

# ***Biomass co-firing***

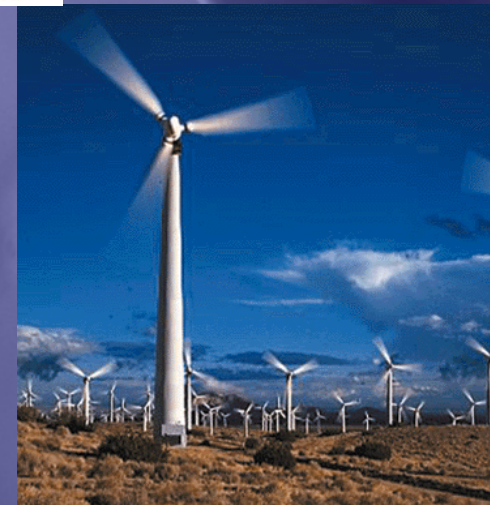
***Technology, barriers and experiences in EU***

TNO Science and Industry



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GCEP Advanced Coal Workshop  
March 15<sup>th</sup> -16<sup>th</sup> 2005, Provo (UT), USA



# Presentation overview

- Biomass co-firing: concepts and technology
- Drivers and Barriers
- Experiences (Europe and NL)
- Research issues
- Concluding remarks

# TNO

- was founded by law in 1930
- assists companies that have no in-house R&D
- is independent of public and private interests
- Market turnover: 400 millions euro
- 5000 employees

# TNO is active in five core areas



TNO Quality  
of Life



TNO Defence,  
Security and  
Safety



TNO Science and  
Industry



TNO  
Environment and  
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TNO Information  
and  
Communication  
Technology



# Department of High Temperature Processes

- Biomass combustion and co-firing
- Waste-to-energy
- High temperature production processes (cement ovens, glass melting,...)
- Gasification and pyrolysis processes
- Liquefaction (HTU)
- Supercritical water gasification ( $H_2$ )



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# Biomass co-firing (concepts)

- Direct co-combustion in coal fired power plants
- Indirect co-combustion with pre-gasification
- Indirect co-combustion in gas-fired power plants
- Parallel co-combustion (steam side coupling)



