SUPERGEN Bioenergy Hub

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Emissions from Domestic Biomass Combustion

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Background

Hub Research Projects

1. **Emissions from solid biomass combustion** led by Newcastle University
2. **Impact of feedstock parameters on airborne emissions** led by University of Leeds
3. **Evaluation of Synthetic natural gas** led by University of Bath
4. **Streamlining the supply chain** led by Rothamsted Research
5. **Carbon uncertainties in the supply chain** led by The University of Manchester
6. **Gasification integration** led by Newcastle University

Targeting GHG emissions from heat (RHPP, RHI and Green Deal) has led to a wood burning renaissance

Simplistic technology – uncontrolled and unabated

In the UK, Clean Air Act and RHI place emission limits on appliances when tested to standard methods (BS PD 6434 and BS ISO 9096)

Variety of emissions limits / test standards around the world

Materials & Methods

Experimental work

6 kW_{th} fixed grate multi-fuel stove

1) Commercially available solid fuels:

- Polish coal
- Peat briquettes
- Low smoke mineral fuel
- Smokeless fuel
- A 50:50 coal/biomass blend
- Mixed wood
  (hardwood logs, pellets, billets, dimensioned pine)

2) Self-sourced fuels:

- Peat turf
- Local cut air-dried mixed wood logs

Materials & Methods

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3) Novel fuels:

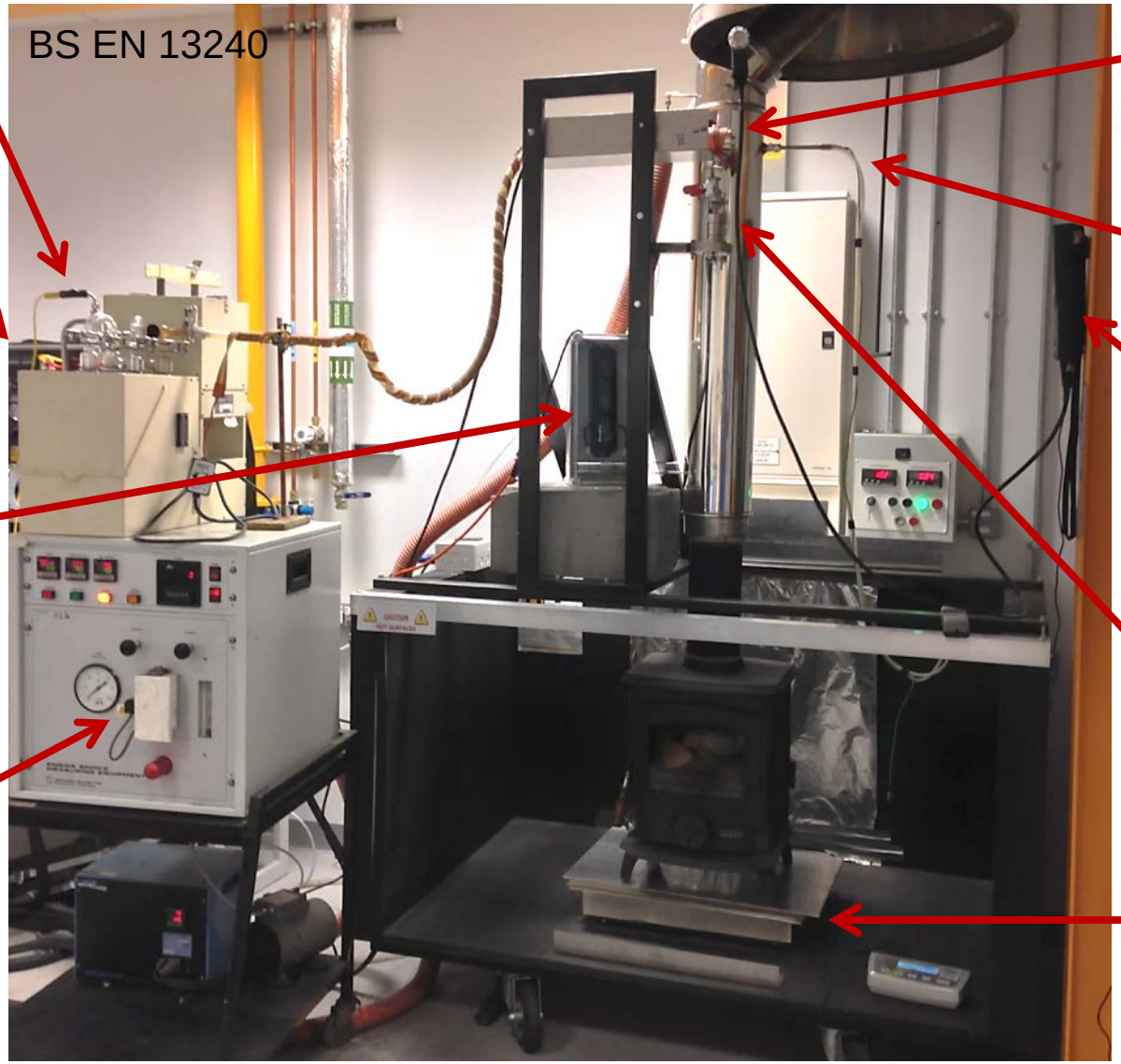
- Sunflower husk
- Straw
- Willow (SRC billets & logs)
- Reed briquettes

