread way of converting biomass to energy :**

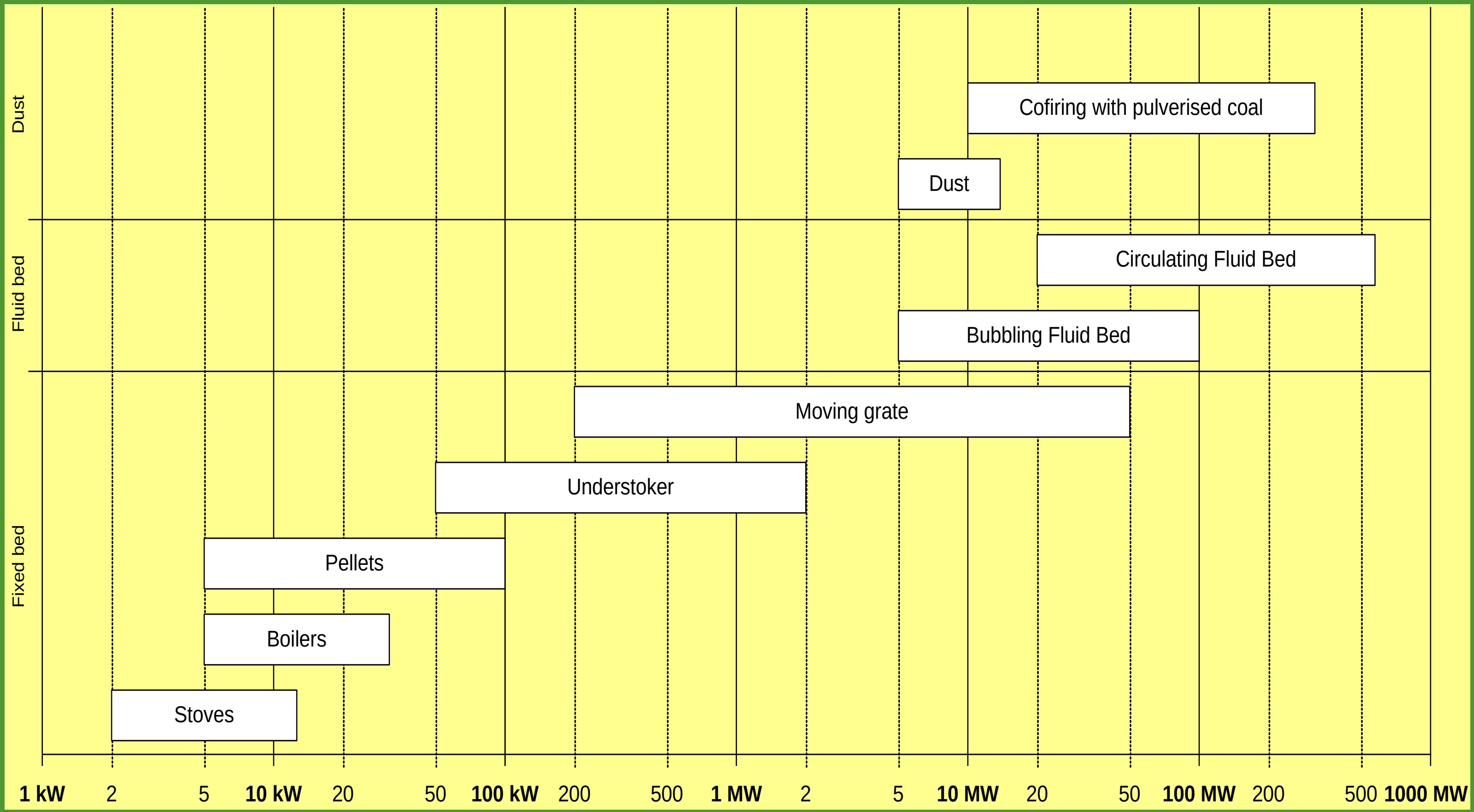
	World	OECD	Developing countries
Traditional biomass [PJ/year]	33,500	40	33,450
Modern biomass [PJ/year]	16,600	8,450	7,450
Total biomass [%]	**11**	3.6	**22.3**

Derived from IEA Energy Outlook statistics



- **Top 10 of EU manufacturers alone: 600 M€ turnover [**EurObserver 2007]

Modern biomass technology is commercially available from 2 kW_{th} to 550 MW_{th}



Rationale of Task 32

- **Biomass combustion is well understood, relatively straightforward, and commercially available, and can be regarded as a proven technology**

- **However, the desire to burn uncommon fuels, improve efficiencies, cut costs, and decrease emission levels results in new technologies being developed**

IEA Bioenergy Task 32: Biomass Combustion and Co-firing

- **Experts from 13 countries:**
  Austria, Belgium, Canada, Denmark, European Commission, Finland, Germany, Italy, Netherlands, Norway, Sweden, Switzerland, United Kingdom

