An Introduction to.....

CHALLENGES OF INCREASING BIOMASS FUEL FLEXIBILITY WHILE MAINTAINING RELIABILITY FOR BIOMASS CHP
Resolving complex emissions challenges for coal, oil, gas and biomass-fired plant through the application of innovative, cost-effective solutions.
Combustion expertise across every fuel type: All coals, lignite, gas, oil, biomass and waste matter

RJM Solution

- Extensive Experience
- Quality Manufacturing
- Professional Management
- Engineering Excellence
- Close Client Collaboration
- Uncompromised Safety
- Extensive Experience

Highly confidential – Protected information
Overview of Presentation

- Introduction
- Why increase fuel flexibility?
- Plant Capabilities & Limitations
- Fuel Options
- Feasibility & Trials
- Looking Forward
Drivers for fuel supply flexibility in the UK

- Fuel requirement depending on plant up to ~400,000 t/y
- Operational, in construction and planned plants mean in the next 2 – 5 years there will be ~900MW of installed capacity firing recycled wood
- On an annual basis the UK market could be short by up to c.500,000 t
- Seasonal winter shortage
- Impact of the pandemic
Biomass CHP

Key Boiler Components

- Virgin wood
- Recycled wood
Plant capabilities and limitations – MHS

Fuel unloading
- Truck unloaders
- Walking floor lorries
- Sampling
- Two separate streams

Fuel storage
- Three silos
- Tube feeders
- Feed from either stream to any silo

Boiler feed
- Can feed from both or either stream
- Capacity of conveyors

Fuel flow characteristics - Contamination Variability Moisture Particle size
Plant capabilities and limitations - Combustion

Circulating Fluidised Bed combustion process has several key advantages:
- Additional turbulence gives more effective chemical reactions and heat transfer.
- Lower temperatures than traditional PF units mean lower NOx formation – CFB 760-930°C vs PF >1200°C.
- Increased variation of fuel diet.
- WID compliant units – residence time in furnace at temperature above 850°C for 2 seconds (can burn recycled waste wood).
- Can inject CaCO₃ to bed to remove SO₂ from flue gas.

Issues:
- Corrosion
- Erosion
- Slagging
Plant capabilities and limitations - Emissions

- Main emissions from virgin wood → Particles → SO2
- Main emissions from recycled wood → Particles → Acid gases (SO2, HCl, HF) → Heavy metals → Dioxins and furans
  - Bag house filter → Captures fly ash and reaction products
  - Calcium hydroxide Ca(OH)2 → Absorbs acid gases
    - Dosing amount is controlled automatically basing on emission measurements in the stack
  - Activated carbon → Absorbs gaseous heavy metals, dioxins and furans
    - Dosing amount adjusted automatically basing on flue gas flow

Ash – potential for increased levels of carbon, contamination, tramp

Costs incurred with increased reagents
Fuel options

- Agricultural residues
  - Biomass pellets
  - Briquetted wood fines
  - Brash
  - Compost oversize
  - Straw

- Byproducts & waste
  - Olive residue
  - SRF
  - Poppy seed residue
  - Oat husk
  - Carpet residue

<table>
<thead>
<tr>
<th>Fuel type – where and how transported, how stored</th>
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<tbody>
<tr>
<td>Issues with transport</td>
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<tr>
<td>Blending opportunities – fuel flexibility</td>
</tr>
<tr>
<td>Suppliers – size, seasonality, processing capability</td>
</tr>
<tr>
<td>Fuel quality &amp; variability</td>
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<tr>
<td>Market forces – availability &amp; price</td>
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<td>Sustainability</td>
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</table>
Fuel quality

SRF Material Identification/Classification

- Treated wood
- Tissues
- Textile/fabric
- Stone/ceramic
- Shoes
- Sanitary products
- Rubber/leather
- Plastic film
- Paper/card
- Other packaging plastic
- Other
- Non-Femetal
- Hazardous
- Glass
- Fluff
- Fines < 10 mm
- Ferrous metal
- Durable plastic
- Composites
- Cinders
- Cartons
- Carpet/mats
- Cables
- Biological
- Batteries

SRF composition

Waste wood variability

Fuel quality

M. Agaristas et al. / Fuel 89 (2010) 3693–3709

Costas Velis, Env Sci. & Tech., 46(3), 2012

Highly confidential – Protected information
Feasibility

- Key to increasing fuel flexibility is to have a comprehensive process to follow which assesses the impact on each part of the plant and operations.

