WP AC1: BECCS – Capture Theme (Combined Systems and Capture)

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Dates: **1st April 2017 – ongoing**

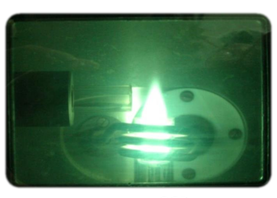
Project overview and objectives

BECCS – bioenergy coupled with carbon capture and storage – is critical for achieving UK and global CO_2 reduction commitments, with much previous research demonstrating the importance of practical trials to build industrial confidence in the technology. Here, pilot-scale testing at PACT is assessing air- and oxy-combustion of a range of fuels, including North American Grade A **white wood**, short-rotation coppice (SRC) **willow** and Grade A **recycled (waste) wood** from clean pallets.

Main objective: to identify key species/pollutants from combustion and evaluate their impacts on solvents and capture plant operation, with:

- extensive analysis of **combustion gases** (through FTIR)
- assessment of real-time entrained **metal aerosol** release (via ICP-OES)
- an examination of **submicron particulate matter** formation, including online particle size and concentration (using DMS)


Gasmet DX4000 FTIR analyser


Spectro CIROS^{CCD} ICP-OES

Cambustion DMS500

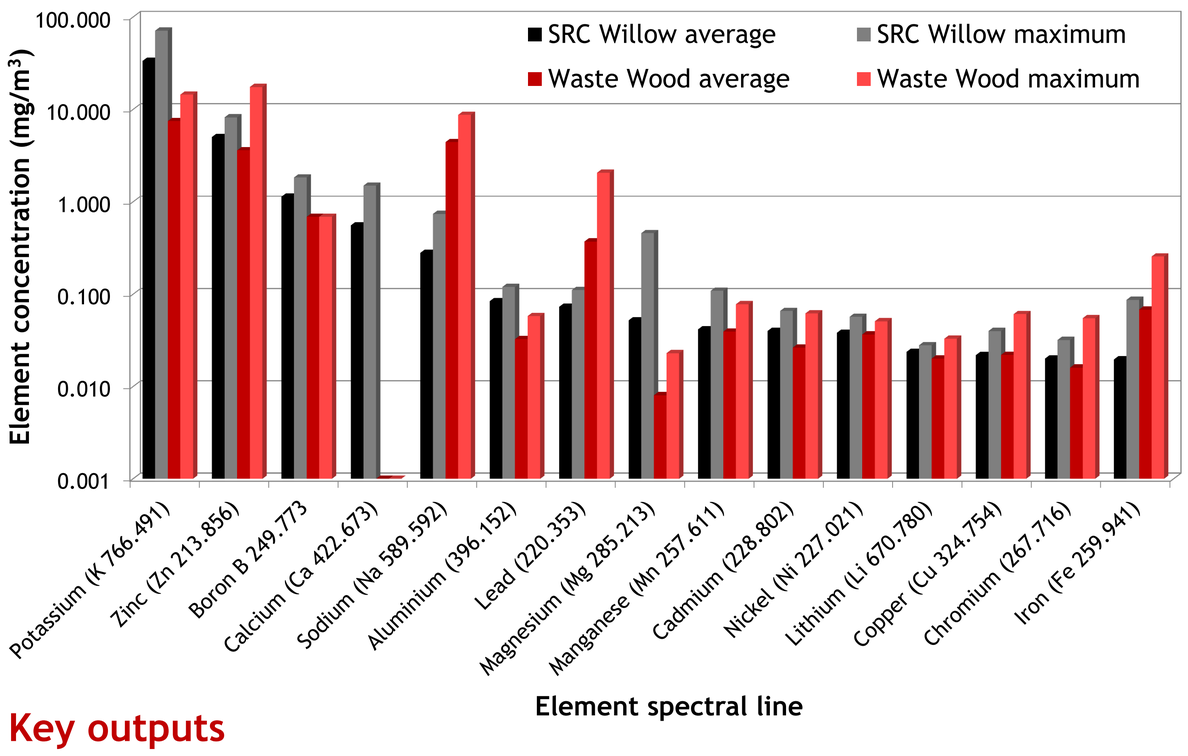
This enables better understanding of element partitioning from these fuels under a range of realistic pilot-scale conditions, leading to the formation of comprehensive and novel datasets on the fates of specific species.