4) Pre-treated fuels:

- Torrefied wood briquettes
- Torrefied olive stone
- Washed fuel (reed, straw, willow)

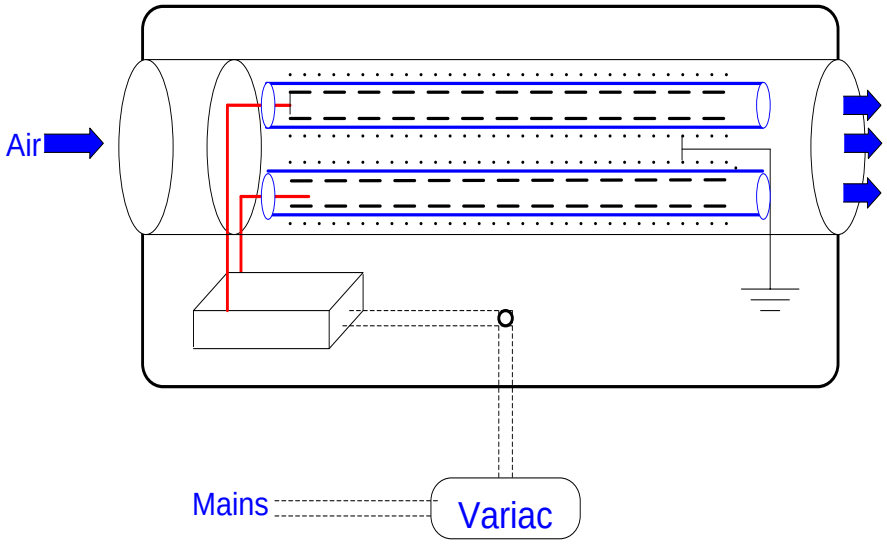
Varying levels of K, Cl, Na and Ca

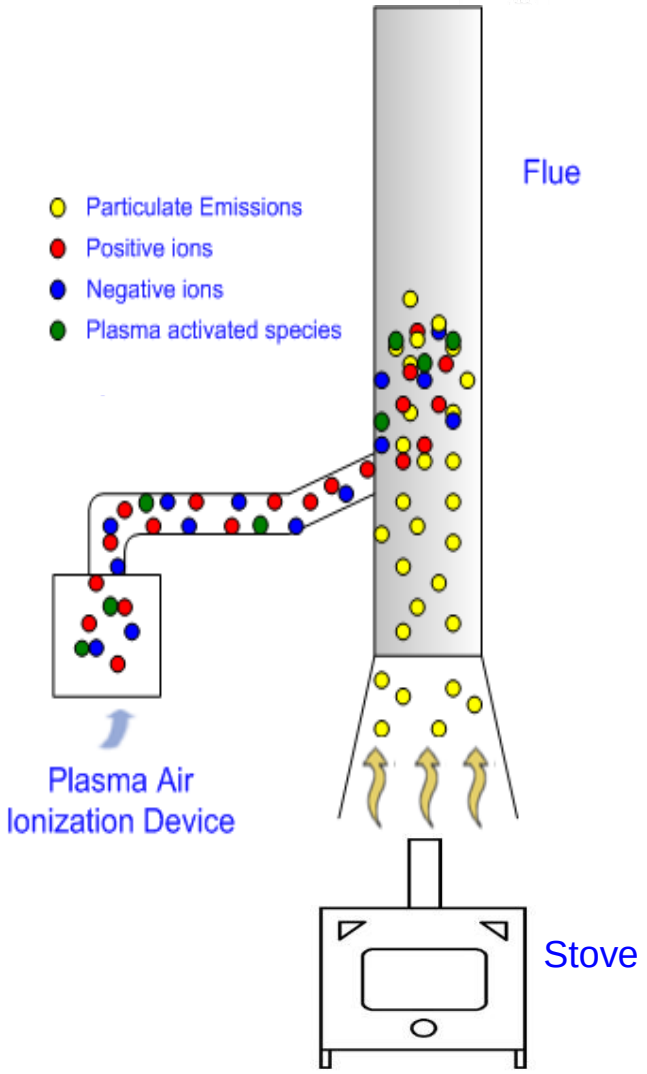
Experimental setup



Experimental setup

Ioniser [low power (5-10 W), cheap (£20), quiet]





