15 Years on – Uniper's Experiences with Biomass Fuels

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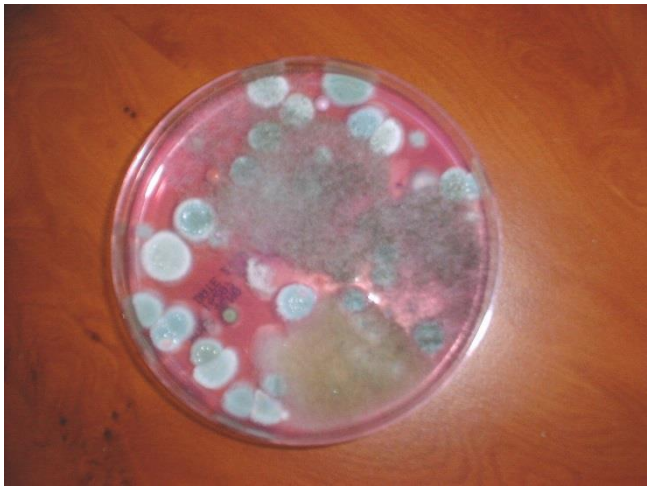
Biomass – The Early Days…

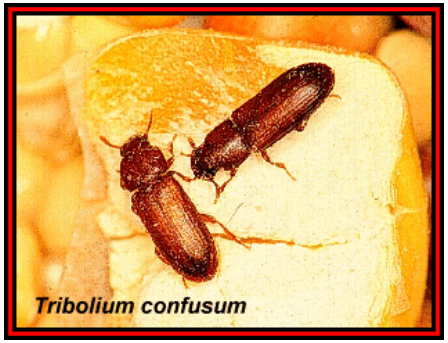
- Four major types of biomass
  - Woods (pelletised / sawdust / chipped)
  - Olive Residues (stones or residues from olive processing)
  - Palm or shea nut Residues (kernel or shell residues)
  - Cereal Products (pelletised wheat, bran etc.)

- Pre-blended with coal, or blended on-site and co-fired with coal (Kingsnorth, Ratcliffe, Ironbridge)

Biomass – The Early Days…

- Concerns over Occupational Health Issues
  - Dust
  - Decomposition, mould, spores
  - Infestation
  - Hardwood dust





Biomass & Waste Wood – Converted Coal Plant

- Ironbridge (UK) 2 x 500MW PF
  - 100% white wood pellet
  - New hammer mills
  - Few fuel quality related issues
- Gardanne (France) 150MW CFBC
  - Mixed biomass blend
  - New biomass handling system
- Maasvlakte (Netherlands) 1100MW PF
  - 20% co-firing white wood pellet
  - Single coal mill conversion

Biomass & Waste Wood – Dedicated Plant

- Steven's Croft BFBC, owned by E.ON
- Challenge of identifying fossil fuel contamination (paint/plastics/resin)
    - Uniper developed Methodology for determining fossil component of waste wood based on Nitrogen marker – now industry standard adopted by OFGEM
    - Alternative dissolution method (CEN 15440:2011) is not reliable and OFGEM limit the waste wood purity to 95% max when using this approach
- Fuel sourcing: 80% virgin timber + 20% waste wood
- Simple but effective fuel sampling & FMS
- Relatively few fuel-related issues

Biomass & Waste Wood – Dedicated Plant

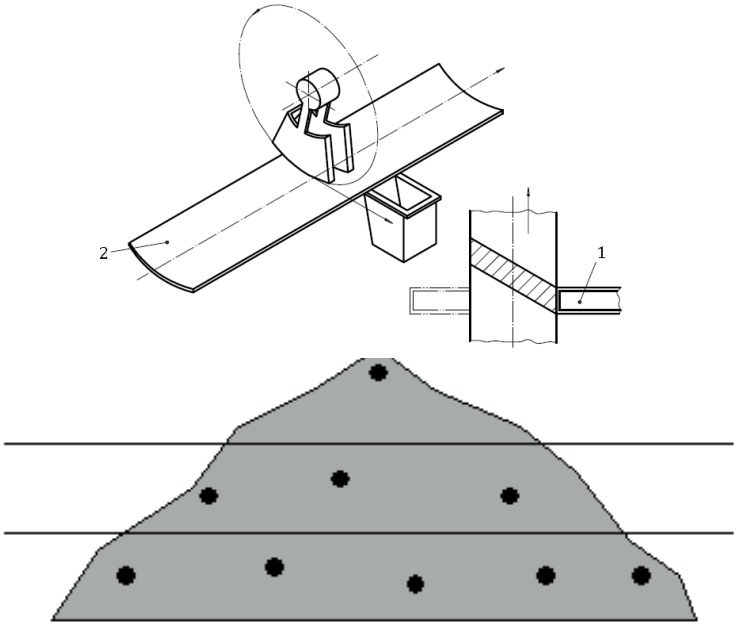
- Blackburn Meadows BFBC, owned by E.ON
- Fuel sourcing: 100% waste wood
- Project benefitted from many aspects of learning from Steven's Croft
- Fuel related combustion issues
  - Corrosion
  - Boiler slagging
  - Bottom Ash Handling

E.ON's Blackburn Meadows Biomass Plant – photo credit: Paul Karalius

The Importance of Sampling

- Often overlooked, but a critical step in the process

  BS EN 14778:2011 replaced by BS EN ISO 18135:2017
- Representative sampling of ‘lots’ (deliveries, conveyers)
- Automatic sampling always preferred to manual sampling
- Particle size (top size) dictates volume of sample increments



Biomass Fuel Analysis

- The ‘Big Six’:

  Moisture, Ash, Volatile Matter, Sulphur, Chlorine, Calorific Value
- Carbon, Hydrogen, Nitrogen
- Ash Composition analysis
- Trace Element analysis
- Particle sizing (raw and processed fuels)
- Biomass purity assessment
- Biomass pellet durability/ fines
- Proportion of Tramp
- Ash Fusion Temperature
- Spon. comb. & Explosion testing
- Bulk density

