Coal & Biomass Characterisation for a Power Generator

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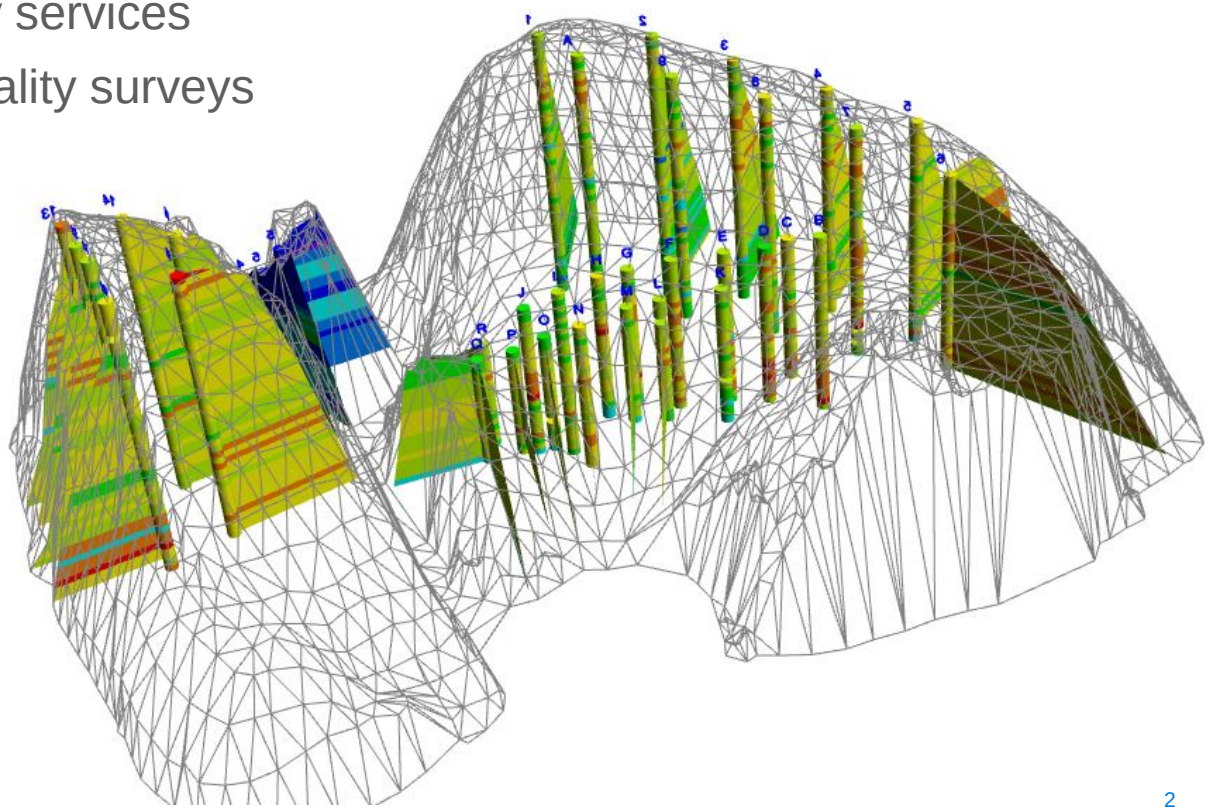
Uniper Technologies Ltd

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)
  - SO_2 (FGD upgrades/ lower S% coals)

