Coal & Biomass Characterisation for a Power Generator

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Uniper Technologies Ltd

Fuel Technology

• UKAS ISO 17025 accredited fuel testing laboratories
• Supporting Uniper UK, E.ON UK and external customers
• Fuel quality consultancy services
• Coal stock density & quality surveys
Current Challenges - Coal

- Tightening of Emissions (IED)
  - NOx reductions (without SCR)
  - SO₂ (FGD upgrades/ lower S% coals)

- Coal is struggling
  
  Low price of oil/gas
  
  Carbon Price Support (CPS) - now £18/te CO₂ (~£40/te of coal)
  
  Growth of Renewables
  
  Political outlook (2025 statement)

- Fuel diet is becoming increasingly critical
  
  Low NOx, low sulphur coals
  
  CPS exemption – ‘Coal slurry for use in electricity generation’
Current Challenges - Biomass

- **Cost vs. quality**
  
  Only clean wood pellet is commodity traded
  Quality standards apply for pellets (ISO 17225-2: 2014)
  Other biomasses cheaper but limited volumes & variable quality
  Energy is a new market for biomass growers and suppliers

- **Sustainability**

- **Steep learning curve**
Fuel Quality Impacts

- **Coal Handleability**
  - Self heating
  - Mills
    - Mill power, grind quality, mill wear, coal drying

- **BOILER**
  - Combustion Stability
  - Heat transfer
    - Slagging
    - Fouling
      - Erosion and Corrosion
      - NOx removal

- **SCR**
  - Particulates Removal
  - Fan power

- **AIR HEATER**
  - Ash Saleability

- **ESP**
  - SO2 removal

- **FGD**
  - Gypsum Quality

- **Emissions**
The Importance of Sampling and Preparation

- Often overlooked, but a critical step in the process (ISO 13909)
- Representative sample division and size reduction
- Periodic checking to ensure sampling processes are bias free
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/ proportion of fines
• Less routine
  Ash Fusion Temperature
  Petrography/char analysis
  Spontaneous combustion testing
  Bulk density
  HGI/FSI etc…
Key Fuel Quality Parameters

• Calorific Value
  Basic standard of value for any fuel.
  Coal pricing is often based on a NCV of 6000kcal/kg (25121kJ/kg) adjusted for the actual CV.
  EU Emission Trading Scheme, power station heat accounts

• Moisture
  Unwanted ‘inert’, reducing NCV
  Can affect fuel handleability
  Critical to ensure biomass pellets are kept dry

• Ash
  Unwanted ‘inert’, reducing NCV
  High ash – more fuel required, more ash to collect/dispose/sell
  Ash deposition – impacted by overall ash content and composition
Key Fuel Quality Parameters

- Volatile Matter
  - Minimum to ensure flame stability
  - Maximum to ensure mill safety/spontaneous combustion
  - Impact on NOx

- Chlorine & Sulphur
  - Acid gas emissions
  - Corrosion (biomass and coal)

- Carbon, Hydrogen, Nitrogen
  - Carbon – EU Emission Trading Scheme
  - Hydrogen – NCV calculation
  - Nitrogen – NOx impact
Key Fuel Quality Parameters

• Ash Composition and Ash Fusion Temperatures
  Traditional indices:
  Base/Acid Ratio = \( \frac{(\text{Fe}_2\text{O}_3+\text{CaO}+\text{MgO}+\text{Na}_2\text{O}+\text{K}_2\text{O})}{(\text{SiO}_2+\text{Al}_2\text{O}_3+\text{TiO}_2)} \)
  Slagging Index = \( \frac{\text{B/A}}{\text{S\% (dry)}} \)
  Fouling Index = \( \frac{\text{B/A}}{\text{Na}_2\text{O\%}} \)

• Uniper has recently developed new risk indices based on ash composition

• Alkali chloride mediated corrosion in biomass plant as well as slagging & fouling issues
Key Fuel Quality Parameters

• Trace Elements
  Main concern is environmental
  Arsenic – SCR catalyst poison
  For biomass plant (waste wood in particular) limits to protect against corrosion (Zn, Pb)
  Occupational Health risks from ash deposits
  Biomass ash disposal costs (Hazardous waste classification)

• Biomass Purity Assessment (mixed materials)
  Handpicking
  Chemical marker
  Dissolution method
  Carbon 14 isotope dating
Key Fuel Quality Parameters

• Biomass Pellets
  Durability & fines determination
  Particle size within pellets (for PF plant)
  Very hydrophillic
  Handleability, dust, decomposition

• Others – more ad-hoc
  Petrography focussed on Russian coals
  FSI (US coals) links with burner slagging ?
  Spontaneous combustion assessment – e.g. Indo/ PRB/ Kazakhstan
Data Interpretation

[Graph showing data for TOTAL and Mine 1 to Mine 4 with frequency on the y-axis and Volatile Matter %daf on the x-axis, with 5%, 10%, 90%, and 95% confidence intervals indicated.]
Data Interpretation
Data Interpretation

Graph showing the Ash % in Dryfuel for different materials:
- Green waste
- Forestry woodchip
- Waste Wood
- Miscanthus
- Wood Pellets
Modelling Fuel Quality Impacts

- Coal buyers aim to minimize the fuel price ($/GJ, $/Btu) delivered to the plant
- The true value of coal is the cost of generating electricity from the coal
- Many fuel quality factors affect plant performance and operating costs,
- Value in Use analysis aims to identify the best value fuels.

