The effect of cofiring biomass and sewage sludge with coal on emissions

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Biomass cofiring with coal

- Potential to reduce CO_2 emissions
- Potential to reduce dependency on fossil fuels/imported fuels
- Potential to reduce transport costs for some fuel
- Potential to use materials otherwise regarded as waste
- Potential to reduce emissions of other pollutants

Biomass is a relatively cheap source of energy

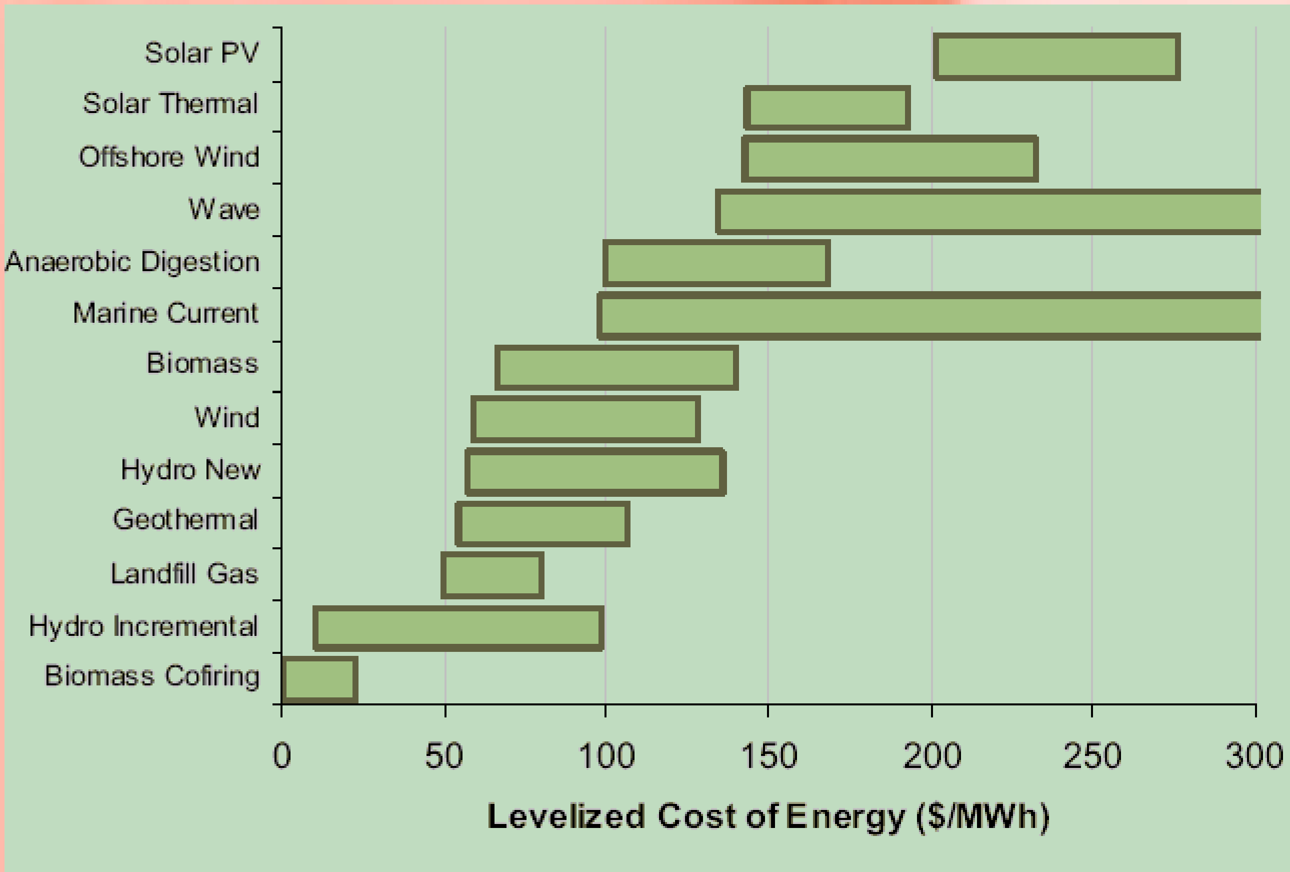


Figure 1-3. Typical Levelized Cost of Generation ($/MWh).