- Coal is struggling

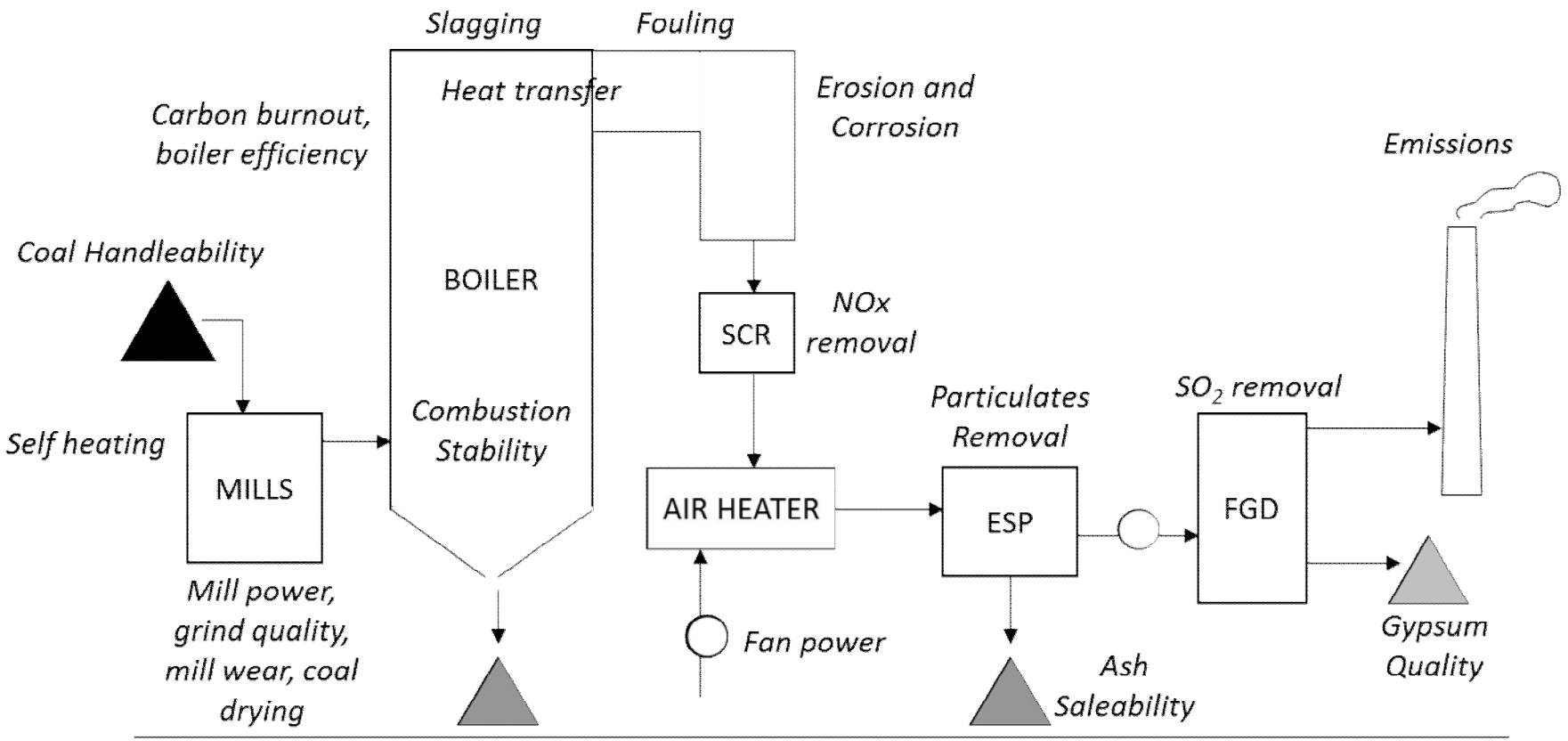
  Low price of oil/gas
  - Carbon Price Support (CPS) - now £18/te CO_2 (~£40/te of coal)
  - Growth of Renewables
  - Political outlook (2025 statement)

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

Current Challenges - Biomass

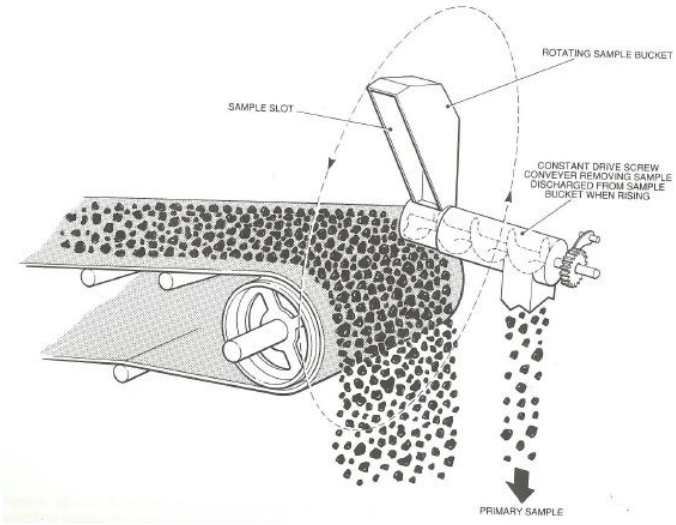
- Cost vs. quality
  - Only clean wood pellet is commodity traded
  - Quality standards apply for pellets (ISO 17225-2: 2014)
  - Other biomasses cheaper but limited volumes & variable quality
  - Energy is a new market for biomass growers and suppliers
- Sustainability
- Steep learning curve