Research highlights (i)

ENTRAINED METAL AEROSOLS

	SRC Willow	Waste Wood	White Wood
Key Elements in Fuel	Ca, K, Zn	Ca, Fe, K, Mg, Na, Zn	Ca, K, Mg, Zn
Combustion Type	grate-fired	grate-fired	pulverised
Key Elements as Aerosols	K, Zn	Al, Fe, K, Pb, Zn,	K

- **K** emissions from the SRC willow were much greater than for the waste
- Average levels of **Pb/Fe** from the waste wood were significantly higher
- **Hg** aerosols were not detected for either flue gas, and only low levels of other heavy/toxic metals (**As/Cr/Cd**) were observed
- Considerable temporal variation in the amount of metals released from the waste wood due to its heterogeneous nature

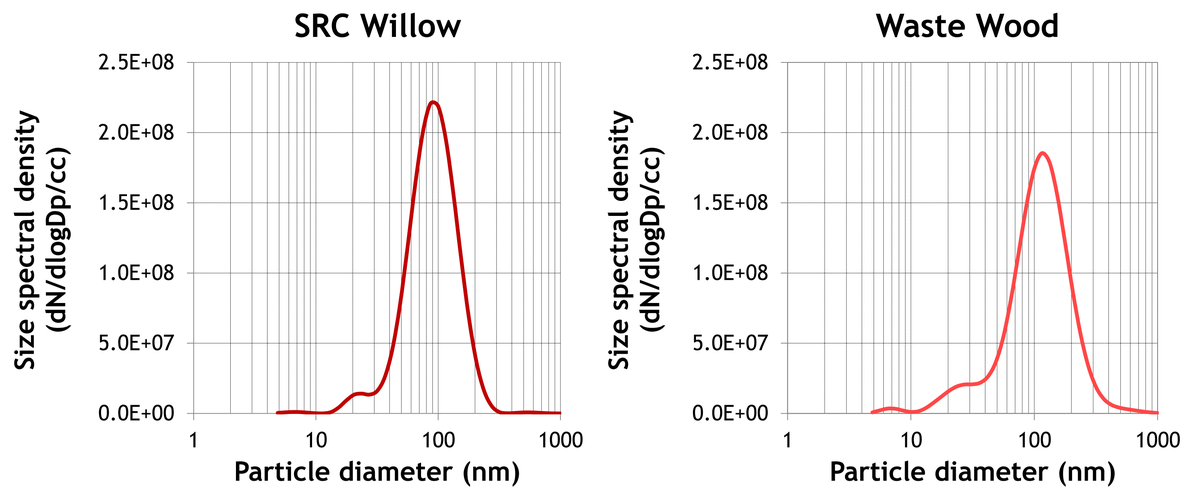


Research highlights (ii)

SUBMICRON PARTICLES

	SRC Willow	Waste Wood
Total (N/cc)	107,637,062	102,449,915
Geometric Mean Diameter (nm)	86.54	103.03
Geometric Standard Deviation of Diameter	1.66	1.95
Count Median Diameter (nm)	89.59	111.18

- The waste wood had a slightly lower total particle concentration
- The SRC willow had smaller particles present on average

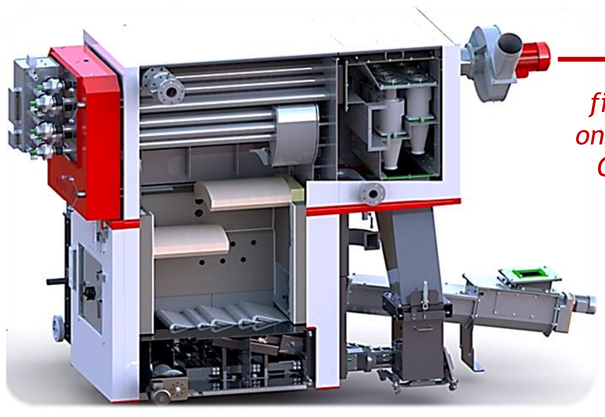


Emerging findings

- The release profiles of entrained metal aerosols showed that waste wood had greater levels of transition metals that can negatively impact capture solvents through initiating/catalysing oxidative degradation
- Due to the differences in gas cleaning between the grate-fired and pulverised burners, grate combustion released many more submicron particles, which can also negatively impact capture performance
- Although ash fusion temperatures were similar, the initial deformation and softening temperatures were lower for the waste wood, indicating more deposition may occur
- Oxy-fuel combustion, compared to air-firing, released much greater levels of metals in the gas-phase due to the variations in the operating conditions and in-furnace environment (combustion/oxidising regime)

Next steps

- Full integration of combustion and capture plants, to assess impacts of alkali/transition/heavy metals on: (i) oxidative solvent degradation and corrosion of capture solvents, and (ii) contamination of high-purity CO_2
- Focus on waste/contaminated fuels with higher concentrations of trace elements that can be detrimental to solvent integrity and plant performance; further research at PACT will provide valuable data on operating CCS under waste-to-energy conditions



filtered flue gas to onsite, solvent-based CO_2 capture plant

Key outputs

- Finney, K.N., Akram, M., Diego, M.E., Yang, X. and Pourkashanian, M. (2019) 'Carbon Capture Technologies', in: Pires, J.C.M. and Gonçalves, A.L.d.C. (eds.) *Bioenergy with Carbon Capture and Storage: Using Natural Resources for Sustainable Development*, Elsevier: UK, pp. 15-45
- Finney, K.N., Szuhánszki, J., Milkowski, K. and Pourkashanian, M. (2019) Comparative analysis of entrained metal aerosol release profiles from biomass combustion under different firing regimes, submitted to *Fuel*

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