# Direct co-firing of biomass

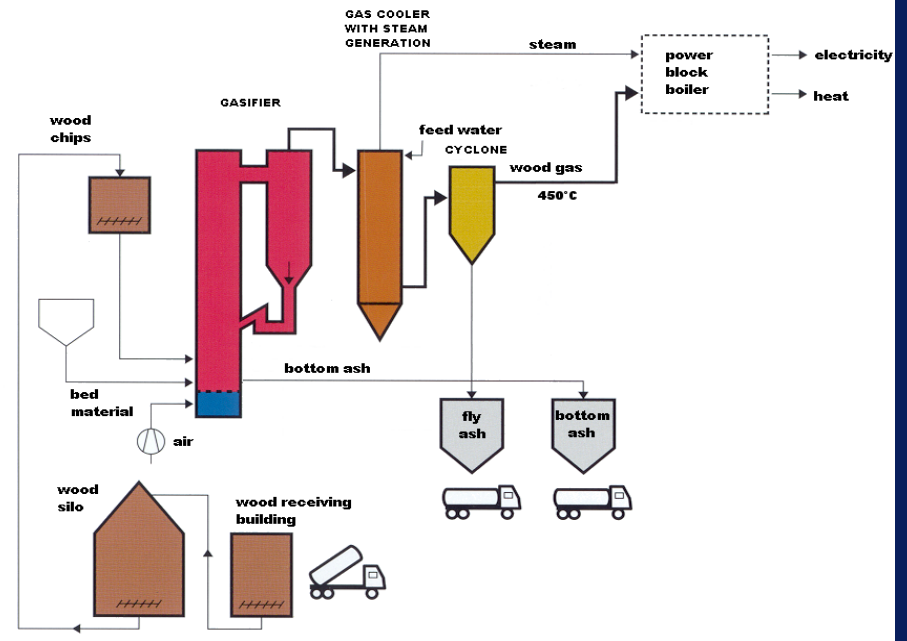
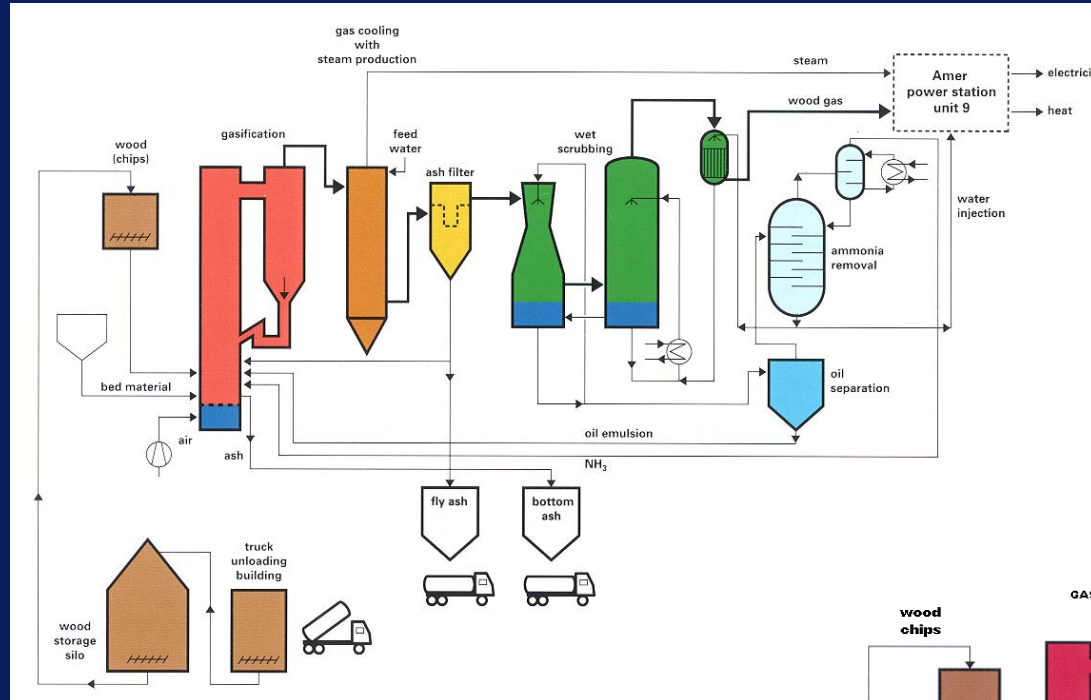
Two methods were developed:

- **Blending the biomass and coal in the fuel handling system and feeding blend to the boiler (20 euro/kW)**
- **Separate fuel handling and separate special burners for the biomass, and thus no impact to the conventional coal delivery system (200 euro/kW)**

# Biomass co-firing via pre-gasification

- Option for waste-derived fuels
- Amer (NL), Lahti (Finland)
- Investment costs: 300-1100 euro/kW<sub>e</sub>