Figure from www.altenergystocks.com

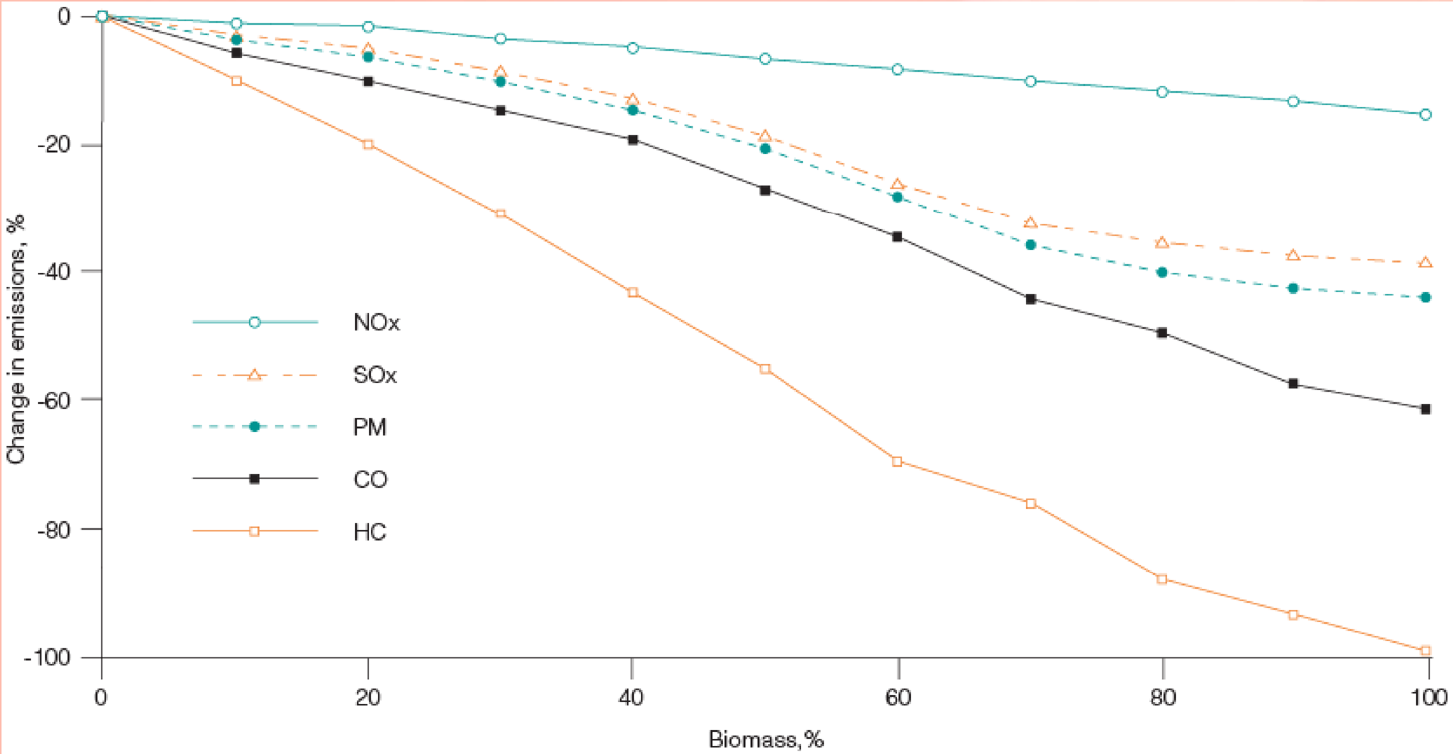
Economics of biomass use are complex

- Availability/reliability
- Transport costs
- Plant modifications
- Effects on emissions
- Effects on fly ash sales

Biomass cofiring – effect on emissions

- Biomass material are generally cellulose based and are therefore chemically and physically very different to coal
- They tend to contain more volatile matter
- They may contain different concentrations of halogens and also different alkali species
- Trace element concentrations of some alternative fuels (MSW, sewage sludge, waste tyres) can be quite distinct

In general, emissions of most pollutants tend to decrease with increased biomass use