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

- **Reports etc. can be found on our website:**
  www.ieabioenergytask32.com

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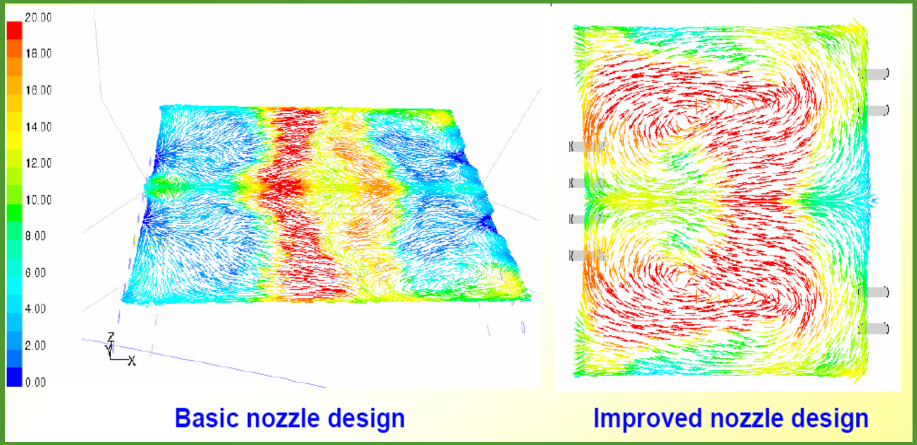
Trends in domestic woodstoves and boilers

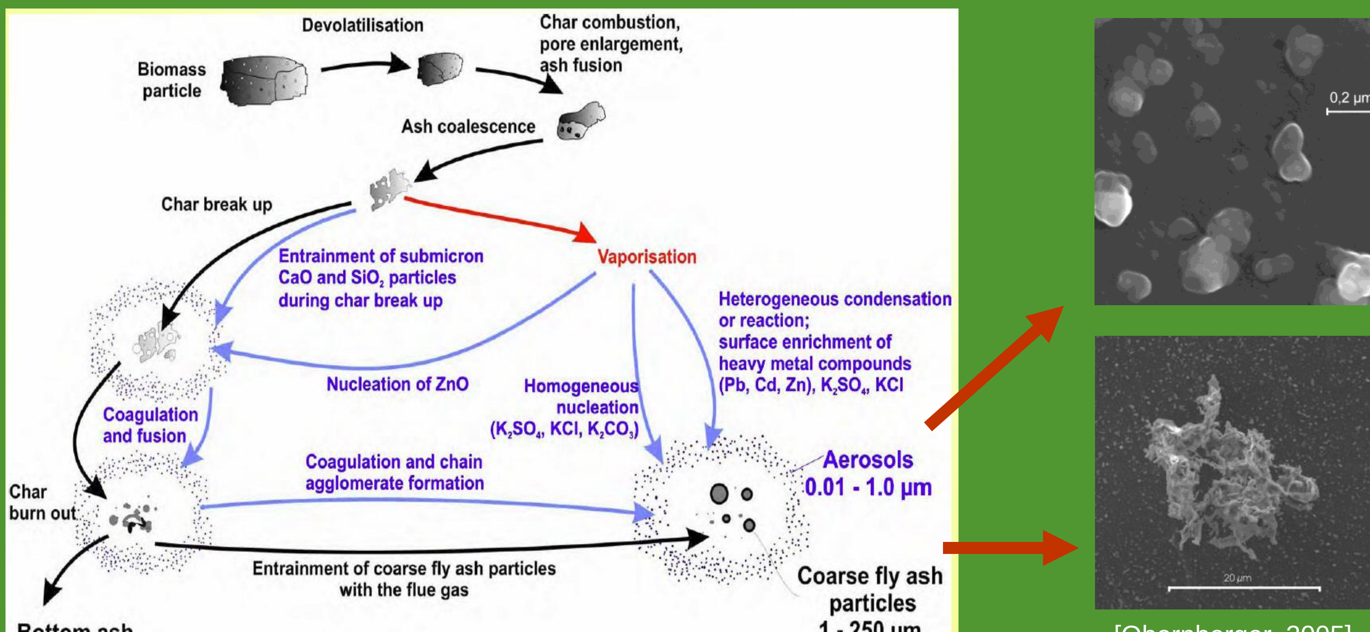
- Customers want fancy design
- Use of pellets for heating
- Emissions need to go down



[Thek, 2005]

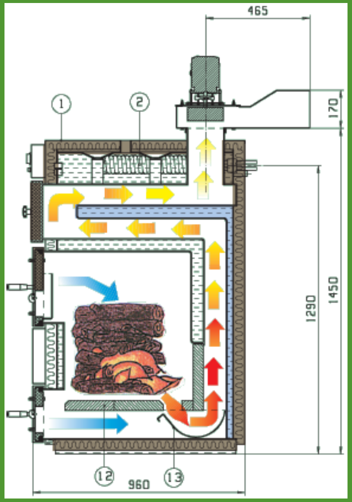
Particle emissions

- Emission of aerosols is of **major concern** (health)
- In some areas emission of aerosols from biomass combustion equals the emission from traffic



[Obernberger, 2005]