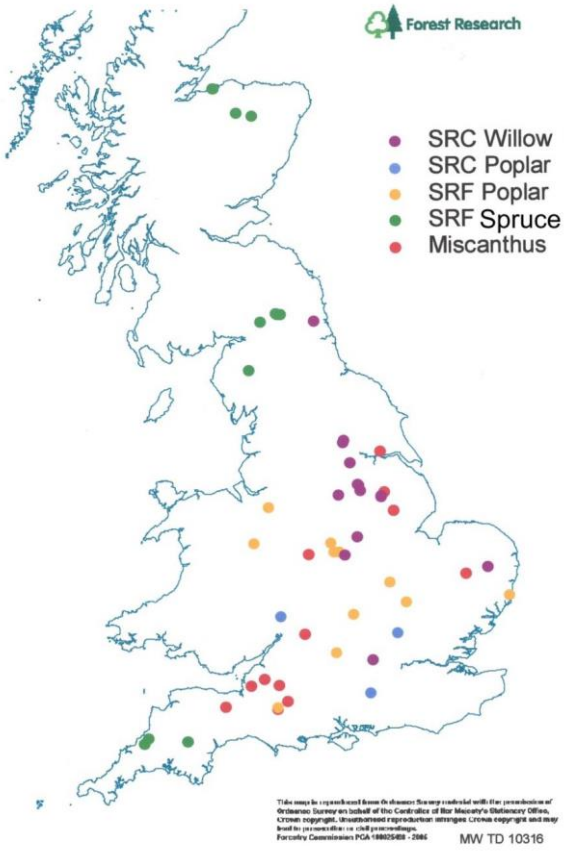
- Suitability of fuel contracts

Biomass Fuel Quality

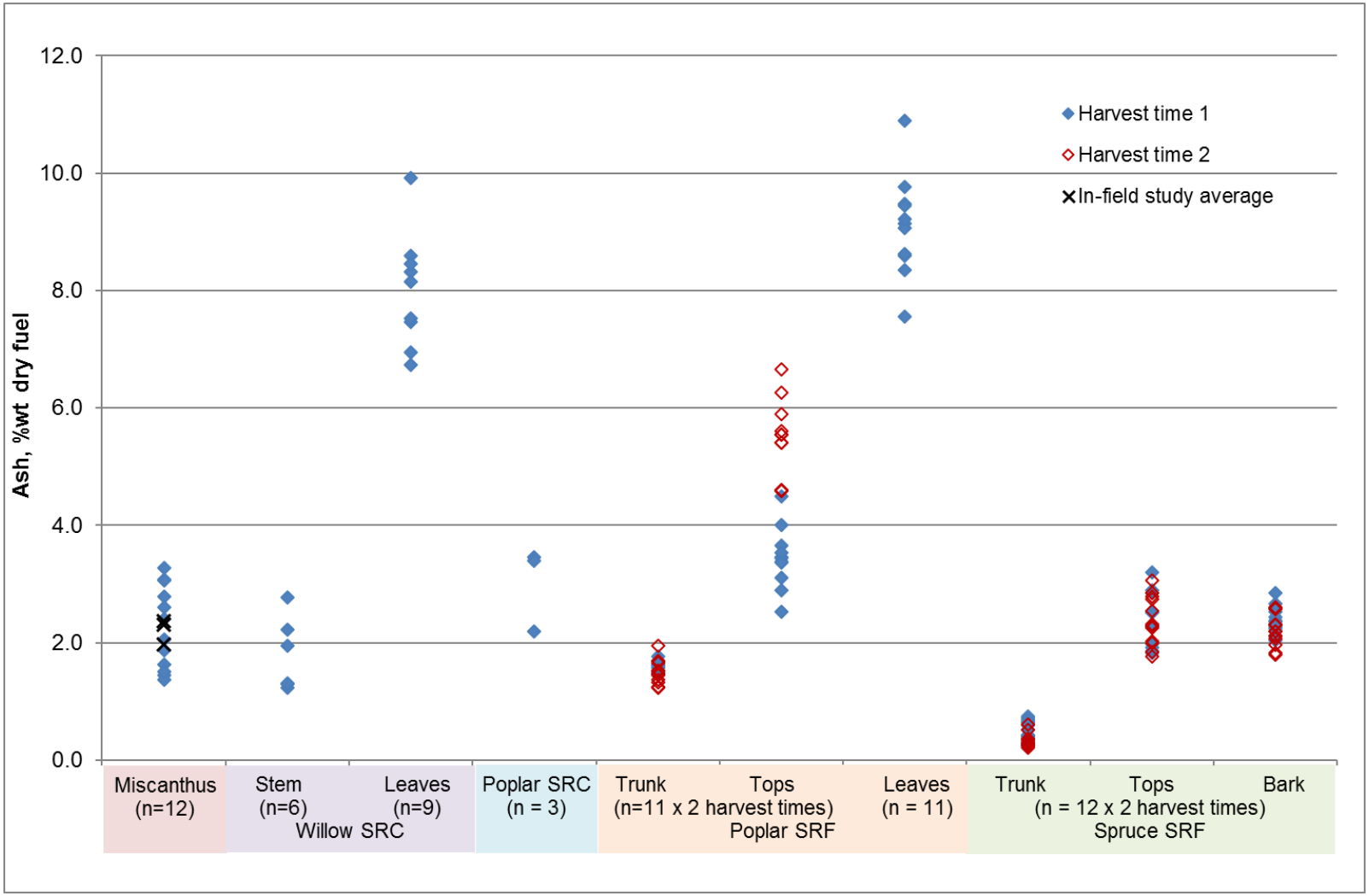
- Physical form can be very different
- Do we fully understand the chemical properties of different biomass types ?
- Energy Technologies Institute (ETI) funded project ‘Characterisation of Feedstocks’ (Uniper and Forest Research) (competed 2016)
- DEFRA-LINK Genetic Improvement of *Miscanthus* as BioEnergy Feedstock
- Biomass upgrading processes (torrefaction etc)

ETI - Characterisation of Feedstocks

- Provides an understanding of UK-produced 2nd Generation biomass properties
- Variation by species, plant part, geography, harvest time & storage (provenance)
- *Miscanthus*, Short Rotation Forestry (Sitka Spruce and Poplar), Short Rotation Coppice (Willow & Poplar)
- Woody Stems, Tops, Leaves, Bark analysed separately
- Harvesting time has an important impact on Fuel Quality (moisture and leaf content)
- Storage has an impact on moisture content
- Climate zone was not influential on SRF crops, but did impact *Miscanthus*
- Plant parts show significantly different properties



ETI - Characterisation of Feedstocks: Dry Ash



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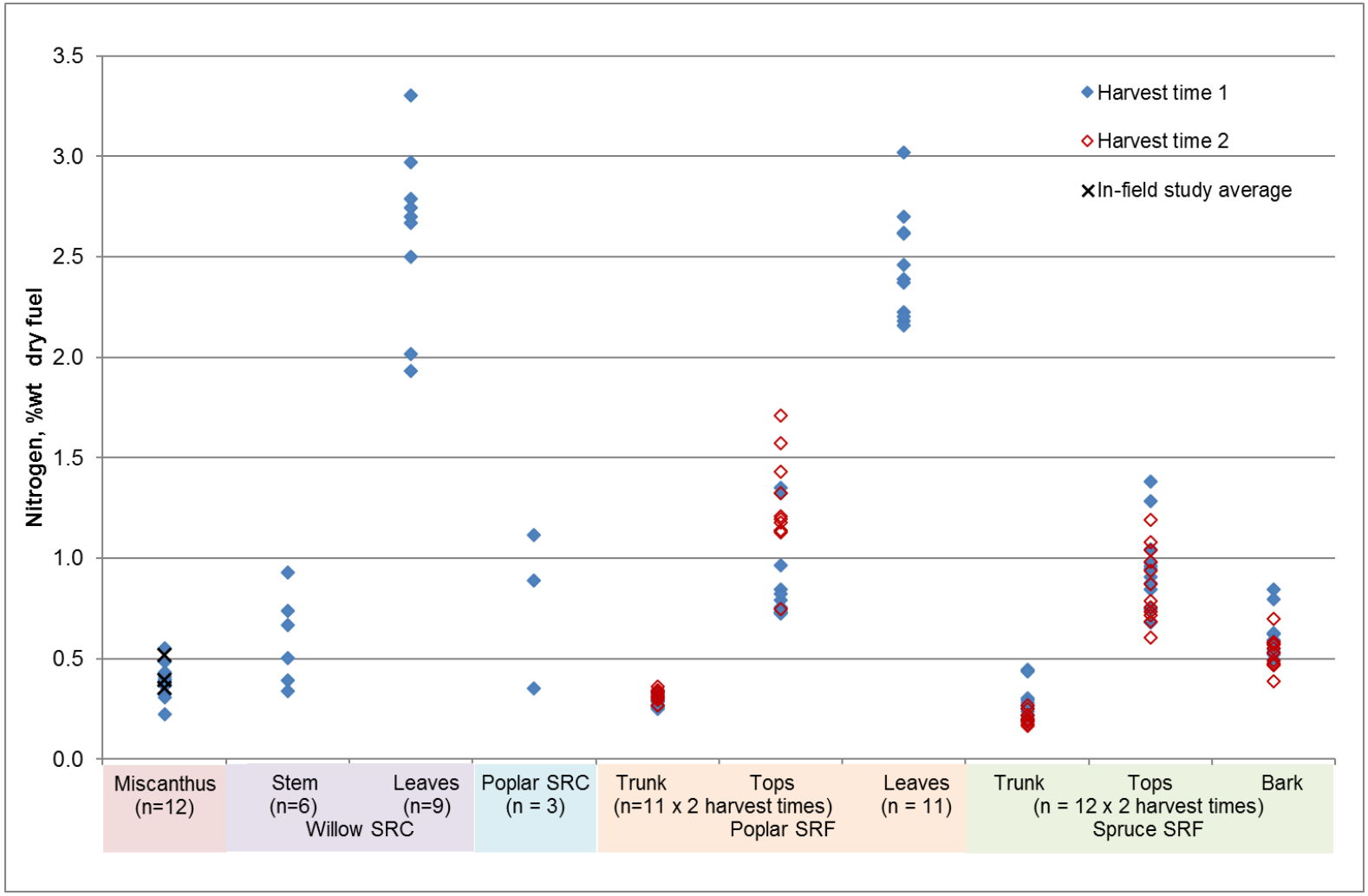