Demirbas, 2005

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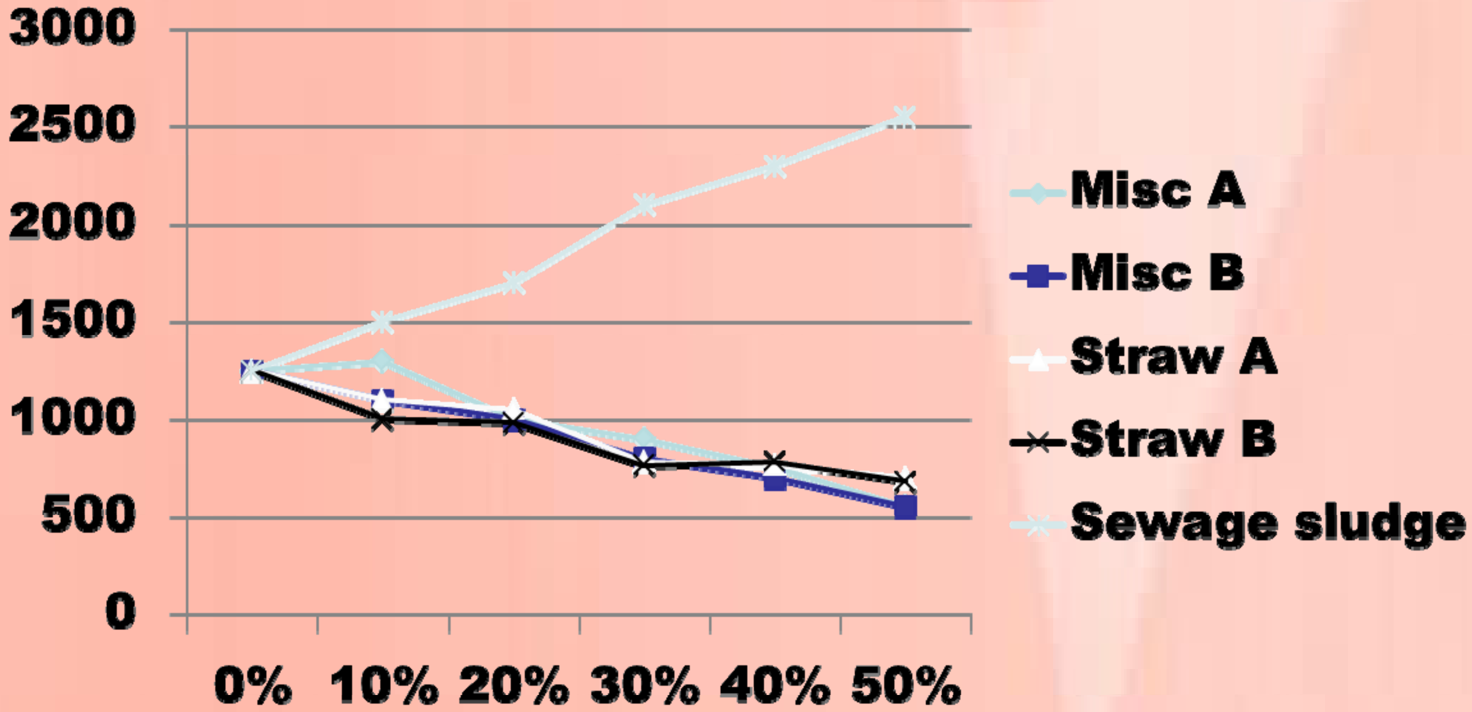
There are always exceptions ...