# Amer-9 wood gasifier

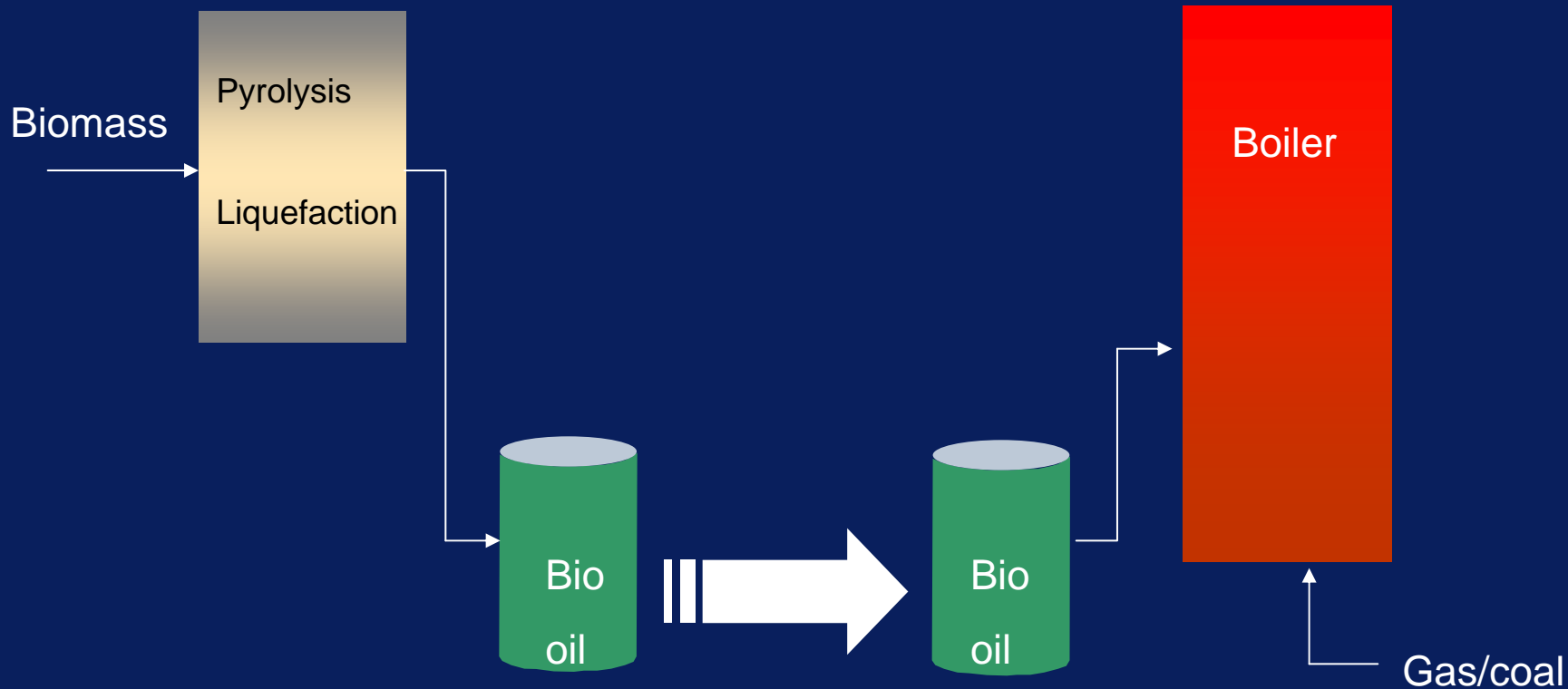


## CFB gasifier

- waste wood
- 83 MWth input
- 170 kton CO<sub>2</sub> red (source KEMA)



# Indirect co-firing for gas fired boilers



# Parallel co-combustion (steam-side coupling)

## Enstedvaerket power plant – Abenraa, Denmark

- Straw
- Highly corrosive nature of straw at high temperatures
- Contamination of the coal ash.
- Biomass boiler: 40 MW<sub>e</sub> and coal-fired unit: 660 MW<sub>e</sub>

## Vasteras CHP plant – Vasteras city, Sweden

- CHP plant has four units using coal and oil with an overall capacity of 500 MWe and 900 MW for district heating.
- CFB boiler for biomass 200 t/ steam)

# Drivers of co-firing biomass

- Reduces the emissions of greenhouse gases and other pollutants
- Co-firing in coal plants would strongly increase biomass use
- Lowest capital cost option for increasing the use of biomass to produce electricity
- Co-firing biomass and coal takes advantage of the high efficiencies obtainable in large coal-fired power plants
- Improves combustion due to the biomass higher volatile content
- Jobs creation

# Technical barriers

- Fuel flexibility (quality, quantity)
- Complete combustion and well mixing in boiler
- Fouling and corrosion of the boiler (alkalis, chlorine)
- Ash utilization (unburnt carbon, contamination)
- Negative impact on flue gas cleaning (SCR DeNO<sub>x</sub>)

# Non-technical barriers

- **Economic aspects (lack of financial incentives, uncertain fuel prices, open market)**
- **Legislative aspects (utilization of fly ash in cement, determining green share, emission legislation)**
- **Public perception of co-firing of biomass/waste**
- **Mountain of Death**

## European activities on biomass co-firing - directives -

- Reduce Greenhouse gas emissions by 8% by 2010 compared to 1990 (Kyoto Protocol)
- Doubling the share of Renewable Energy sources from 6 to 12% by 2010 (White Paper)
- National countries need to support initiatives (e.g. 12% co-firing in NL in 2008-2012)
- EU Directive on Transport Biofuels may increase the amount of residues generated via the production of biofuels