Fuel Quality Impacts



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

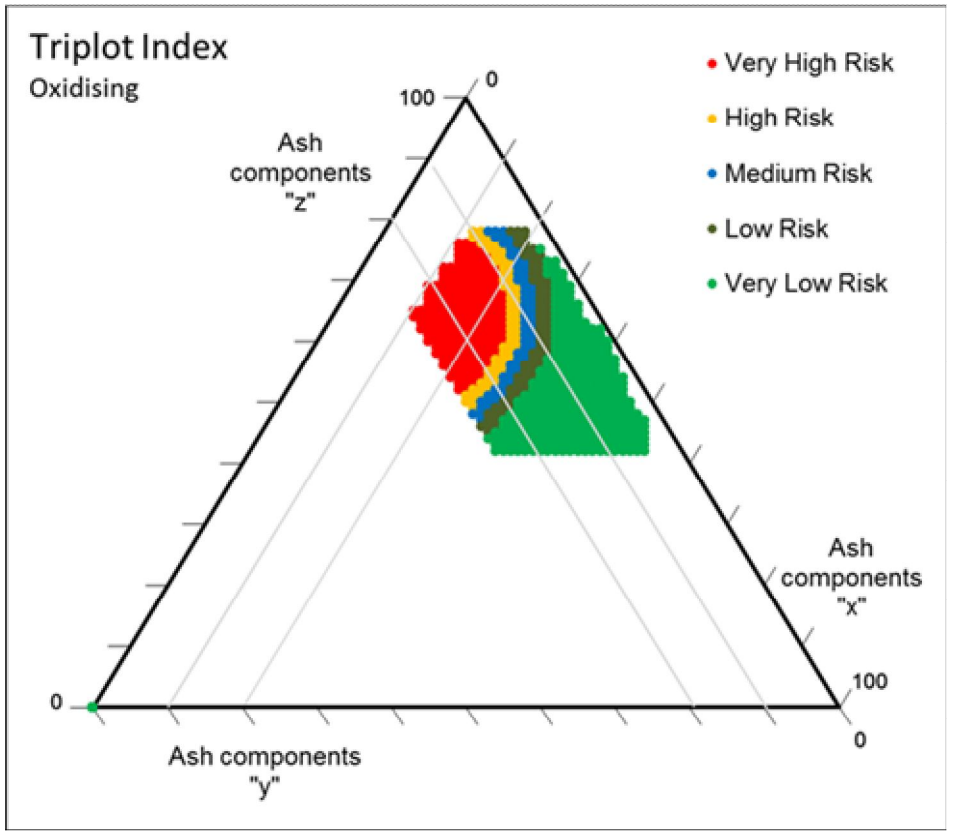
  Traditional indices:

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

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

  Fouling Index = B/A x Na_2O%

- 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)