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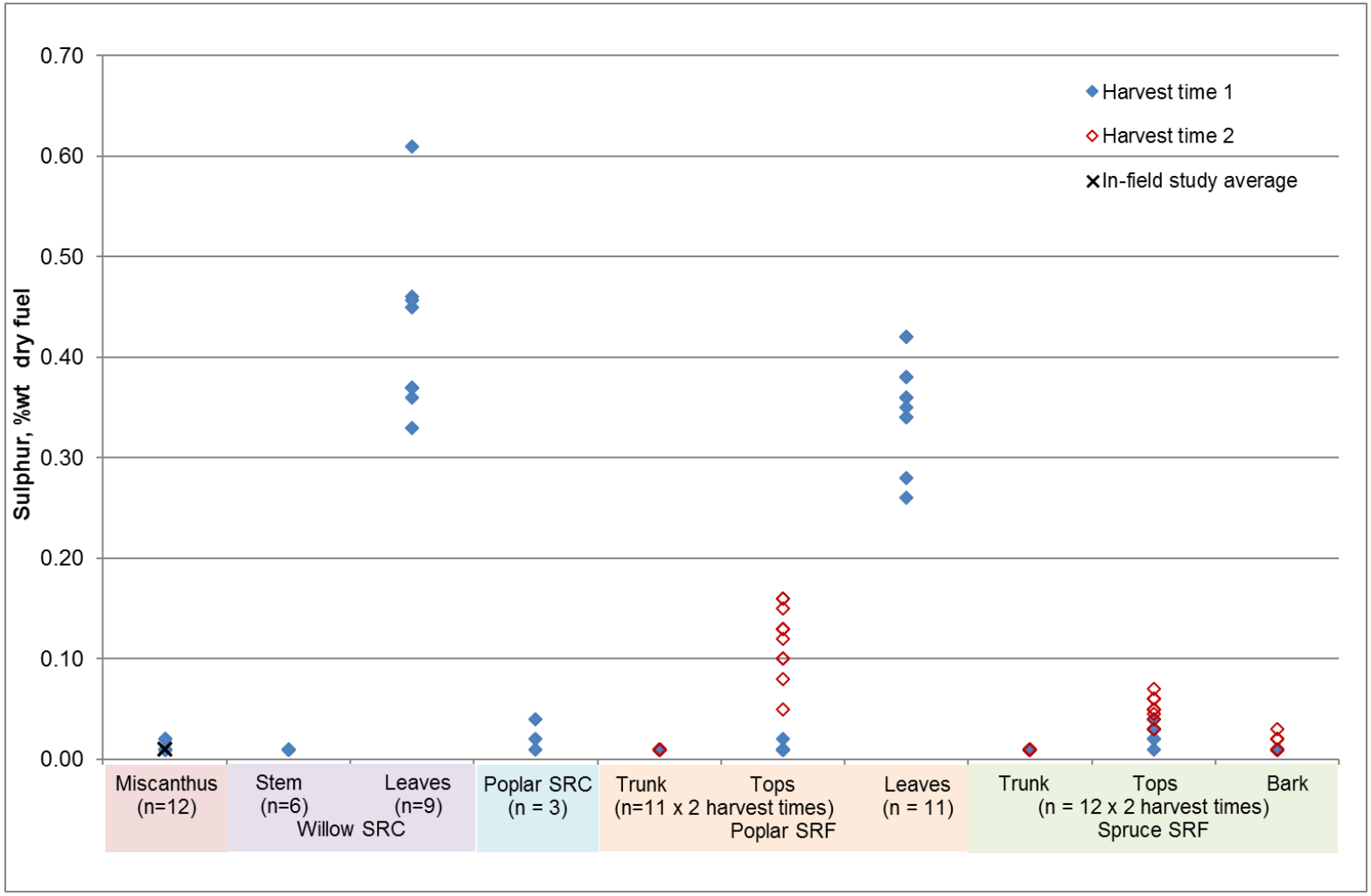