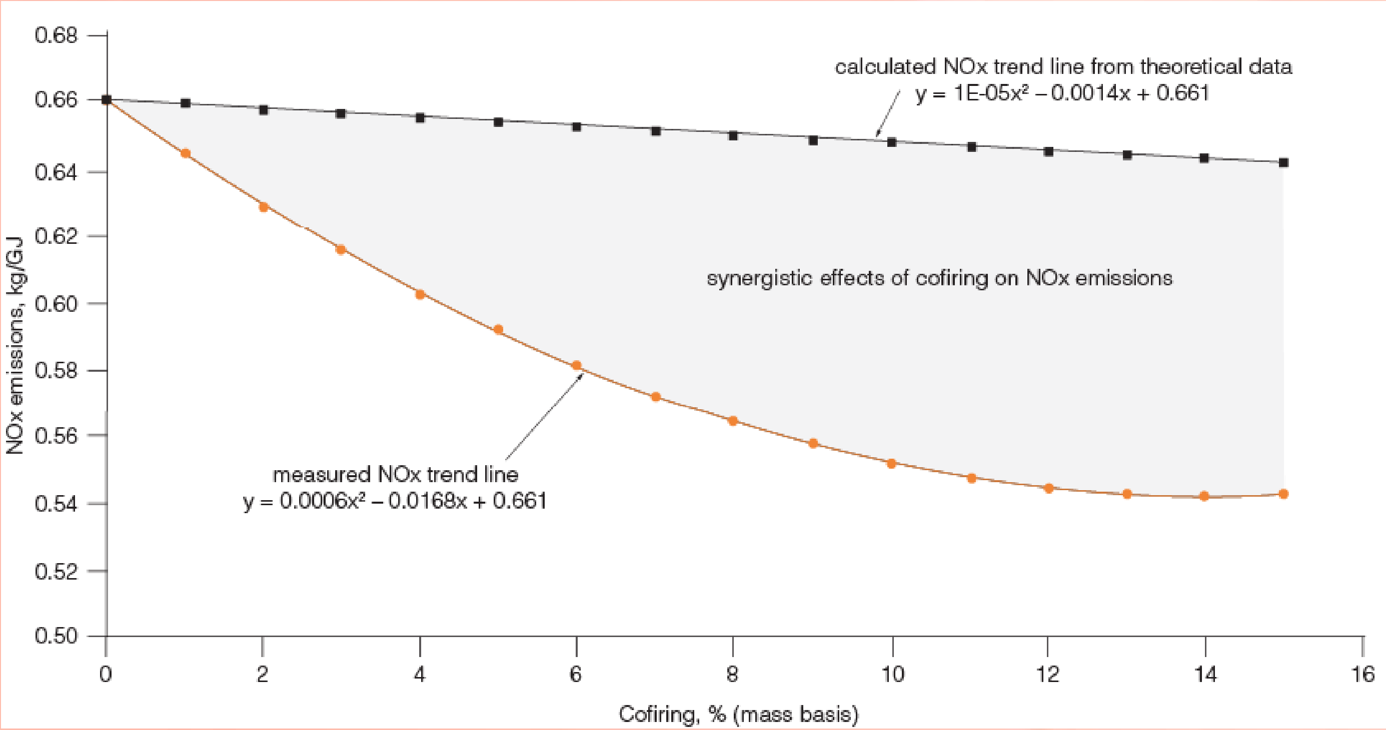
Emissions of SO_2 as a function of biomass ratio, mg/m^3 at 6% O_2