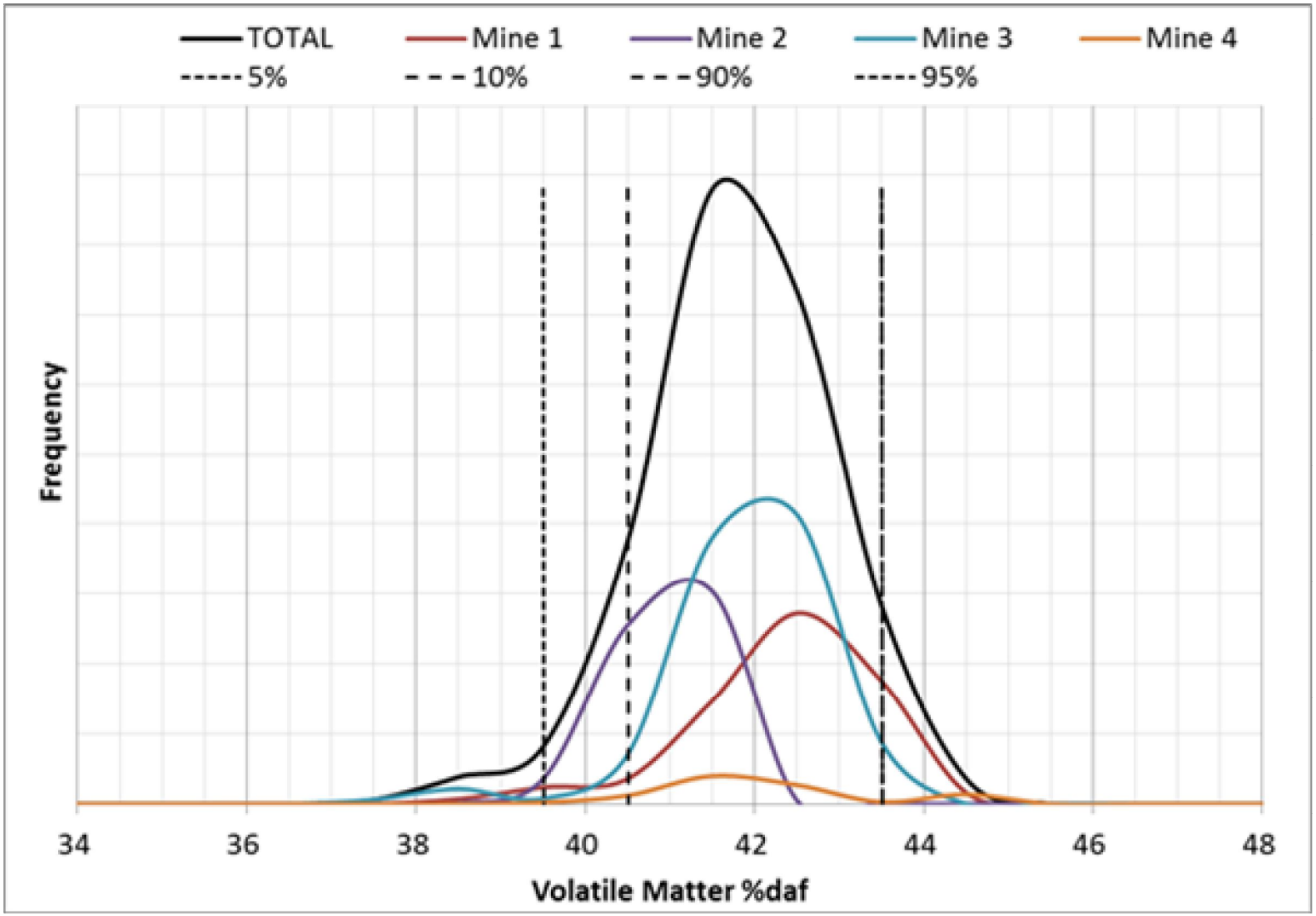
- Biomass Purity Assessment (mixed materials)
  - Handpicking
  - Chemical marker
  - Dissolution method
  - Carbon 14 isotope dating