# European activities on biomass co-firing - activities -

- EU-countries have set goals of 5 – 12% of power production utilizing biomass
- Near term goals are being accomplished through co-firing
- In The Netherlands co-firing is applied in all available Dutch coal-fired plants at about 5% of the energy input level
- 150 fluidized bed boilers in Scandinavia use secondary fuels such as sawdust, wood chips, forest residues which are co-fired with peat, wood or coal
- PC plants (Lignite and coal) in Germany:
  - sewage sludge commercially,
  - trials with straw and wood

# Overview of biomass co-firing initiatives

- Recently done by IEA Bioenergy Task 32
- Internet database produced at [www.ieabcc.nl](http://www.ieabcc.nl)
- 135 plants identified that co-fire biomass in plants that originally fire coal as main fuel
- 105 direct, 1 parallel, 5 indirect, 24 yet unknown

# IEA Bioenergy Task 32 database (1/2)

http://www.ieabcc.nl/database/cofiring.php - Microsoft Internet Explorer provided by TNO-MEP

Bestand Bewerken Beeld Favorieten Extra Help

Vorige Zoeken Favorieten Media

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**cofiring**

Continent	Country	Location	Plant name	Owner	Cofiring type
All	All	All	All	All	All

Boiler type	Burner config	Output (MWth)	Output (Mwe)	Primary fuel	Cofired fuel(s)
All	All	All	All	All	

Results of the above selection:

Continent	Country	Plant name	Location	Cofiring type	Boiler type	Burner config	Output (Mwe)	Primary fuel	Cofired fuel(s)
Asia	Indonesia	Ocean Sky Co		direct	BFB			Coal	peat, bark, oil
Asia	Indonesia	PT Inhad Kiat Pulp & Paper		direct	BFB			Coal	peat, wood chips, bark, oil
Asia	Taiwan		Peikang	direct	CFB			Coal	sludge
Asia	Thailand		Chiang Mai	direct	CFB		20	lignite	RDF
Australia	Australia	Muja	Collie	direct	PF		1040	pulverised coal	plantation forest waste and green waste
Australia	Australia	Swanbank B	Ipswich, SE Queensland	direct	PF		4 x 125	pulverised coal	wood waste
Australia	Australia	Vales Point	Lake Macquarie, Newcastle, New South Wales	direct	PF	T-fired	2 x 660	pulverised coal	wood waste
Australia	Australia	Liddell	Liddell, New South Wales	direct	PF	T-fired	4 x 500	pulverised coal	wood waste (sawdust, shavings)
Australia	Australia	Mt Piper	Lithgow, New South Wales	direct	PF	Wall fired	2 x 660	pulverised coal	wood waste (fresh sawdust)
Australia	Australia	Wallerawang	Lithgow, New South Wales	direct	PF	T-fired	2 x 500	pulverised coal	wood waste (plantation sawmill residue and construction and demolition waste timber)
Australia	Australia	Stanwell	Rockhampton	direct	PF		4 x 350	pulverised coal	wood waste (sawdust and shavings)
Australia	Australia	Tarong	Tarong	direct	PF		2 x 350	pulverised coal	wood waste
Europe	Austria		Ebensee	direct	CFB			Coal	lignite, gas, oil, wood
Europe	Austria		Frantschach	direct	CFB			Coal	lignite, oil, wood

Internet

# IEA Bioenergy Task 32 database (2/2)

**Cofiring** Allen (T.H) Fossil Plant, Memphis, Tennessee

Station	Allen (T.H) Fossil Plant #1,#2, and #3
Nominal Size	272 MWe
Boiler Type	Cyclone
Fuel	Sawdust / bit and subbit coal
Max cofiring %	20% wt
Duration	10-24 tests, 3-6 hours each
Fuel Preparation	Fuel screened (most $\leq$ 1/4" but up to 1") and introduced before crusher

**Power Plant Description:**

Allen Station is located five miles southwest of Memphis, Tennessee. The plant is owned and operated by the Tennessee Valley Authority (TVA) and consists of three coal-fired boilers with cyclone-fired furnaces. Each boiler is rated at 272 Gross MWe and was manufactured by Babcock & Wilcox in 1959.