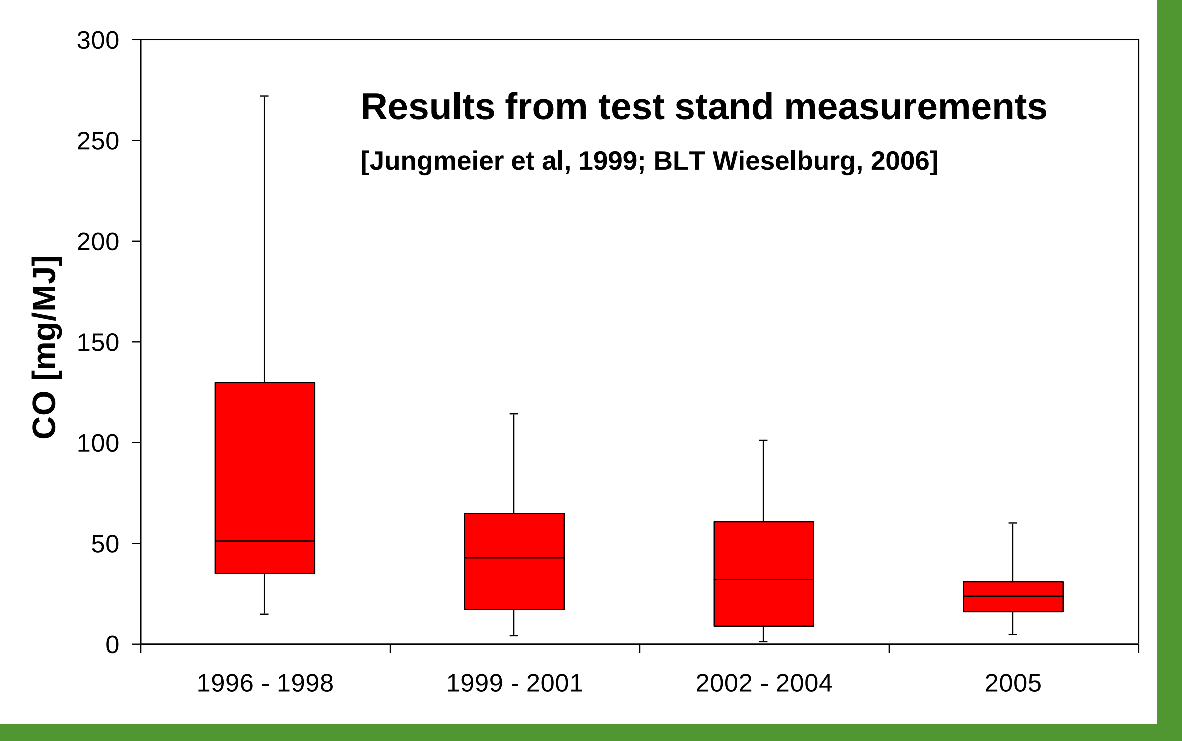
What can be done to obtain better efficiency and reduced emissions?



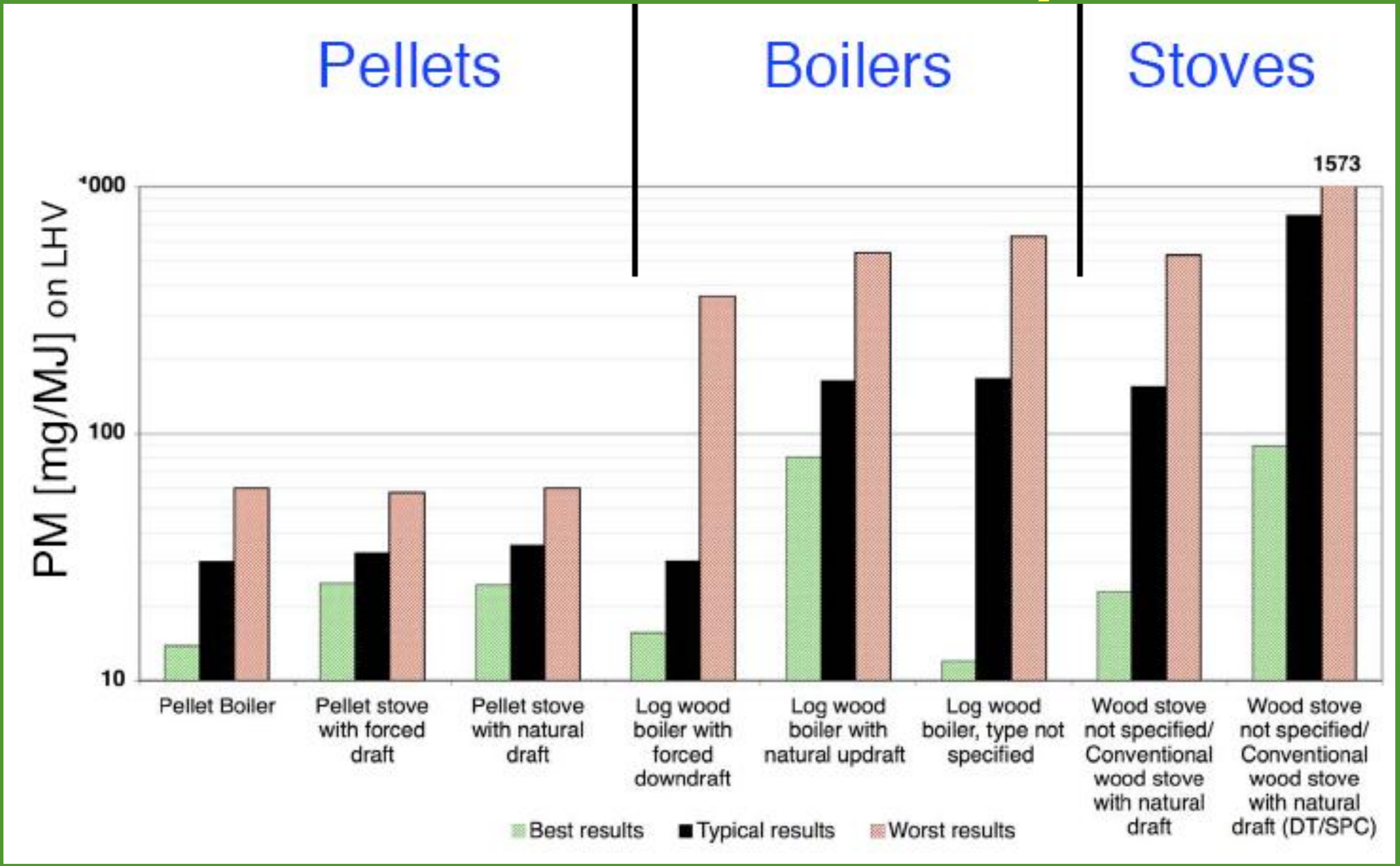
- Better furnace designs
- Better information to the users
- Better installations
- Proper test standards
- Develop flue gas cleaning systems