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



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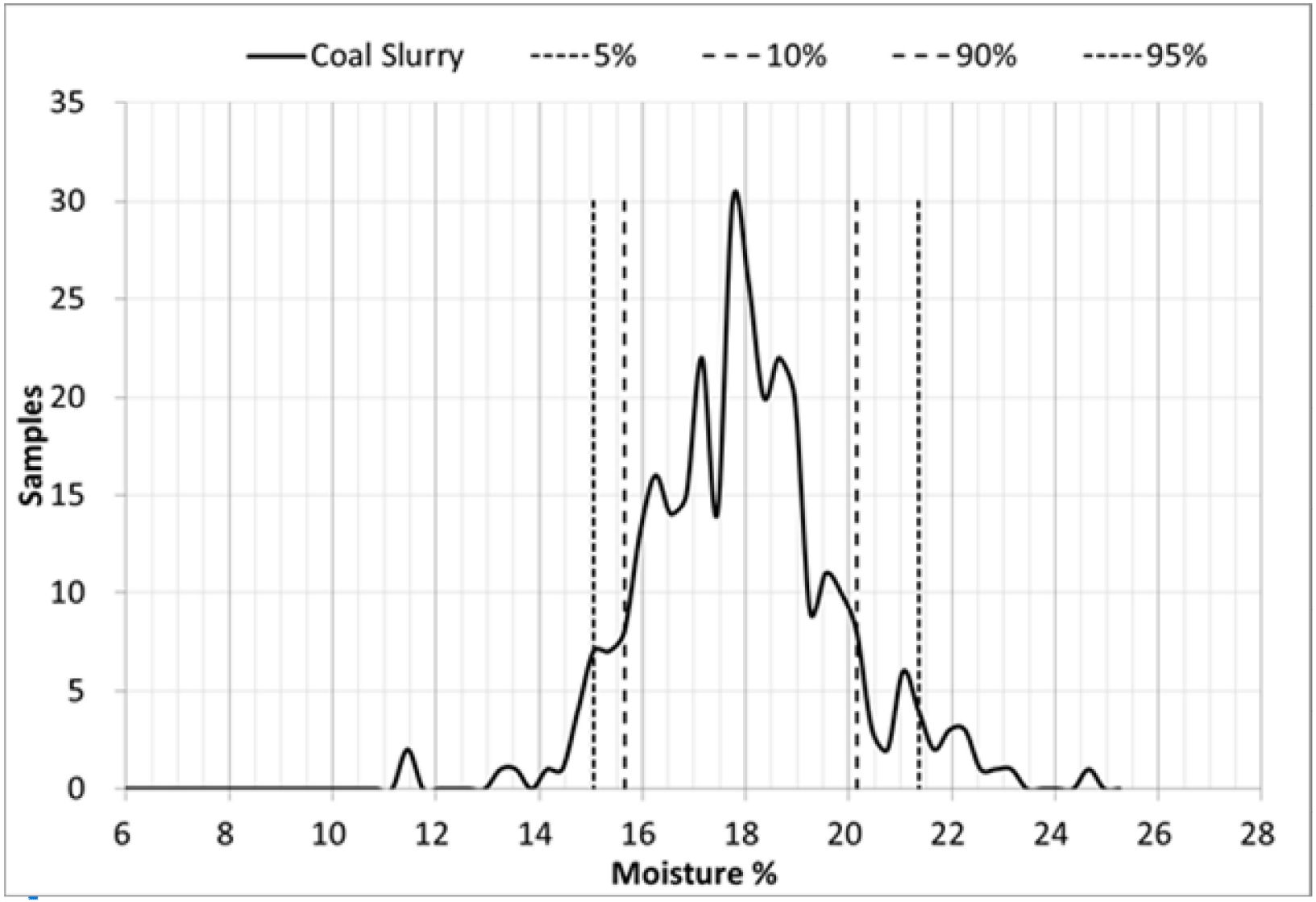