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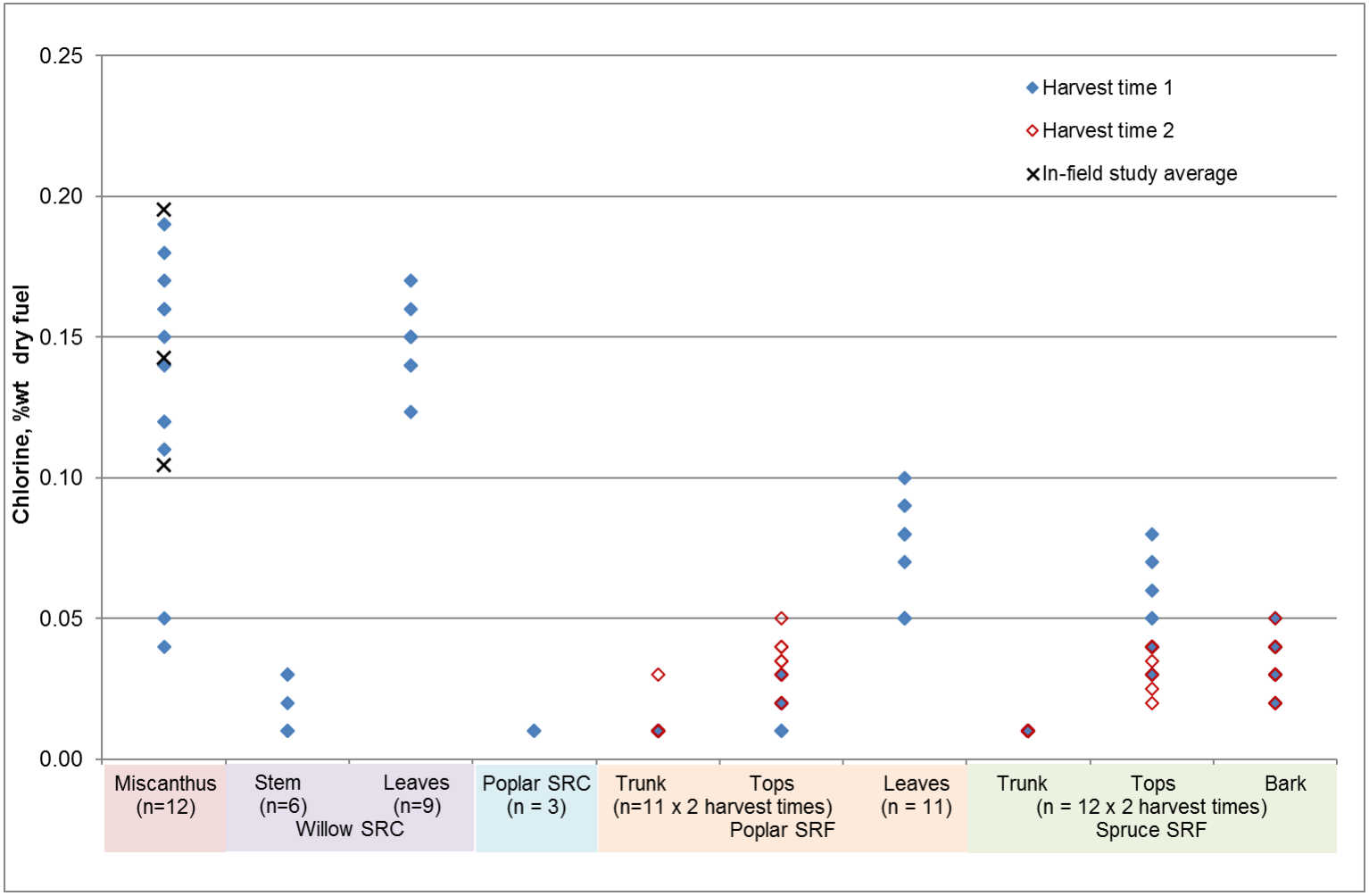
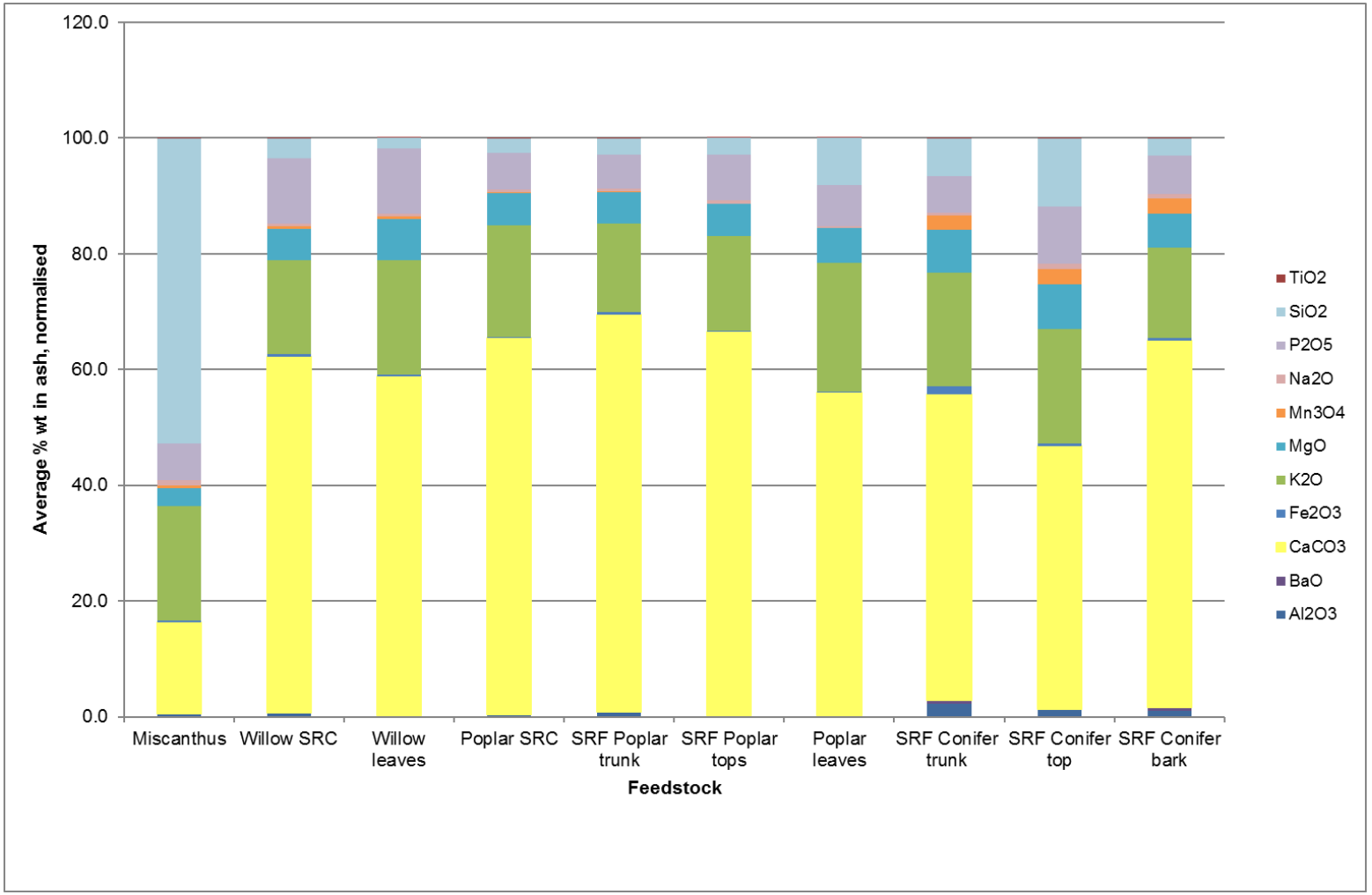
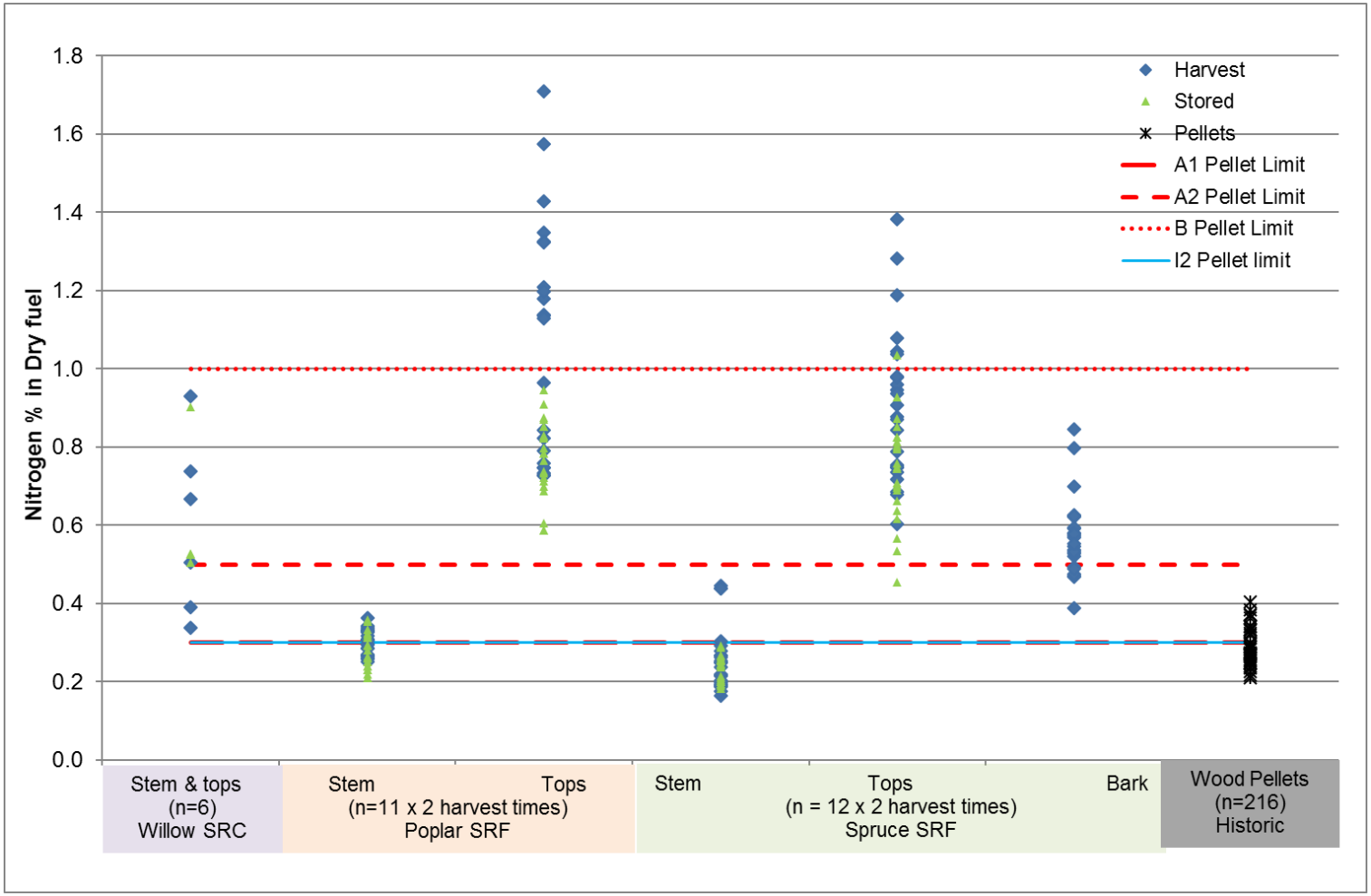