- Questions to answer:
  - Materials Handling – can you feed the boiler demand?
  - Combustion & Emissions – can you burn the fuel reliably and efficiently while meeting regulatory requirements?
  - Can you burn the fuel safely?
  - Is there an economic case?

*Introducing a new fuel to an existing plant requires a holistic approach*
## Areas of concern

<table>
<thead>
<tr>
<th>Fuel Consideration</th>
<th>RJM Rating</th>
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<tr>
<td>Fuel variability and tramp</td>
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<tr>
<td>Material handling</td>
<td>🟢</td>
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<tr>
<td>Size reduction</td>
<td>🟥</td>
</tr>
<tr>
<td>Combustion stability at high co-firing rates</td>
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<td>Combustion of heterogeneous material</td>
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<td>Corrosion risk (Cl based)</td>
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<td>Safety</td>
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<td>Erosion</td>
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<td>NOx emissions</td>
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<td>Ash behaviour – slagging and fouling</td>
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<tr>
<td>Ash disposal</td>
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<td>PaHs, PCBs and dioxins</td>
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## Risks and Mitigation (example)

<table>
<thead>
<tr>
<th>Risk</th>
<th>Cause</th>
<th>Consequence</th>
<th>Mitigation</th>
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</table>
| Corrosion                                  | High chlorine content in the fuel                                      | Excessive tube damage                                                    | • Fuel supplier limits the Cl content in the fuel  
• Co-fire with a low Cl content fuel  
• Use of additives applied to the pellets  
• Use of additives added in the furnace  
• Plasma coating of boiler tubes         |
| Non-compliance with Environmental Legislation (IED / BREF) | Alteration in fuel (away from specification)  
Misoperation of secondary control systems | Loss of generation, loss of income, prosecution | • Project to include detailed combustion system  
• Assessment of boiler during design phase/operation  
• Routine sampling of fuel  
• Return to service plan in place     |
| Liberation/deposition of fuel dust         | Due to poor handling of the fuel pellets                               | Potential for fires/explosions to occur resulting in occupational health risks to employees and damage to equipment | • Design system for containment as far as practicable  
• Compliance with NFPA regulations  
• Plant practice to clean “dusty” surfaces  
• Silos designed with bursting discs to keep dangerous atmosphere away from personnel |
| Asphyxiating gas build up in confined spaces | CO released from fuels while in fuel store                             | Occupational health risk to employees                                    | • Gas monitoring systems  
• Operator training and personal gas monitors |
| Tramp metal / foreign objects delivered in fuel | Poor quality of fuel production                                        | Damage to plant, especially hammer mills. Fire and Explosion             | • Design to incorporate suitable staged screening and separators.  
• Fire detection to be installed as required. |
| Risk of non-combustion of the new fuel     | Combustibility testing is limited  
No previous experiences of anyone burning this as PF                     | Loss of generation  
Large particles fall out of the furnace                                   | • Maximise testing in project FEED stage  
• Use of expert knowledge and experience in SRF combustion  
• Combustion trials  
• Burn out grate has been costed as potential solution |
| Materials handling                         | Material chemical makeup may cause self-heating  
Incorrect milling                                                      | Fire risk  
Poor combustion burnout                                                   | • Fuel testing prior to implementation  
• Milling trials |

Risks and mitigation are reviewed in detail in the table above. The table lists various risks associated with fuel and their corresponding causes, consequences, and mitigation strategies. Each risk is addressed with specific measures to prevent or manage the potential issues efficiently.
## Alternative Fuel Matrix

### Commercial

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<th>7500</th>
<th>1800</th>
<th>5000</th>
<th>30000</th>
<th>30000</th>
<th>15000</th>
<th>300000</th>
<th>50000</th>
<th>100000</th>
<th>150000</th>
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<td>Biomass content</td>
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### Legislation

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### Logistics/Material Handling

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### Technical

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</tbody>
</table>
Fuel trials – oat husk

Conclusions

- Off site blending & storage
- Fuel mix for dust control & off loading
- No issues with reclaim
- Management of blend ratios & shut downs
- Combustion & emissions acceptable

- Monitoring of flow characteristics
- Bed temperature control
- Flue gas temperatures
- Emissions monitoring
- Ash monitoring
Fuel trials – SRF

Conclusions

- All fuels blended successfully to meet required biomass content
- Feed to boiler acceptable
- Longer term potential fuel quality issues depending on variability
- Combustion & load acceptable
- Emissions within limits
Looking Forward

Continuing pressure on waste wood supply, emissions and operational flexibility

- Understand the fuel
- End to end plant performance
- Innovate to stay competitive
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