Designs have already significantly improved!

Type / Origin		
Gases		
Particles		



Still big variations in technical performance exist: result of Task 32 inventory



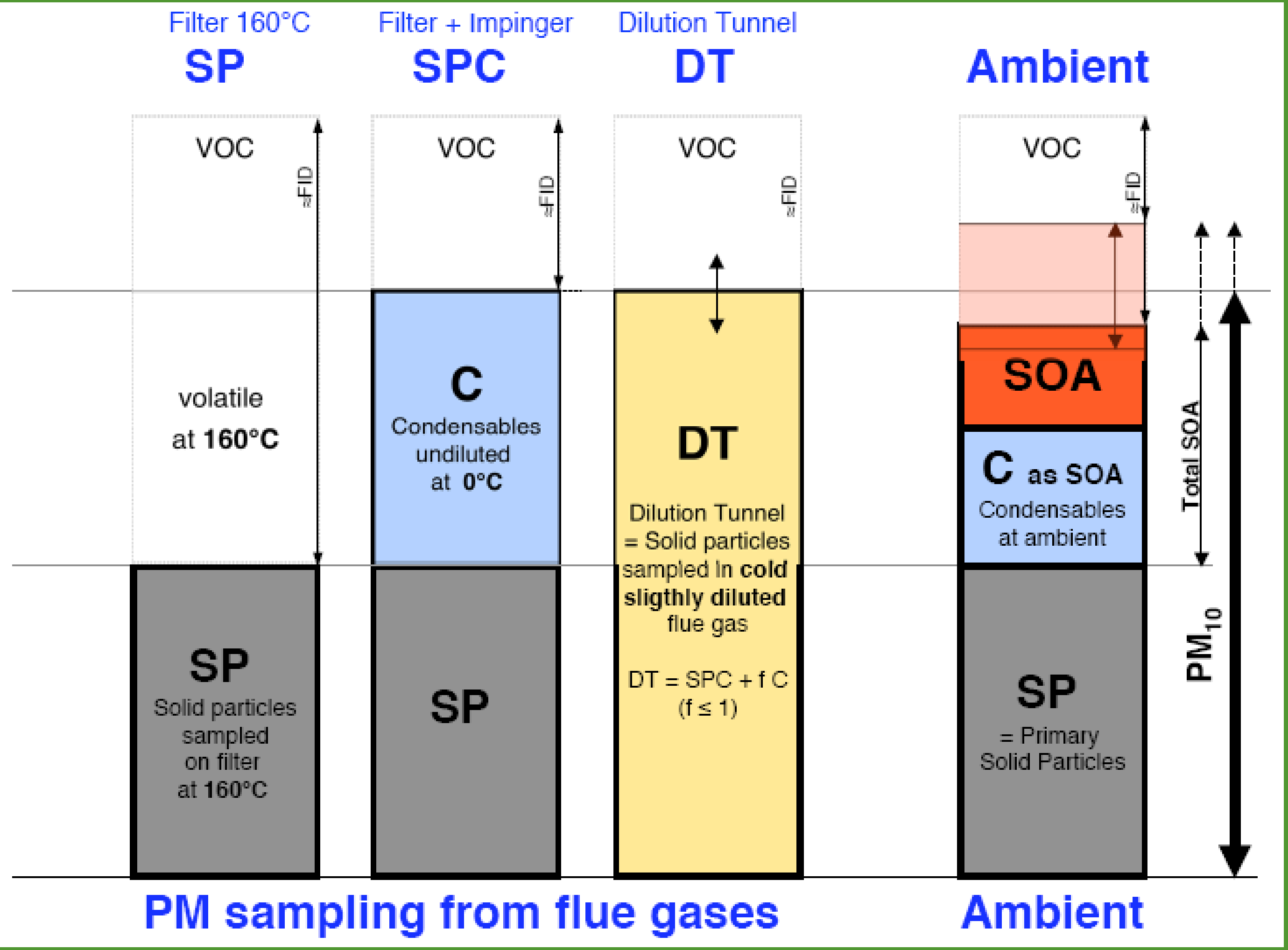
Influence of user behaviour

Even a good stove can have a very high particle emission if smoldering
(mg/m^3 total fly ash at 13 % O_2)

Particle emission	Stove at **ideal** operation	Stove at **typical** operation	**Smoldering** stove
Salt	<20	<20	<20
Soot	<20	<100	5,000
Tar	<5	400	10,000
Total	**<50**	**500**	**15,000**

[Nussbaumer, 2007]

What aerosols do we measure?