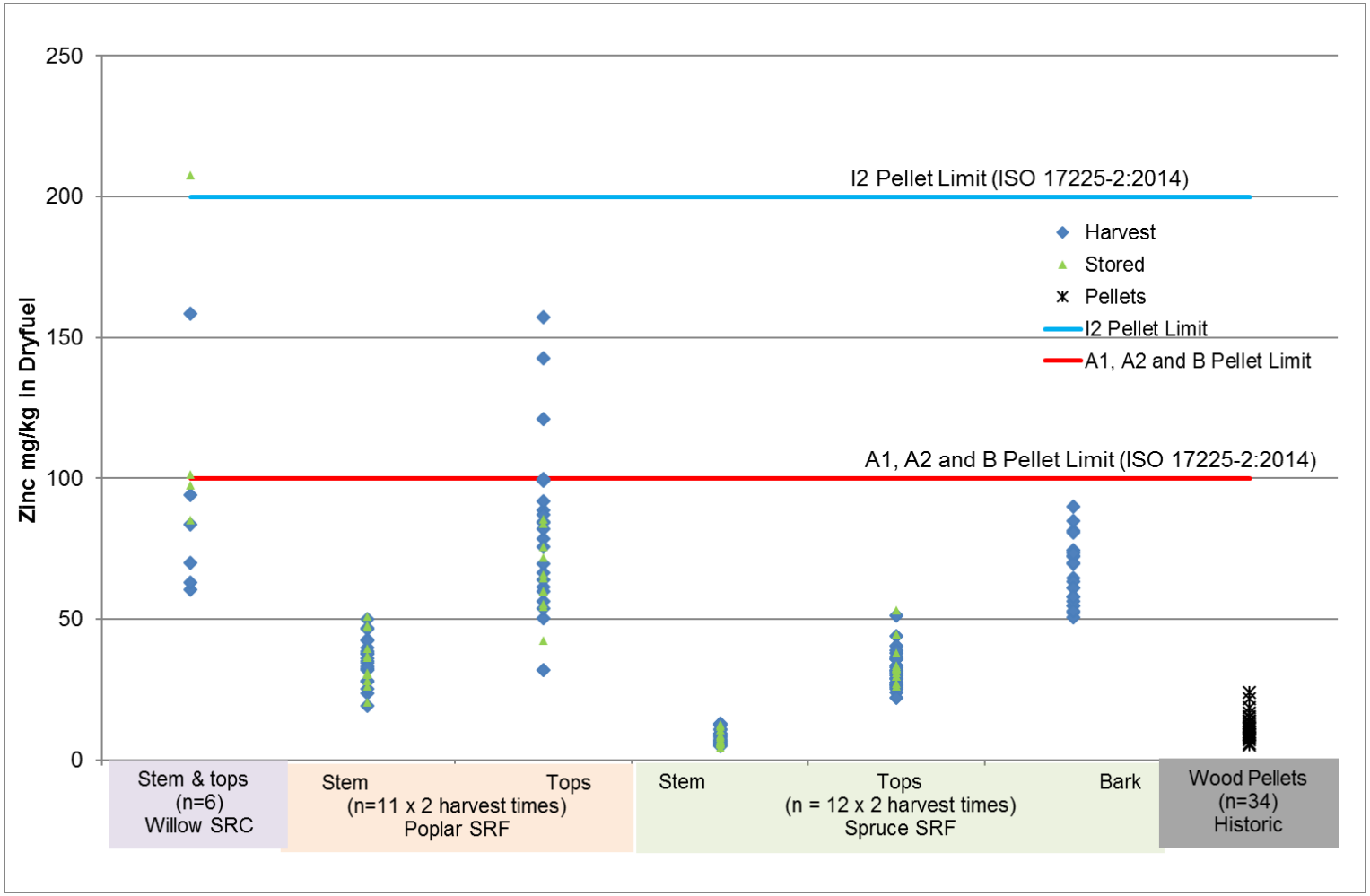
ETI - Characterisation of Feedstocks: Ash Composition