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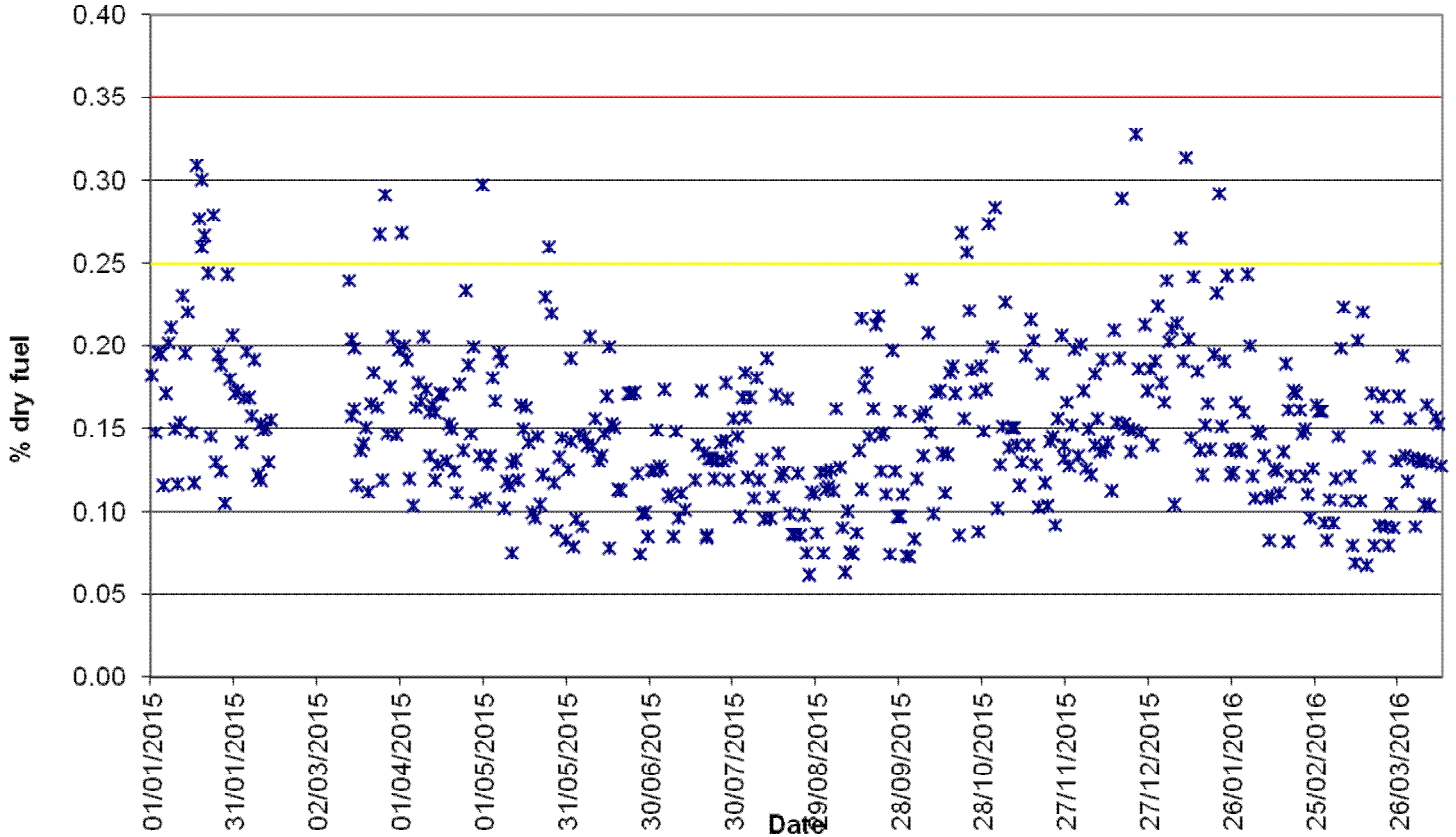