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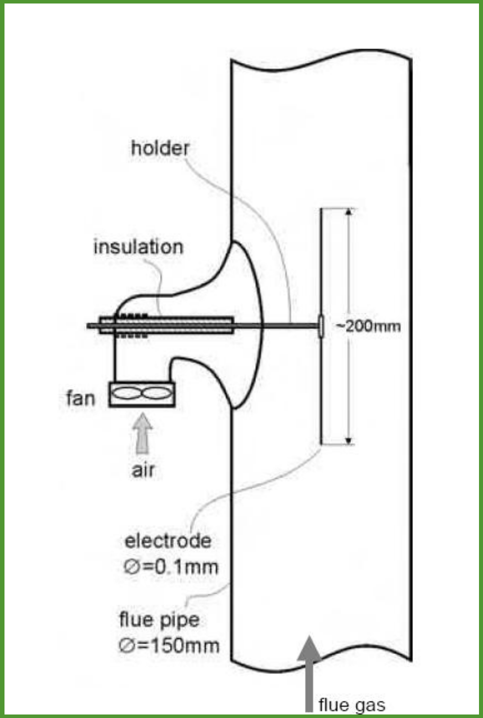
Small scale dust removal systems

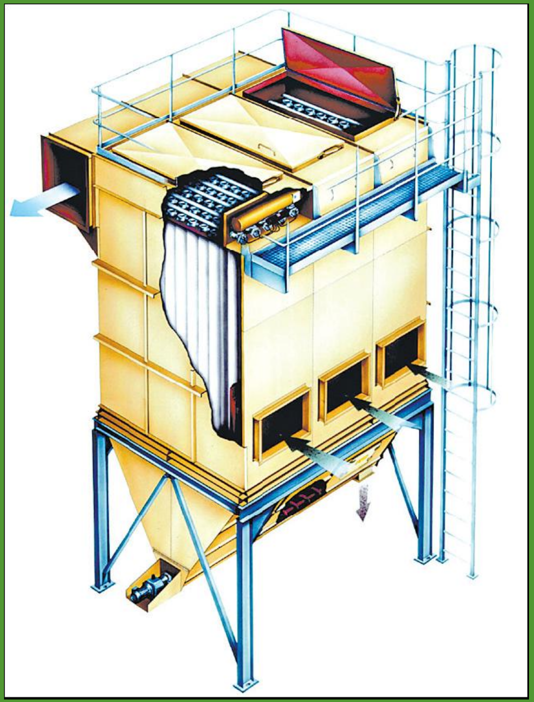
Electrostatic Precipitators

[APP, 2006]



[Schmatloch, 2005]

Cloth filter



[Scheuch, 2006]