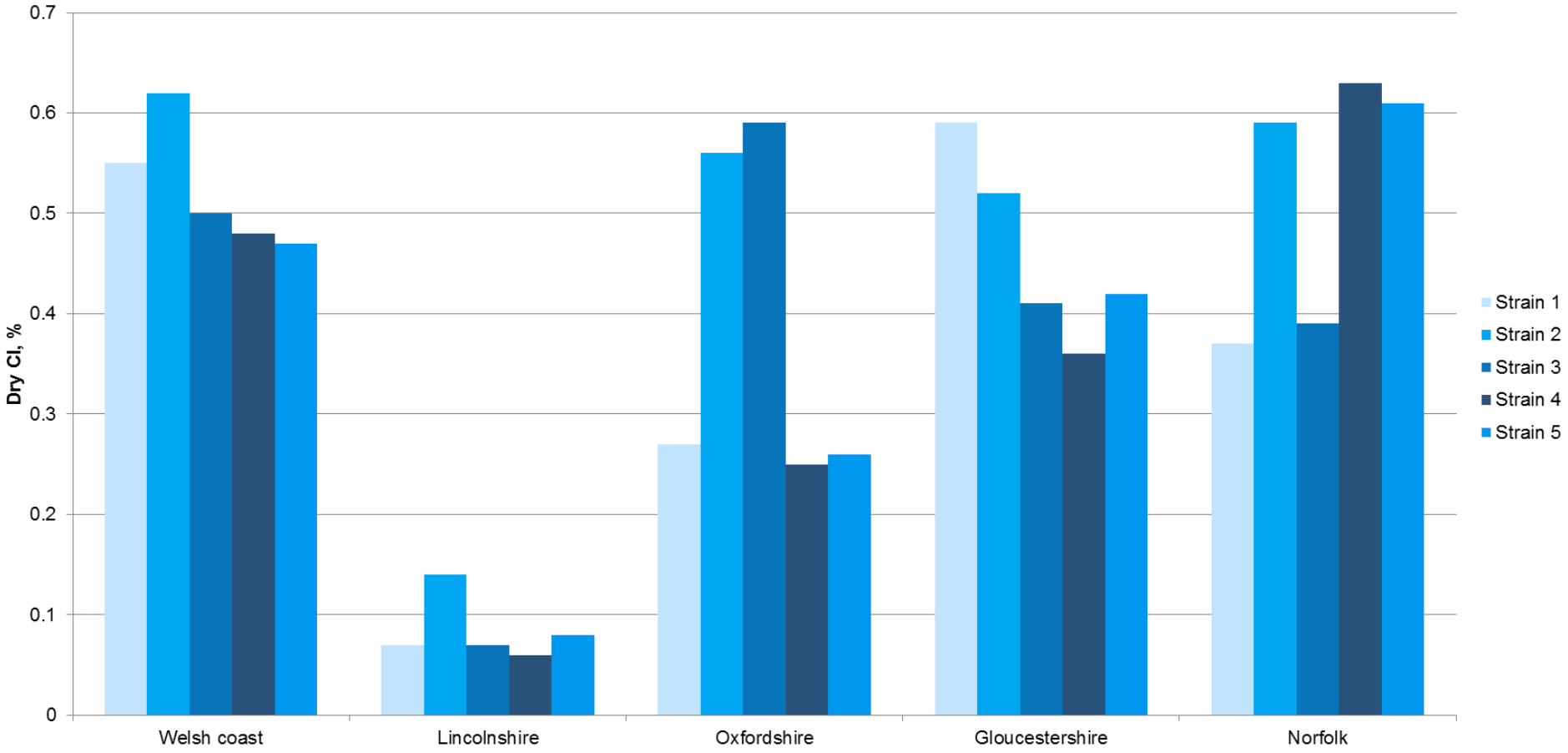
ETI - Characterisation of Feedstocks – Comparison with White Wood Pellets: Dry Nitrogen



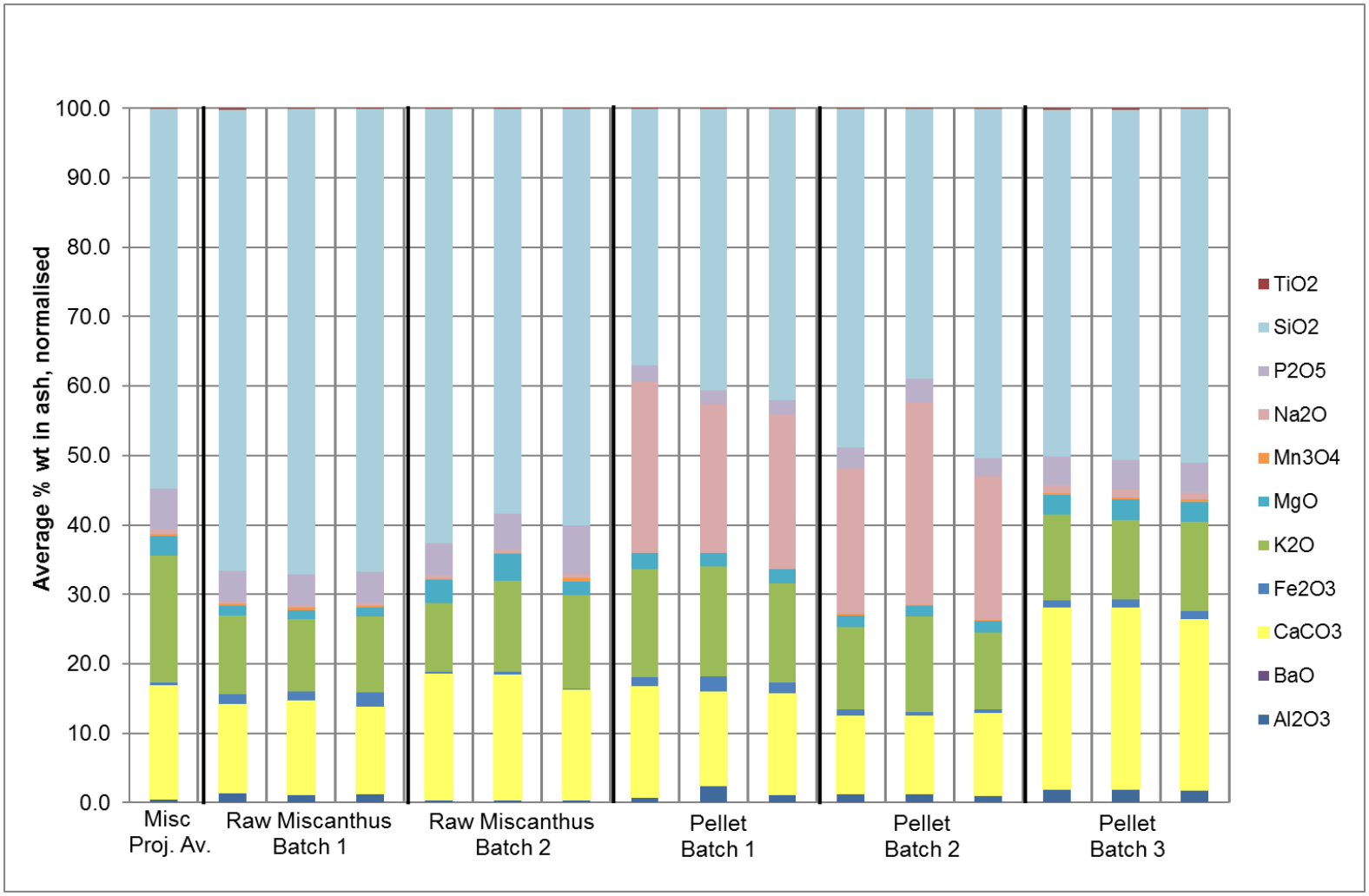
ETI - Characterisation of Feedstocks – Comparison with White Wood Pellets: Zinc



Miscanthus LINK: Variation of chlorine in *Miscanthus* hybrids with site and strain



Do you ever buy Biomass Pellets ?!