In **dry air**, ioniser generates:
e^-, O_2^+, O_2^-, $O_2(a^1\Delta_g)$, $O(^3P)$, $O(^1D)$, O_3
$N_2(A^3\Sigma u^+)$, $N_2(B^3\Pi_g)$, $N(^4S)$ and $N(^2D)$.

In **humid air** or **flue gas**, ioniser also generates:
H, OH, HO_2 and H_2O_2.

Results
Effects of fuel properties

* Results were presented comparing the PM10 and PM2.5 emissions factors for several commercially available fuels. *

* It was found that wood and coal fuels exceeded 200 mg/MJ and only the smokeless fuel, low smoke fuel and torrefied wood briquettes met the RHI emissions limit of 30 mg/MJ *

Results
Effects of fuel properties

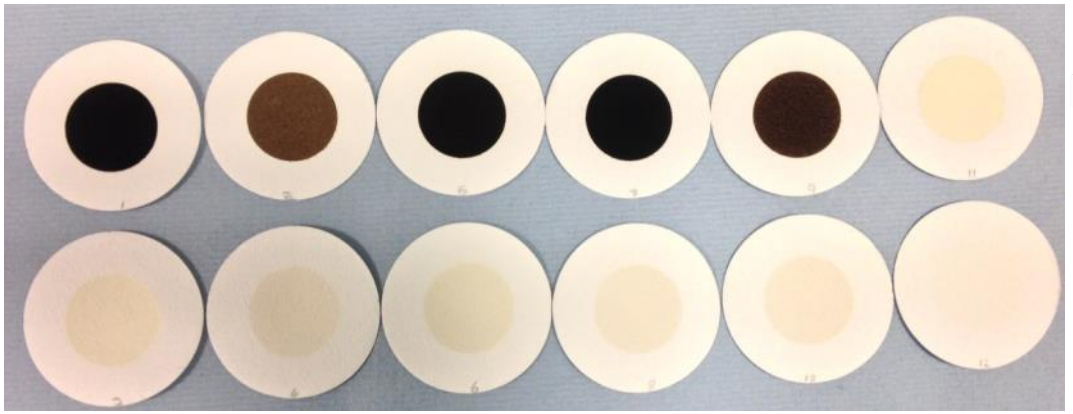
* Results of trace element analysis showed high levels of Cl, Na, K and Ca in the reed briquettes *