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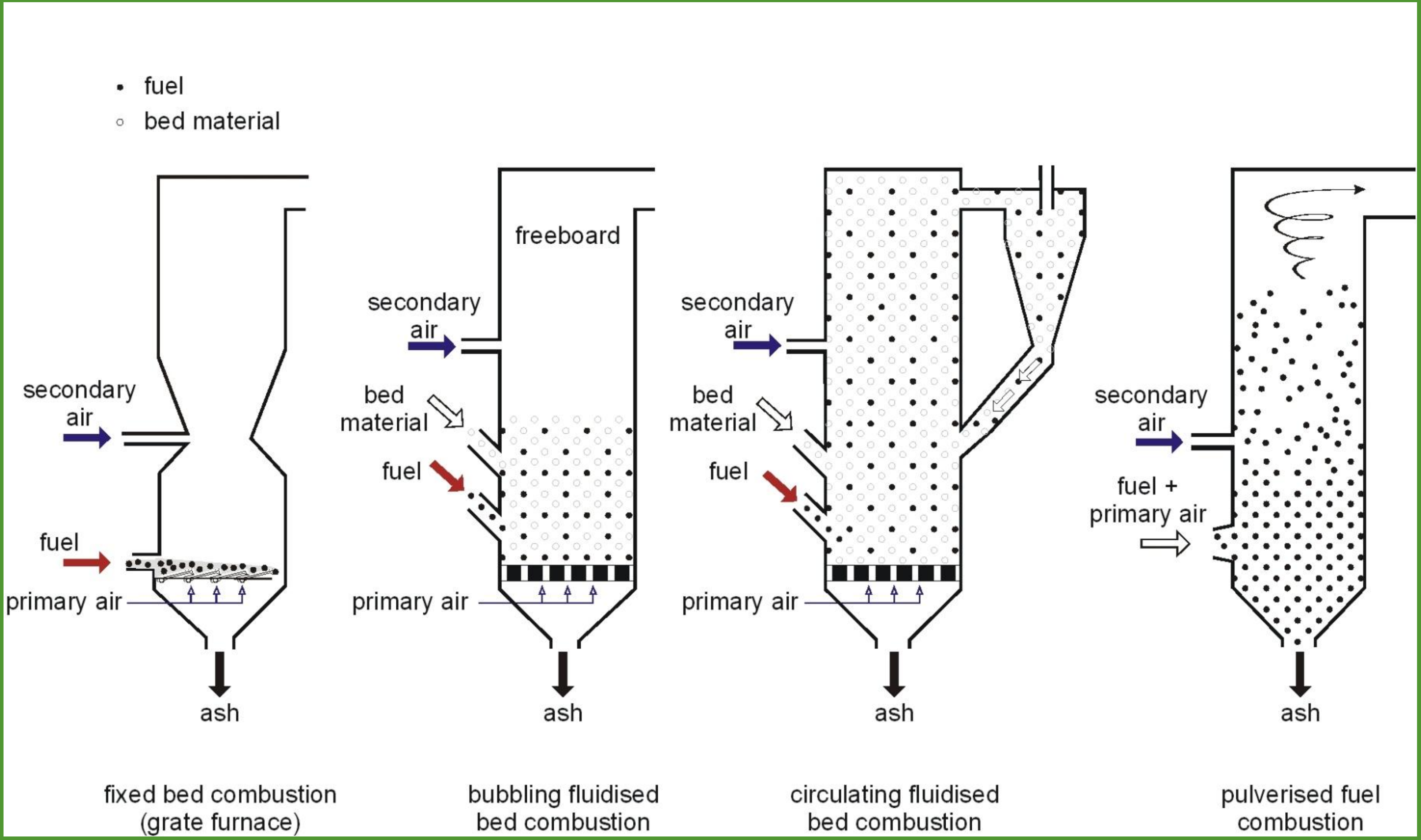
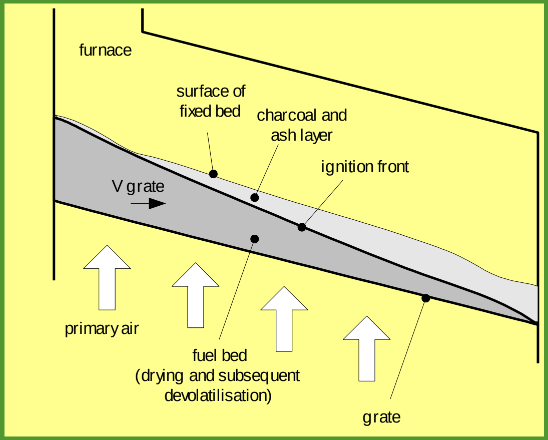
Main industrial scale combustion principles



Fixed bed furnaces

- up to ±20 MW_{th}
- Fuels may be humid and varying particle size but not too much fines.
- Fuels with low ash melting temperature are usually problematic



Small scale CHP

Working medium	Engine type	Typical size	Status
Liquid and vapour (with phase change)	Steam turbine	500 kWe – 500 MWe	Proven technology
	Steam engine	100 kWe – 1 MWe	Proven technology
	Screw type expander	not established, similar size as steam engine	Demonstration
	Steam turbine with organic medium (ORC)	500 kWe – 1 MWe	Some commercial biomass plants
Gas (without phase change)	Closed gas turbine (hot air turbine)	not established, similar size as steam turbine	Development
	Stirling engine	20 kWe – 100 kWe	Demonstration

BFB/CFB furnaces

- Only for plants larger ±20 $MW_{th,}$ ±30 MW_{th}
- Fuels may be humid
- Fuel particle size < 80 mm, < 40 mm
- Low NO_x through air staging
- High operating costs
- High dust load
- Ash slagging may occur
- Problematic partial load

Chicken litter combustion, Moerdijk

- 120 MW_{th} BFB, 4 passes by Austrian Energy.
- Steam conditions 67 Bar/470°C
- 36 MWe

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Slagging, fouling & corrosion can lead to severe problems

[Bowie, 2006]

Examples of design changes:

- Large platen superheating surface
- Increased tube pitch
- Fully retractable soot blowers
- Use of additives

"ChlorOut"

ChlorOut (ammonia sulphate) is sprayed into the flue gases and converts chlorides to sulphates, which reduces corrosion and fouling.
It also reduces NO_x and CO.