Slagging & Fouling

- Traditional indices used for coal, as well as ash fusion temperature:

  Base/Acid Ratio = $(Fe_2O_3+CaO+MgO+Na_2O+K_2O)/(SiO_2+Al_2O_3+TiO_2)$

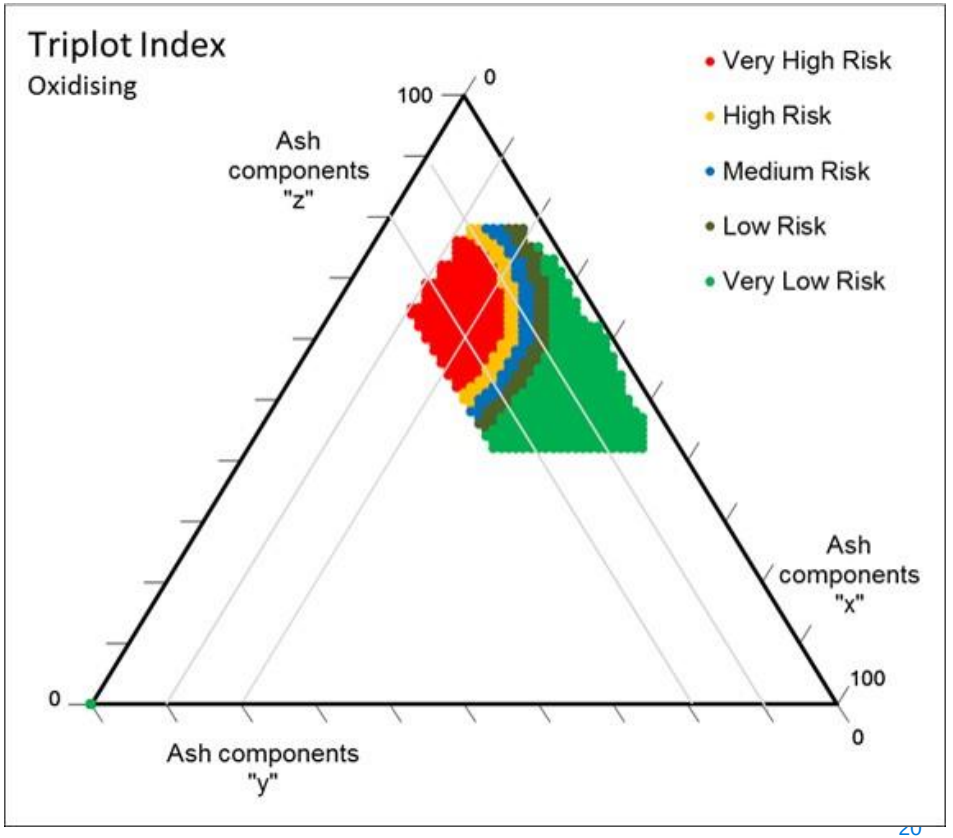
  Slagging Index = B/A x S% (dry)

  Fouling Index = B/A x Na_2O%

- Biomass-specific indices
  e.g. Alkali Index
  kg (Na_2O+K_2O)/GJ (GCV dry)

- Uniper has recently developed new triplot risk indices based on ash composition of coals using extensive databases

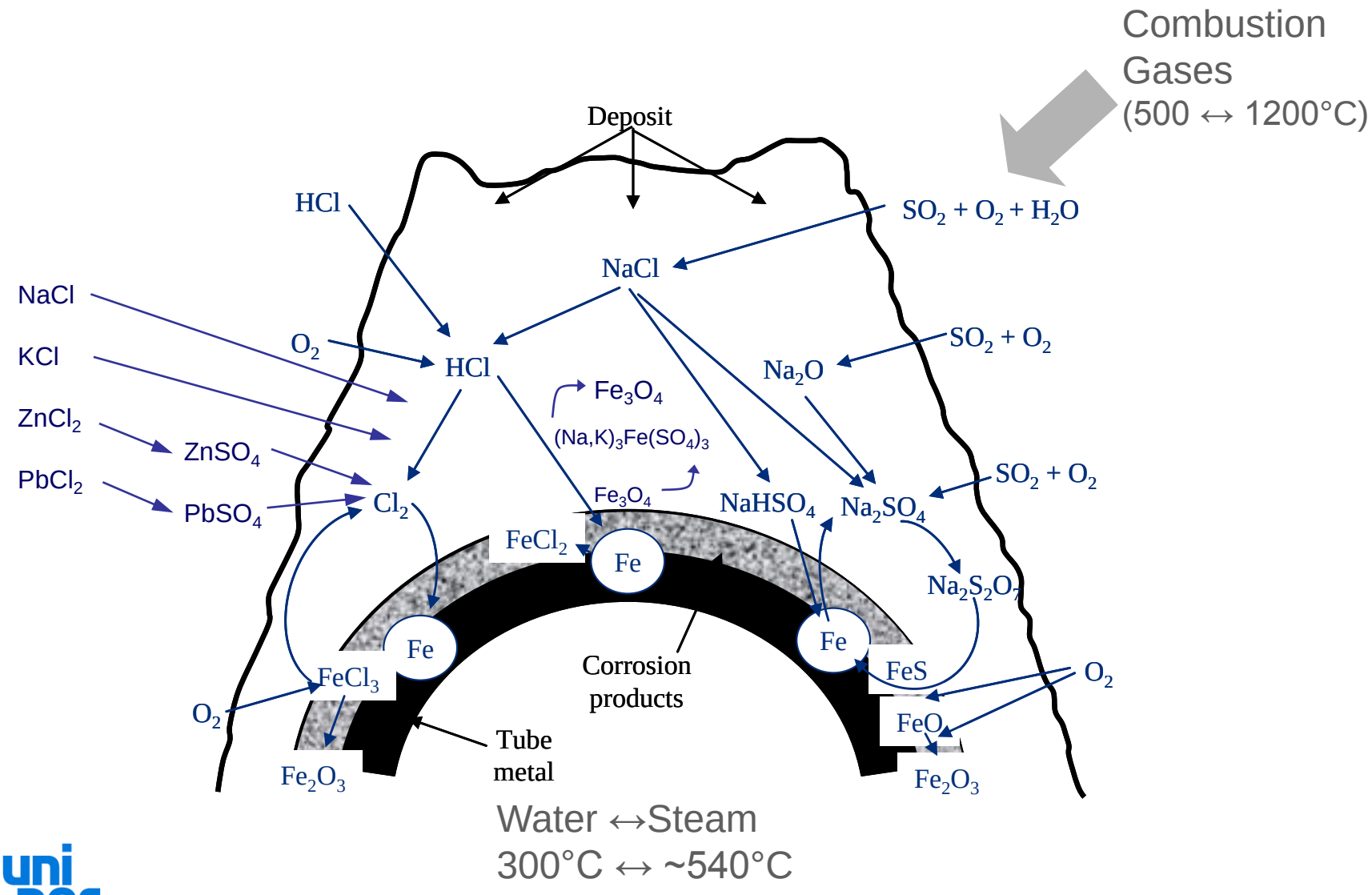
- Uniper is developing similar risk indicies for biomass fuels, work ongoing



Corrosion

- Alkali & Heavy Metal Chloride based corrosion
- Metal temperatures
- Stoichiometry
- Flue gas velocities

Corrosion Damage Mechanisms



Biomass Ash

- Generally consists of Bottom Ash (IBA) and Air Pollution Control Residue (APCr) (plus boiler ash)
- Impacts on operation - IBA agglomeration/ extraction from furnace
- New biomass/waste wood plant are directed to Env. Services Assoc. (ESA) IBA Protocol for hazard assessment - is this appropriate for waste wood ??
- APCr is deemed ‘hazardous’ when containing lime & activated carbon
- Can we re-use biomass ash ?
- UK Quality Ash Association – biomass ash (only Drax)
- Is there a need for a Biomass/ Waste Wood Ash Community ?