Coal Price → Delivery
- International Freight
- Port costs
- Inland transport

Power Plant Operation
- Efficiency
- Reagents & By-products
- Emissions
- Maintenance & Availability

POWERS
Value in Use Modelling - Application

- Identify the best value coal from a range of offers
- Optimize performance & costs across a portfolio of power plants
- Quantify benefits of plant improvements/upgrades that give enhanced fuel flexibility
- Optimize coal preparation to deliver improved value coal products

The best value coals are not necessarily the cheapest

The best value coals are not the same for different power plants
Value in Use Assessment

Requirements

A number of inputs are required for VIU assessment:

- Fuel analysis
- Power plant design and operating data
- Economic data

Utilizing more detailed input data enables more accurate VIU assessment

Computer Models

For detailed VIU assessment it is necessary to use a dedicated computer model:

- EPRI’s VISTA Coal Quality Impact Model
- Uniper Technologies’ Fuel Evaluation Tool

Detailed plant performance and economic impact analysis can be performed on unit specific models.
VISTA Coal Quality Impact Model

Background

Black & Veatch Corp. developed the Coal Quality Impact Model for EPRI in the late 1980's. In 1997 CQIM was deemed a mature product and continued funding switched to a Users Group. The model was renamed VISTA.

Key features

• Highly detailed ‘Unit Models’ describing the power plant. Full performance calibration on known coals enables performance on alternative fuels to be predicted.

• Maintenance and Availability impacts based on NERC database.

• Ongoing model development, funded each year by Users Group (~20 utilities).

• VISTA is relatively complex and requires effort to develop unit models and train personnel in its use, but it is fully supported by Black & Veatch experts.
Uniper’s Fuel Evaluation Tool

Background

The FET was developed by Uniper (formerly E.ON) in 2010 to address a need to account for coal quality variation in transactions between coal buyers and power plants.

Key features

- Detailed model incorporating site-specific power plant models, all coal logistics and most power plant impact costs affected by coal quality.

- All calculations and coding within model are fully documented and auditable.

- Model is highly flexible and is regularly updated to reflect issues at power plants – unit specific calculations are included, as well as unit specific inputs.

- The model is routinely used by Uniper coal buyers to optimise purchasing decisions and for steering coals around the European power plant fleet.
Example Value-in-Use Assessment

Comparison of coal options for a European Power Plant

Major export coal suppliers include Colombia, Russia, USA, South Africa and Indonesia.

- US high sulphur coals available at price discount
- Colombian / Russian coals close to API#2 (benchmark price for imports into NW Europe)
- S African & Indonesian coals are more expensive to deliver into Europe

Which coals offer the best overall value?
Plant performance impacts

Mill performance

![Mill Performance Chart]

- Mill inlet temp
- Mill outlet temp
- Mill drying capability

- COL A
- COL B
- RSA
- RUS
- INDO A
- INDO B
- USHS
- 80:20 RUS / USHS

Mill Drying Capability (%)
Plant performance impacts

Unit Efficiency
Plant performance impacts

Slagging & Fouling

Boiler Performance - Slagging & Fouling

Graph showing the number of sootblowing cycles per day for different categories like Slagging, Fouling, and AH Fouling for various locations such as COL A, COL B, RSA, RUS, INDO A, INDO B, USHS, 80/20 RUS/USHS.
Plant performance impacts

### Emissions

<table>
<thead>
<tr>
<th>Location</th>
<th>SO2 (boiler outlet)</th>
<th>NOx (boiler outlet)</th>
<th>Particulates (ESP outlet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COL A</td>
<td><img src="chart.colA.png" alt="Graph Data" /></td>
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<tr>
<td>COL B</td>
<td><img src="chart.colB.png" alt="Graph Data" /></td>
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<tr>
<td>RSA</td>
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<td>RUS</td>
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Value in Use Results

Differential Plant Operating Costs

Even when coals are technically suitable, incremental increases in operating costs (e.g. ash sales, reagents, CO2 permits, maintenance etc) can make the difference between good value and poor value coals.
Value in Use Results

Total Power Generation Costs

- Coal purchase
- Delivery
- Power plant variable costs

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Value in Use - Conclusions

• Recognition in Uniper that coal quality significantly affects Power Plant Variable Costs.
• Fuel Evaluation Tool is the basis behind the transfer price agreement between Uniper’s fuel traders and power station fleet
• Incentive for fuel traders to purchase best value fuels.
• Accurate value assessment of out-of-spec / opportunity fuels.
• Identification of most suitable Power Plant for a given coal supply option.
• Optimisation of coal supply logistics.
• Optimisation of coal-related CO₂ emissions.
Conclusions

• Coal
  Challenging market
  Increasing need for good quality data
  Ever-tighter regulations
  Drive to minimise generation costs
  Move to use of models rather than ‘personal experience’

• Biomass
  Quality vs. price
  Pre-treatment options
  Regulatory compliance (ROCs, GQCHP etc)
  Need to improve models/ predictive indices etc. in line with coal
Thanks for listening !