[Kassman, Vattenfall, 2006]

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Biomass co-firing trends:

- Co-firing is a key application
- High efficiency
- Low investment costs
- High CO_2 avoidance per tonne of biomass
- Up to 10% on energy basis “daily practice”
- New PC units up to 40% of co-firing

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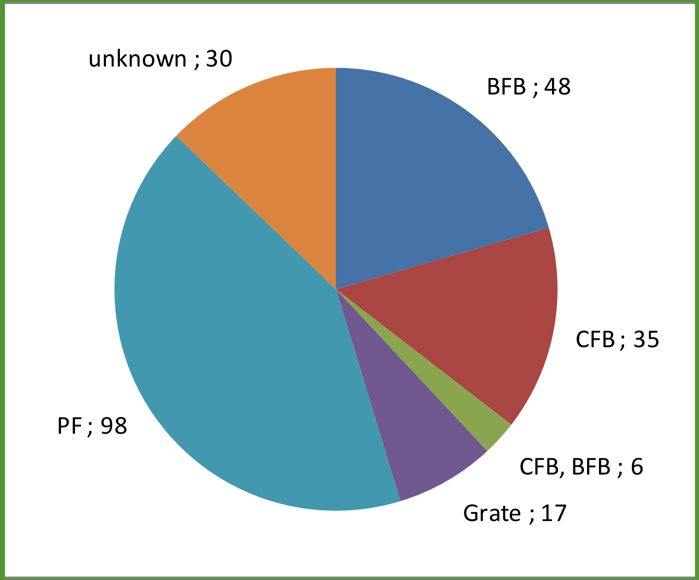
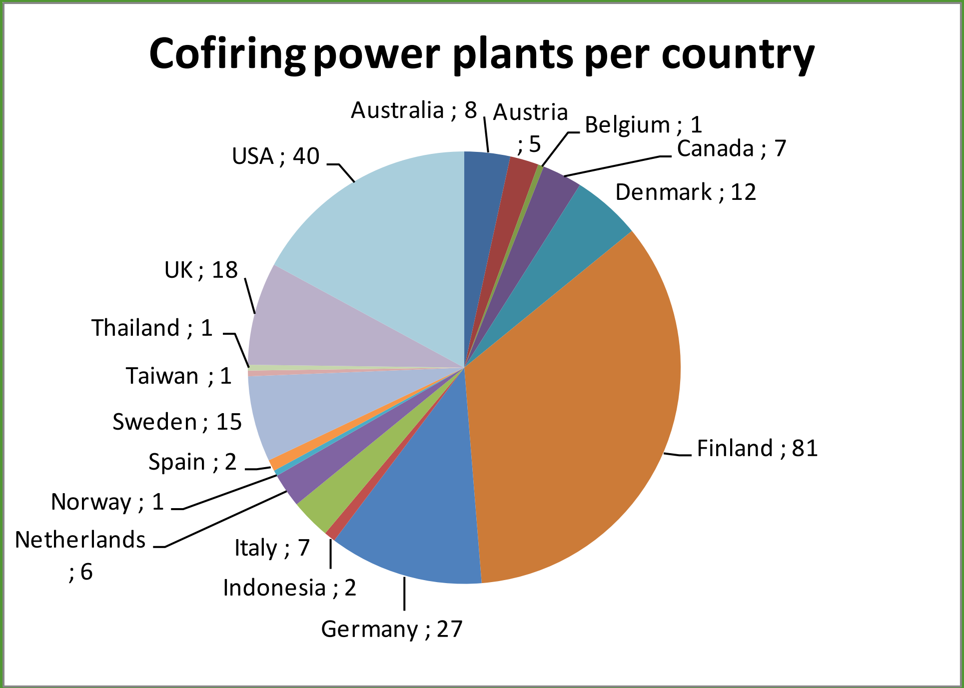
Biomass cofiring experiences