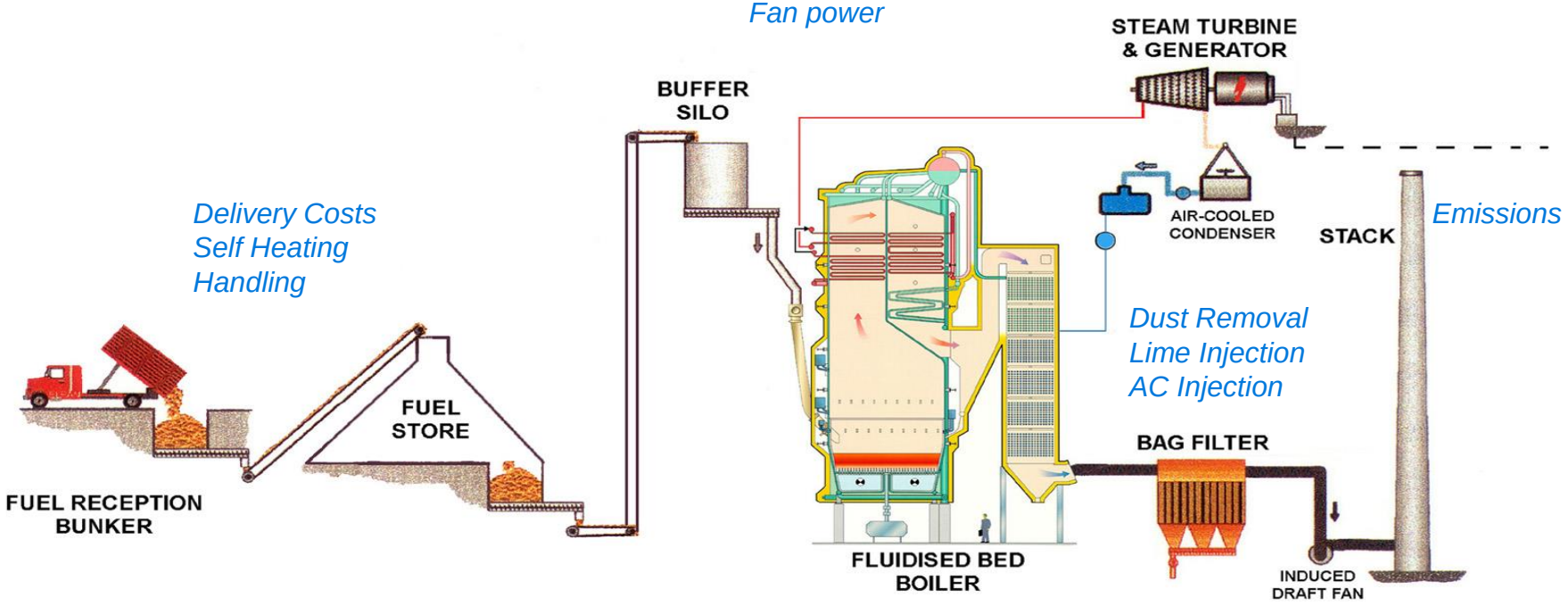
Modelling Fuel Quality Impacts

- Aims to calculate the costs of operating a plant with a given fuel
- Allows assessment of whether cost effective to look at:
  - Alternative fuels
  - Upgrading or blending existing fuels

- Optimize performance & costs
- Quantify benefits of plant improvements/upgrades that give enhanced fuel flexibility

Fuel Quality Impacts

Ash Deposition
Erosion & Corrosion
Heat Transfer
Combustion Stability
Bed/Grate issues
NOx control
Urea injection
Fan power



Delivery Costs
Self Heating
Handling

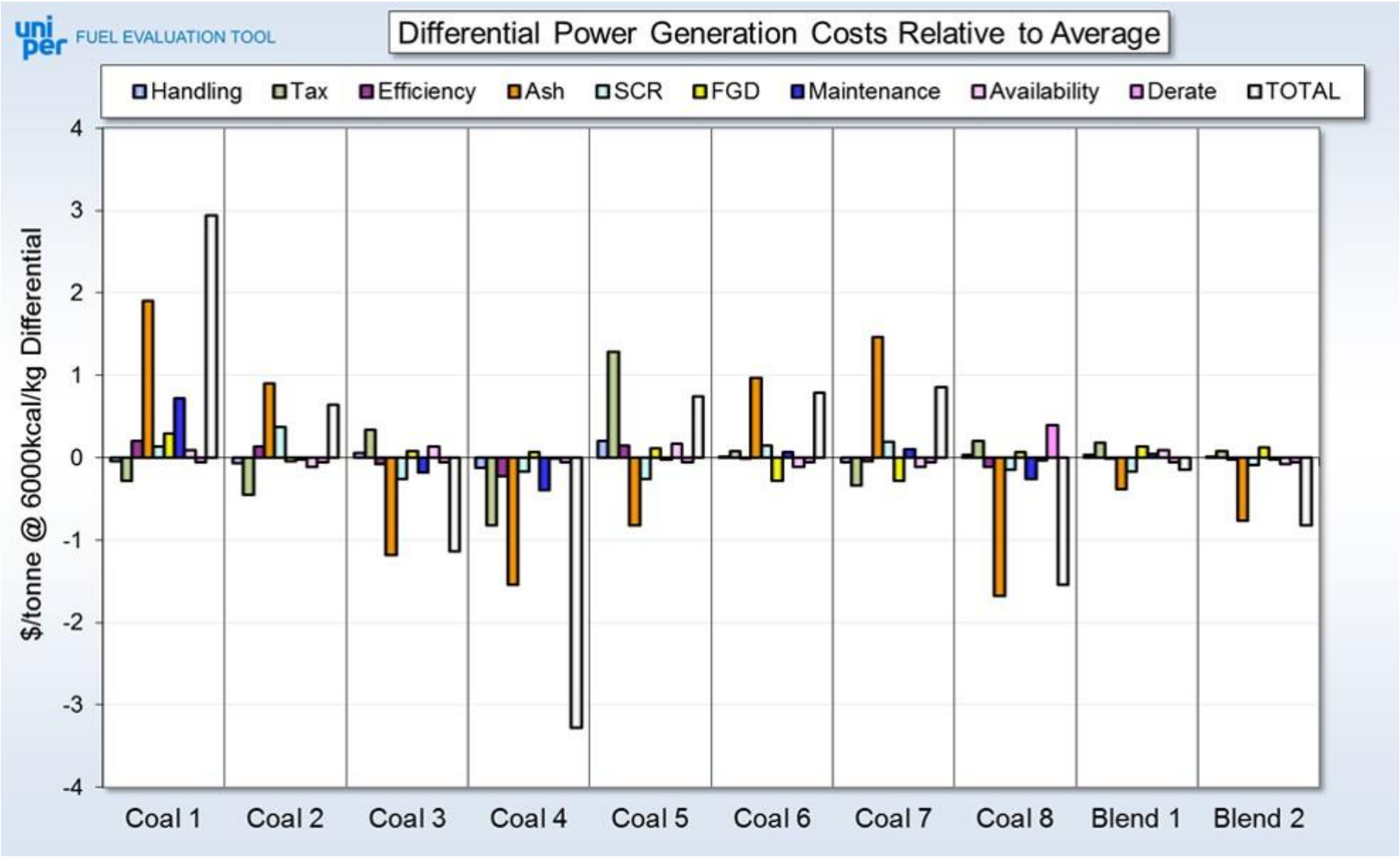
Emissions

Dust Removal
Lime Injection
AC Injection

Ash Removal/ Agglomeration
(Sand Consumption)

Ash Production/ Saleability

Plant performance impacts



Thanks for listening !