- Evidence of ash melting with some fuels
- Analysis of impinger water underway

Results
Effects of fuel properties

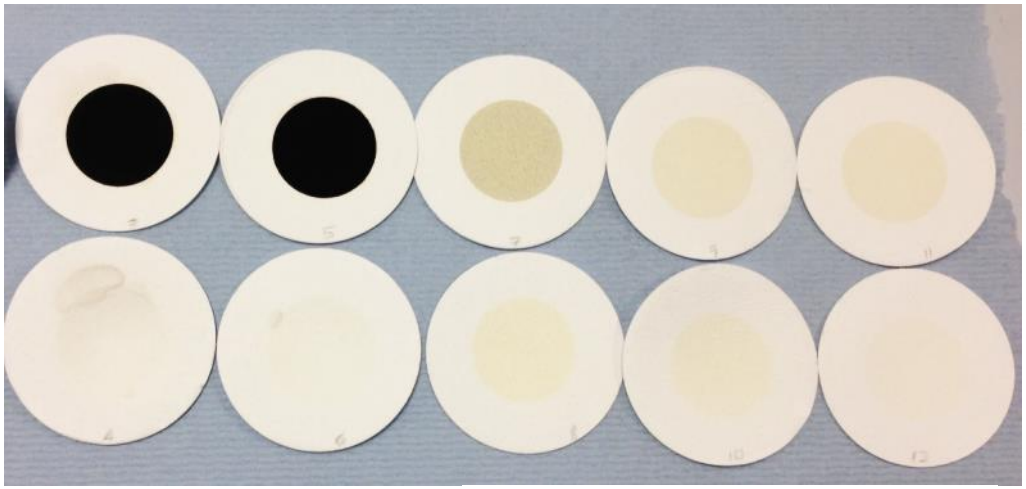
Results
Effects of fuel properties

Ash logs



Results
Effects of fuel properties

Pellets



Effects of plasma on PM

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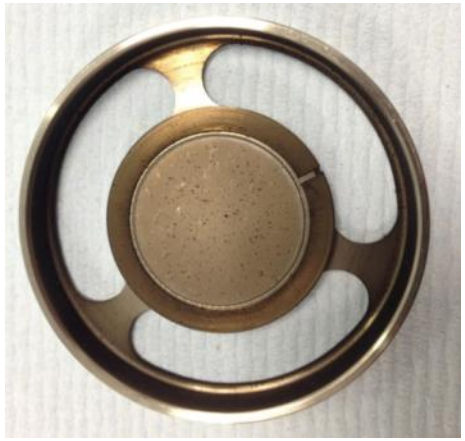
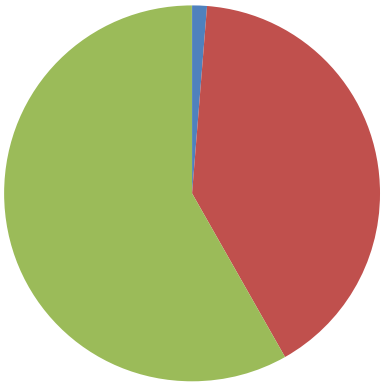
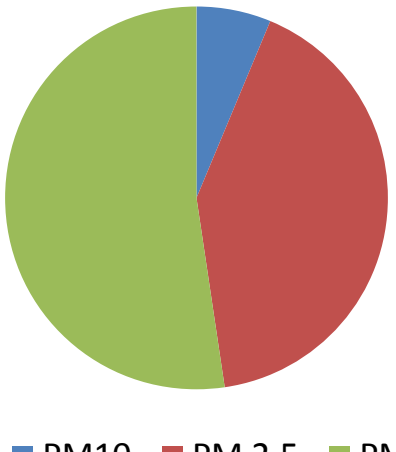
	PM_{10} stage	$PM_{2.5}$ stage	Distribution	Impingers
Without plasma				
With plasma				