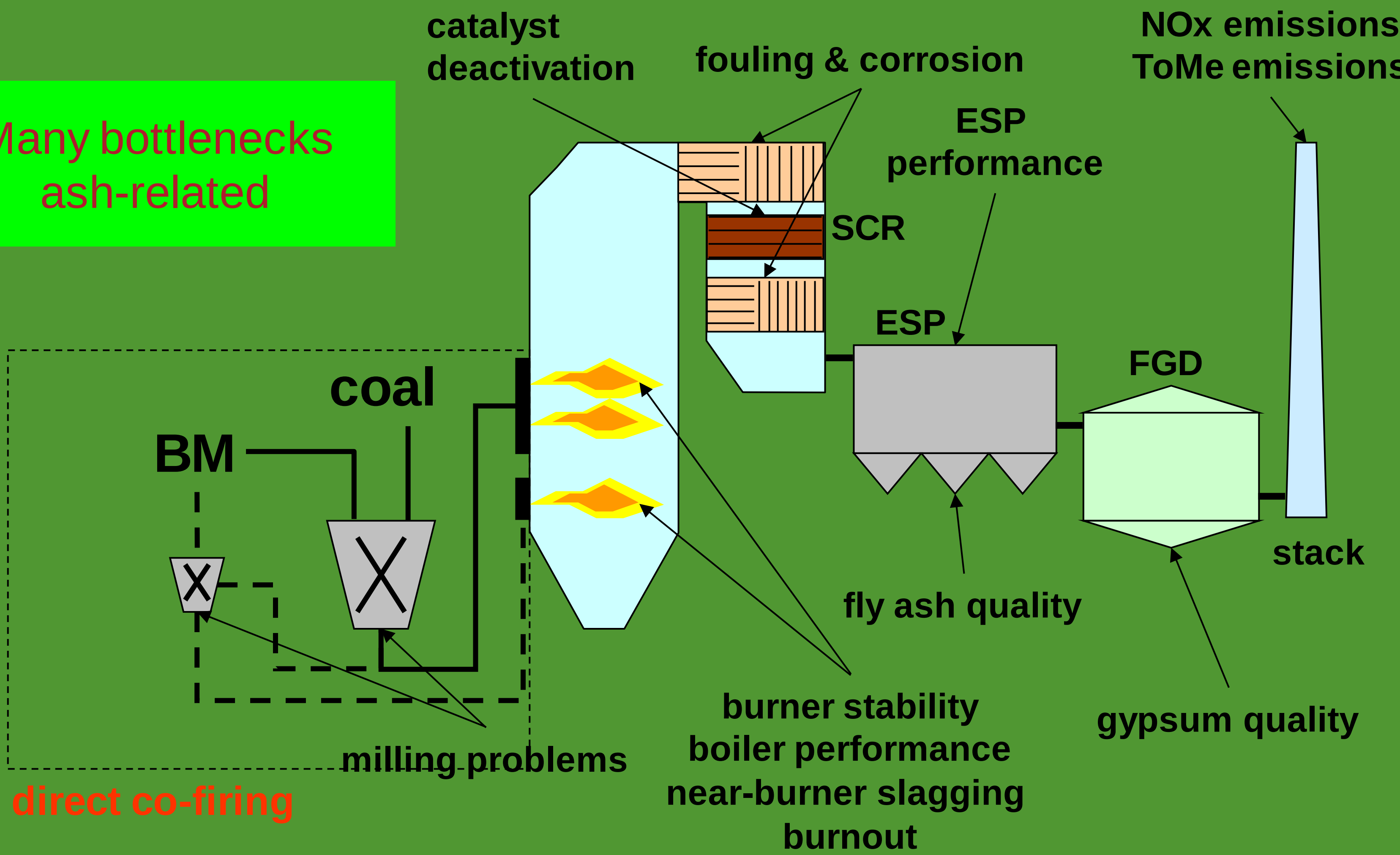




Source: IEA Bioenergy task 32 cofiring database

Technical bottlenecks in biomass co-firing

Many bottlenecks ash-related



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Thermal pre-treatment options for co-firing

Biomass characteristics		Power plant type			
Grindability	**Contaminations**	**Pulverised coal boilers**	**Fluid bed boilers**	**Natural gas boiler**	**Natural gas turbines**
Good	Low	Direct, Torrefaction	Direct	Pyrolysis Gasification	Pressurised gasification
	High	Gasification	Gasification	Gasification	Pressurised gasification
Poor	Low	Gasification, Torrefaction	Direct, Gasification	Gasification	Pressurised gasification
	High	Gasification	Gasification	Gasification	Pressurised gasification

TOPELL EXPECTS TO BUILD 60,000 MT PLANT IN DUIVEN (THE NETHERLANDS)

Operational per Q3 2010

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Aerosol emissions from small scale combustion

- **How are they formed and what can be done about it?**
- **To what degree does improved furnace design help?**
- **How can aerosols be reduced through end-of-pipe technologies?**

Actions of Task 32 in 2010-2012:

- **Workshop on formation mechanisms, reduction measures and health impact of aerosols from biomass combustion**
- **Workshop on low emission woodstoves (Ecodesign)**
- **Review on technical performance and cost effectiveness of new particle removal technologies, incl an assessment of different measurement techniques**

CHP concepts for small scale applications

- For **medium scale, novel CHP concepts** are being demonstrated and implemented. The scale of biomass CHP is going down.
- Steam cycle usually only feasible above 1 MWe/5 MWth
- Several R&D efforts for small scale CHP technologies
- Financial aspects and reliability yet uncertain

Action of Task 32 in 2010-2012:

- Workshop on small scale CHP technologies to provide better insight in latest developments

Challenging biomass fuels

- **Nox emissions, ash melting, corrosion, aerosols , SCR deactivation**
- **Outlook for new boiler materials and limits in steam temperature**

Action of Task 32 in 2010-2012:

- **Workshop on use of challenging fuels in domestic and industrial scale combustion devices**

Biomass cofiring

- The largest contributor to bio-electricity in several countries
- Largest and easy potential is in existing PC boilers because of size and public opinion
- Relevance of different technical issues however varies per power plant and biofuel considered

Action of task 32 in 2010-2012:

- Workshop with VGB Powertech on high percentages co-firing and increased fuel flexibility
- Update of existing cofiring database

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Pretreatment, storage, handling and sustainability of biomass resources

- **Biomass logistics for large scale cofiring are very complex**
- **Self ignition of fuels has caused problems in practise**
- **Very large interest in torrefaction**

Actions of Task 32 in 2010-2012:

- **Technical evaluation of suitability of torrefied fuels for different appliances (both small scale and cofiring)**
- **Technical review on safety issues in fuel storage, handling and preparation**
- **Workshop with T40 on large scale fuel supply**

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Utilization of ash

- **As fertilizer, in road construction, or cement**
- **EN450 and ASTM set limitations on use of flyash in cement, which may hinder high percentage cofiring**

Action of task 32 in 2010-2012:

- Technical paper on
    - characteristics of different ash fractions from various biomass/technology combinations,
    - how the ashes are currently utilized and
    - what can be done to improve ash utilisation.
- The paper will contain a guideline for utilisation of various types of ash, which could be used to improve national policies on ash utilisation

Any ‘burning’ questions?