Boilers #1, #2, and #3 each have the capacity to generate 1,920,000 lbs steam/hour at 1000°F and 2400 psig with a single reheat. There are three cyclone barrels on one wall of each boiler and four barrels on the opposite wall.

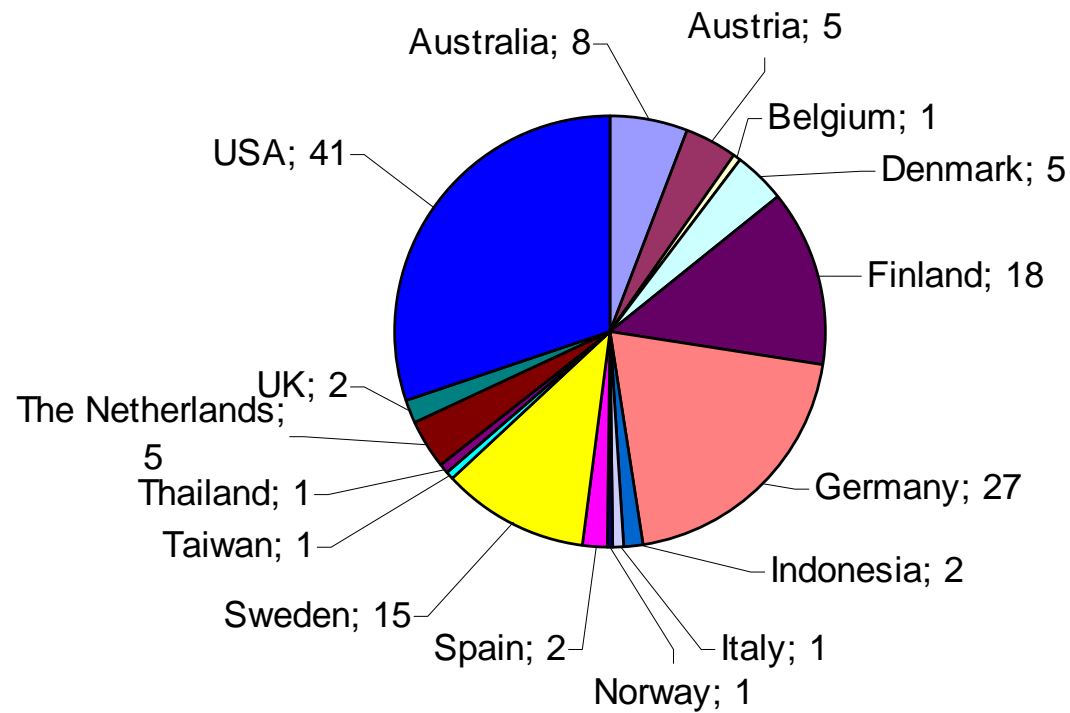
The boilers are typically fired with bituminous coal at a rate of about 105 tons/hour. Each boiler has an electrostatic precipitator for particulate control.

**Project Description/Objectives:**

A series of biomass cofiring tests have been conducted at Allen Station over the past several years to determine the operational feasibility and performance of cofiring with biomass, to determine what fuel particle sizes for wood fuel allow acceptable operation and performance, and to investigate the role of biomass cofiring in NOx emissions control.

The tests were accomplished by blending various amounts of waste sawdust and wood chips with coal and burning the resultant mixture in the cyclone boilers at the

# Countries where cofiring has been done:



# Co-firing biomass in the Netherlands

- Since 1993 more than 40 small and full scale trials co-firing up to 40 wt% of a wide variety of biomass and waste fuels with coal.
- Currently experience up to 10+ wt% co-firing
- Co-firing is daily practice in all Dutch coal-fired power plants
- **Coal covenant**

# Co-firing - Current issues in EU

- Permits
- The quality of biomass
- Fuel flexibility and pre-treatment
- Maximizing co-firing
- Thermal behavior and efficiency
- Environmental constraints - emissions
- Quality and applicability of by-products
- Integration, optimization
- Economics