Spleithoff and others, 2000

Changes in emissions

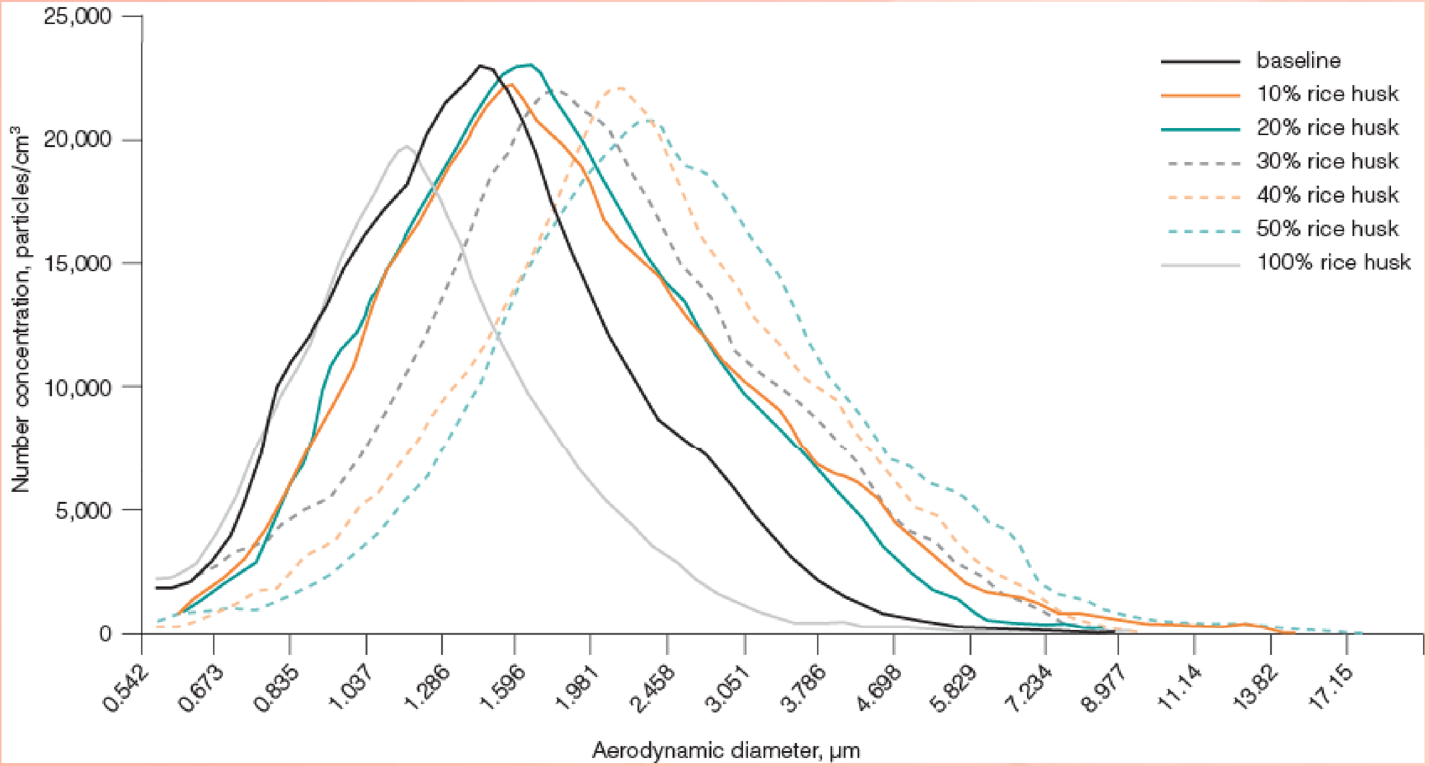
- SO_2 emissions generally reflect the amount of sulphur in the fuel
- NOx emissions arise as a result of two pathways:
  - Fuel NOx – emissions of NOx formed from the N in the fuel itself
  - Thermal NOx – emissions of NOx from N in the combustion air