Effects of plasma on PM

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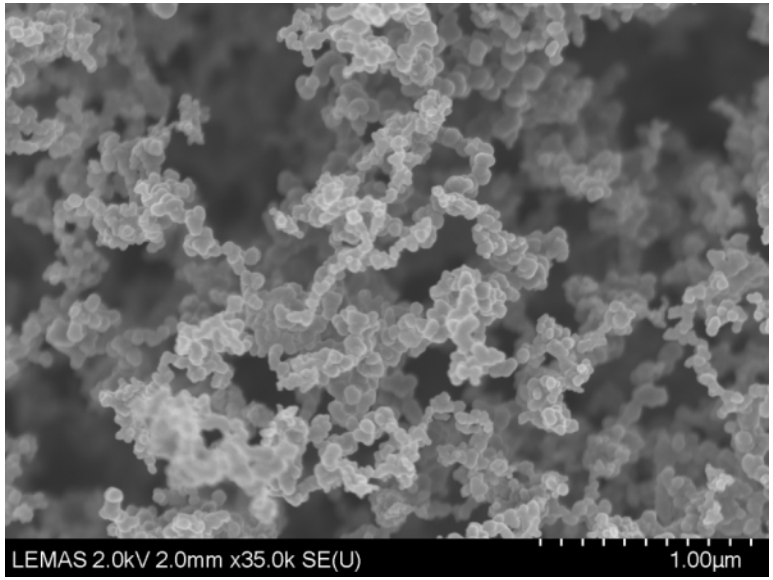
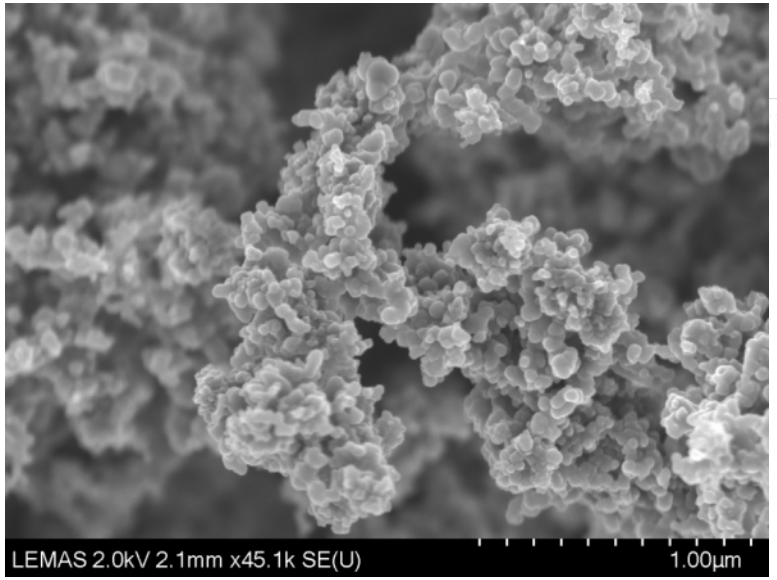
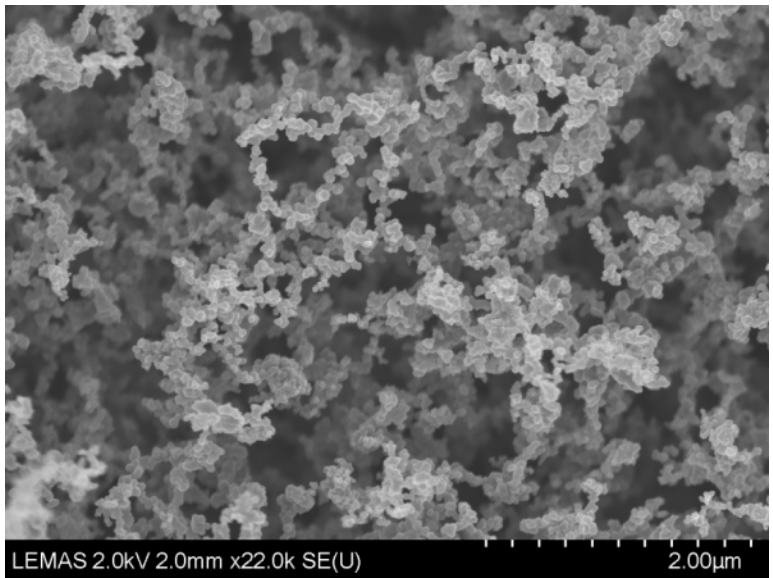
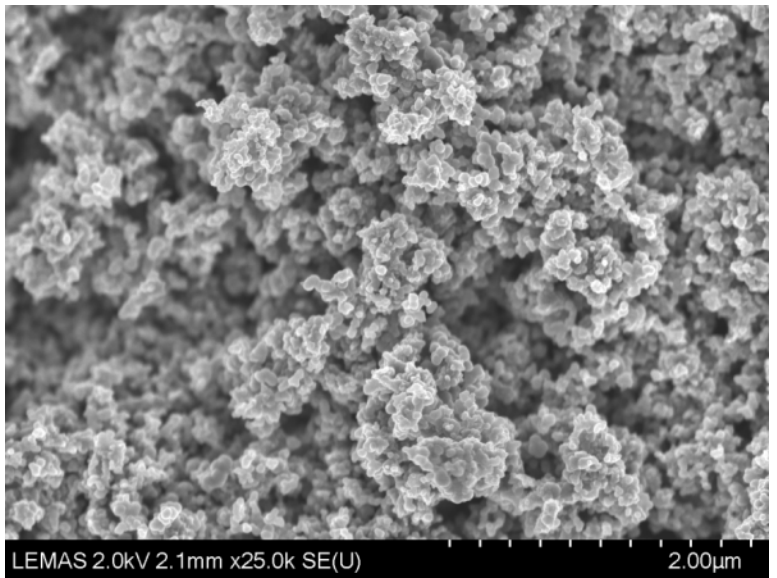
With-out plasma









With plasma

Effect of plasma on NO_x

* Results showed that some NO was being converted or destroyed with the plasma applied *

* NO2 peaked towards the end of the run *

	k_{298} (cm^6 $molecule^{-2}$ s^{-1}) (NIST database)
$NO + O_3 \longrightarrow NO_2 + O_2$	1.8 x 10^{-14}
$NO + O \longrightarrow NO_2$	1.0 x 10^{-31}
$CO + O \longrightarrow CO_2$	1.16 x 10^{-36}

Conclusions

- Domestic solid fuel combustion already contributes significantly to ambient air pollution across the world
- Increased numbers of boilers/stoves increase levels of fine PM, NO_x, CO and PAH/VOC
- Feedstock parameters and operating conditions significantly influence emissions of pollutants
- A novel plasma device has been found to increase particle size from PM_1 to PM_{10} and $PM_{2.5}$ and convert NO to NO_2
- Further testing is underway to examine the effects of plasma on downstream agglomeration of particles and formation of POA

Acknowledgements & References

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Thank you

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