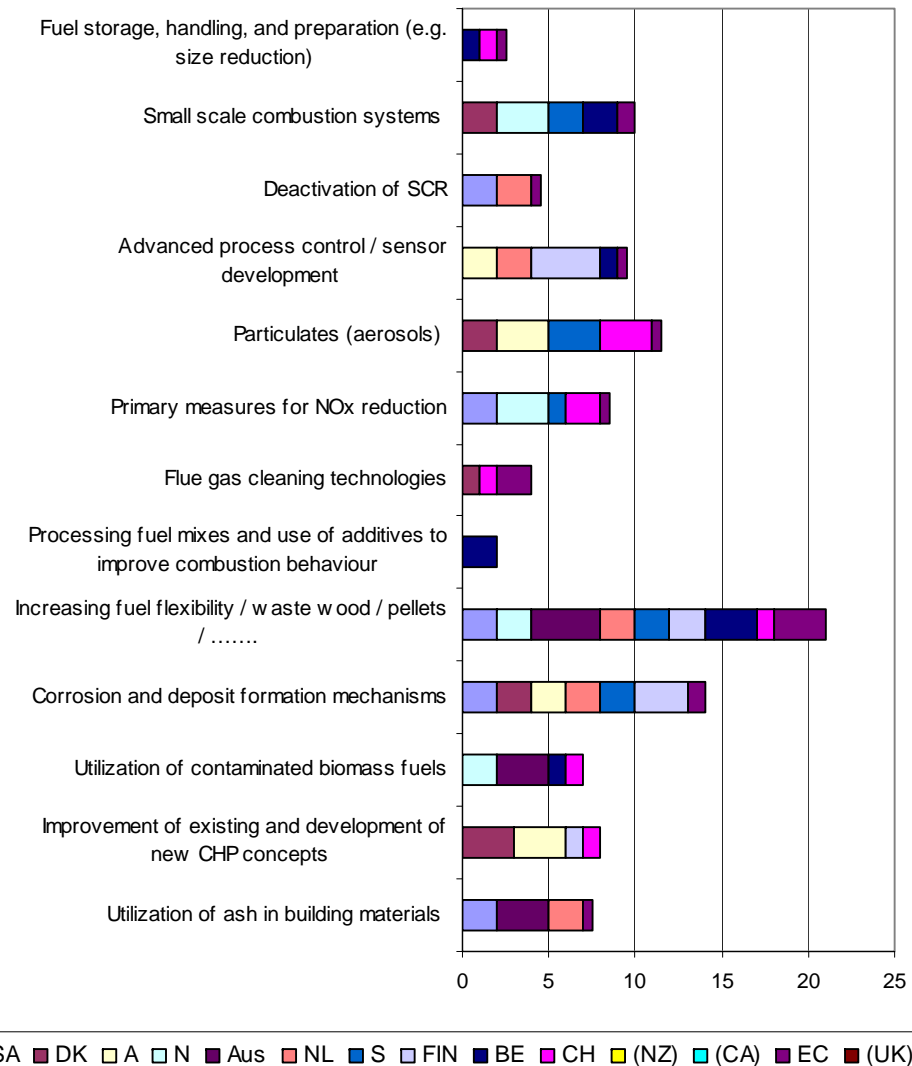
# Identification of research topics

- Corrosion mechanisms
- Ash deposition mechanisms
- Fuel flexibility (characterization)
- Particle burn-out and gas mixing
- Particle size control
- Fuel mixes / use of additives
- Ash reuse in building materials
- Contaminated biomass
- High temperature steam boilers
- Effect on gas cleaning / DeNO<sub>x</sub> catalysts
- Pre-treatment of biomass (torrefaction)

# Biomass co-firing

## IEA Task 32 Biomass Combustion and Co-firing

Country priorities next triennium IEA Combustion and Cofiring



# Concluding remarks

- Co-firing represents a cost effective, short term option at a large scale
- Although more needs to be done, there is already a wealth of practical experience under different conditions
- For low co-firing ratios are no irresolvable issues but there are poor combinations of fuel, boiler, and operation.
- For higher co-firing ratios additional research needs to be done.

*Thank you for your attention*

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