Synergistic effects of cofiring on NOx emissions



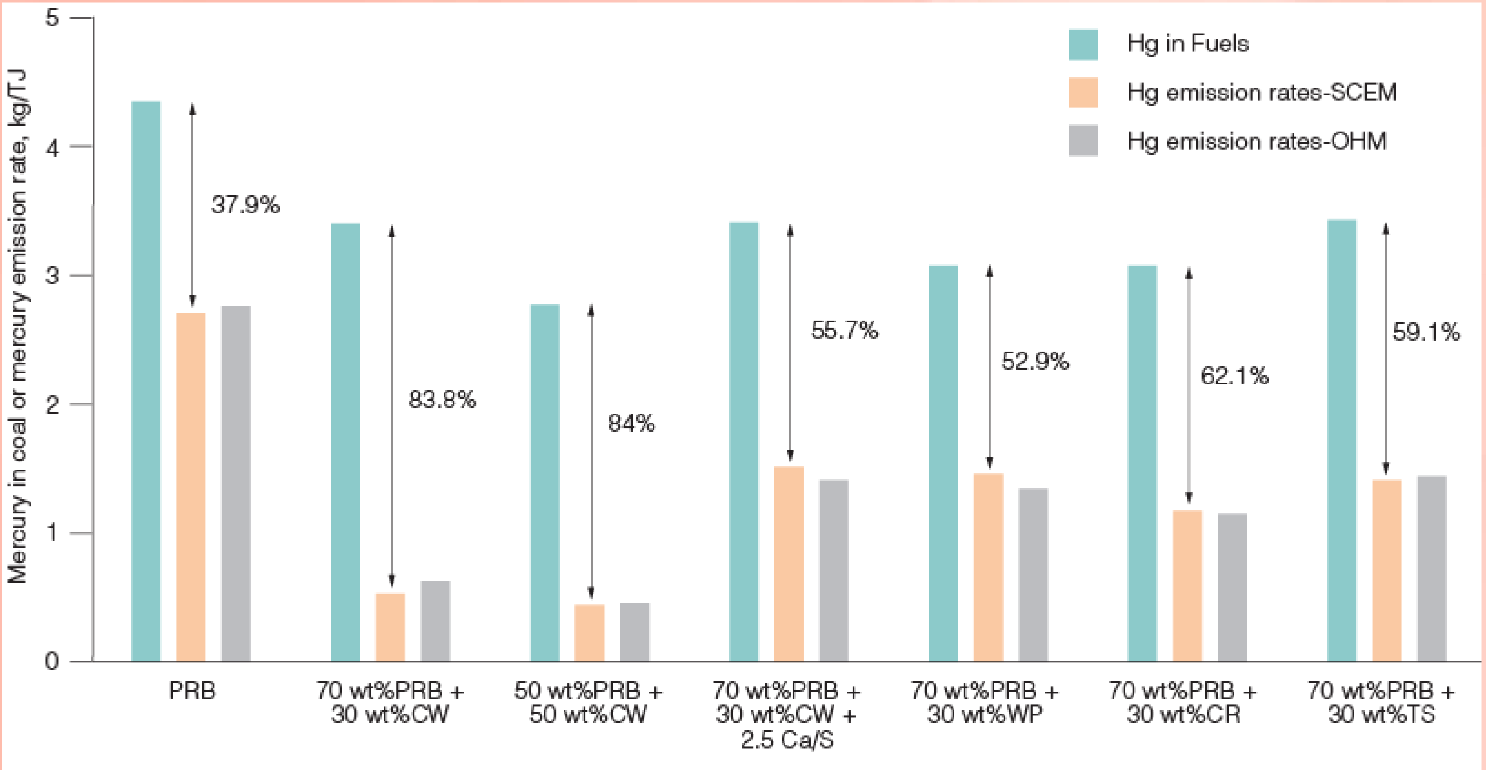
Lawrence and others, 2009

Changes in particle size distribution when cofiring rice husk



Chao and others, 2008

Variation in Hg emissions during cofiring of coal and biomass



Cao and others, 2008

Applicable legislation

- Changes to fuel can mean changes to emissions – emission limits apply
- Changes to fuel also mean changes to fly ash characteristics

Emission limits (daily mean values) in the EU (Leckner, 2007)

Combustion plant	Solid fuel	Biomass	Waste Incineration
NOx, mg/m^3	300	300	200
SOx, mg/m^3	525	200	50
Hg, mg/m^3	0.05	0.05	0.05
Ref O_2, vol%	6	6	11

“Mixing rule” applies in some cases

- Under the mixing rule, plants firing waste materials defined under the EU WID must calculate a new emission limit based on the amount of material being co-fired;
- Applies to emissions of organic compounds, HCl and HF

$$EL = (V_w EL_{iw} + V_{bf} EL_{ibf}) / (V_w + V_{bf})$$

- V_w = exhaust gas volume from waste only, 11% O_2, m^3/h
- V_{bf} = exhaust gas volume from base fuel (coal) only, 6% O_2, m^3/h
- EL_{iw} = emission limit for pollutant i in a waste combustion plant, mg/m^3
- EL_{ibf} = emission limit for pollutant I for power plants, mg/m^3

Acceptable ash for concrete/cement

Standard/legislation	Details
EN450-1 (original)	Only ash from pure coal or anthracite combustion
EN450-2 (since 2005)	Ash from cofiring accepted as long as <20% by mass of fuel and contribution is less than 10% of ash weight
USA ASTM C618	Fly ash only from coal combustion (but with regional and task specific exceptions)

Legislation is evolving

- Pulverised fuel ash (PFA), the UK's largest waste stream, will escape waste classification when used in certain applications following agreement of a waste protocol by the power industry, the government's Waste and Resources Action Programme (WRAP) and the Environment Agency.
- It will allow more than 300,000 tonnes per year of PFA and furnace bottom ash (FBA) to be used in bound materials, such as concrete blocks and grout, without the need for special permits. The move will prevent the ash being landfilled.

Conclusions

- Biomass can be an inexpensive fuel but may require subsidies for large scale use
- Biomass cofiring of most materials reduces most if not all emissions of concern
- Materials such as sewage sludge and more toxic wastes require case-by-case evaluation
- Emission limits may change when cofiring waste materials which may make cofiring more of a challenge
- Changes in fly ash characteristics and use in cement and concrete can generally be overcome