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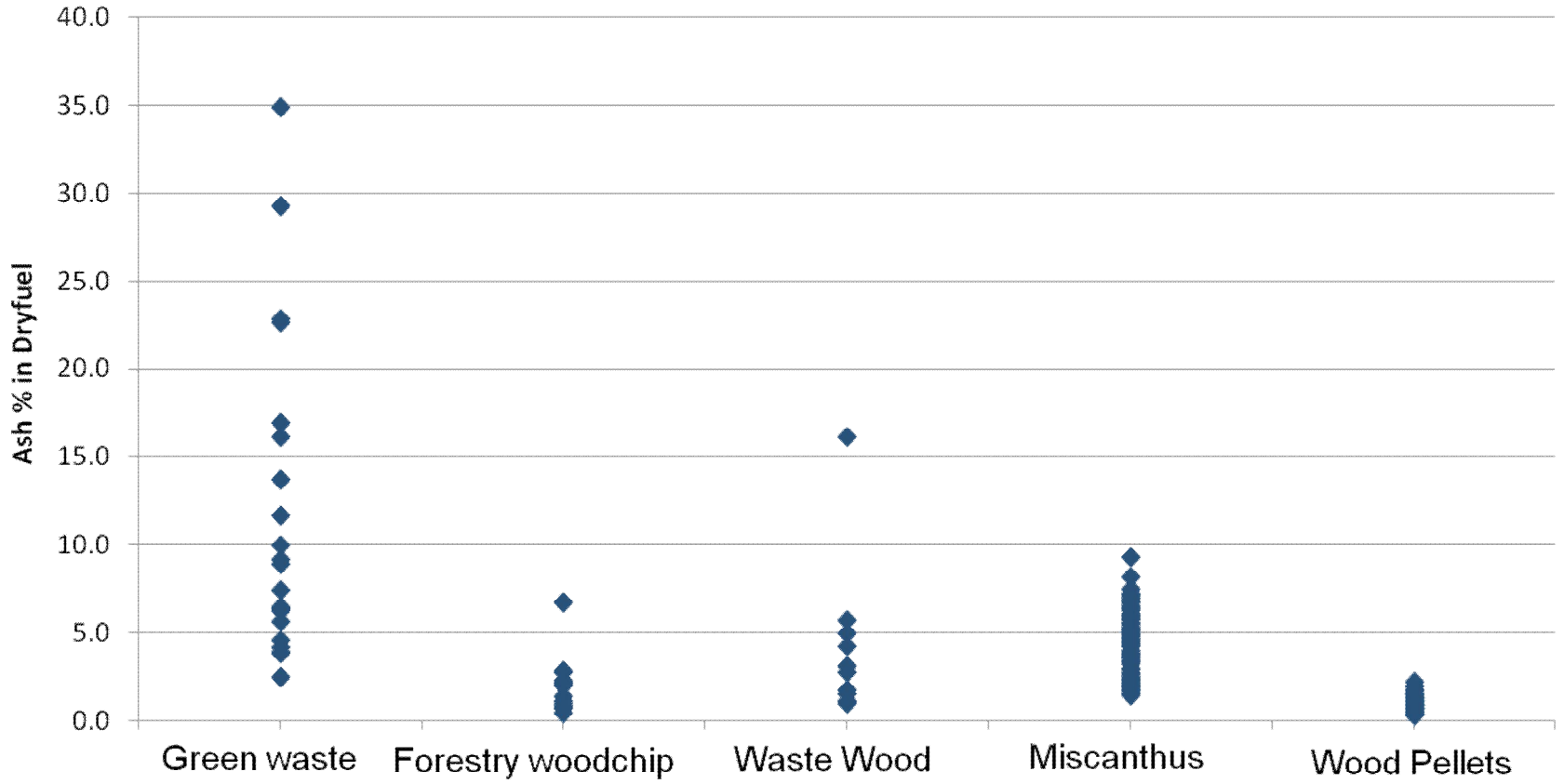


Modelling Fuel Quality Impacts

- 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

POWER

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:

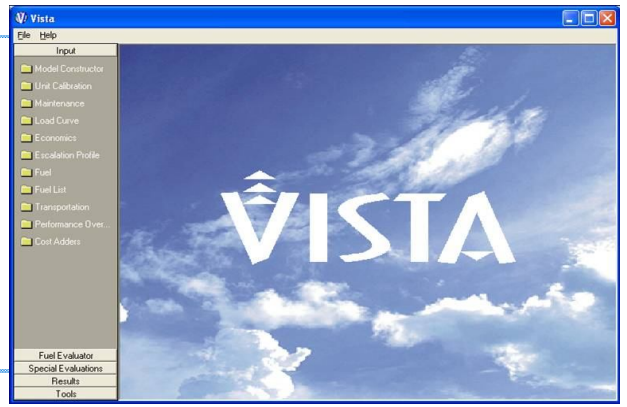
- EPRI's VISTA Coal Quality Impact Model
- Uniper Technologies' Fuel Evaluation Tool

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.



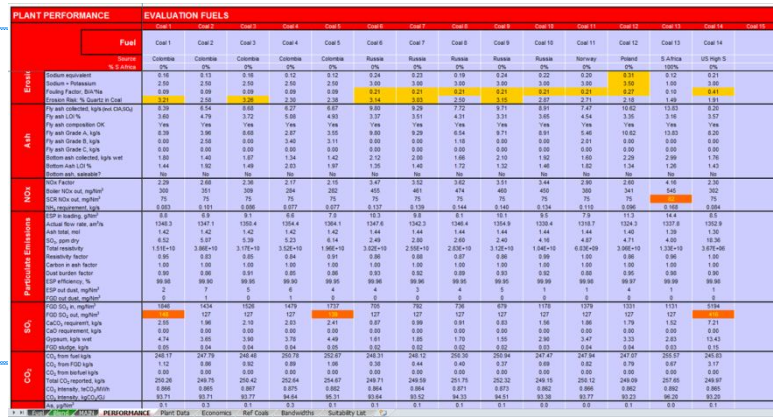
Key features

- 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.

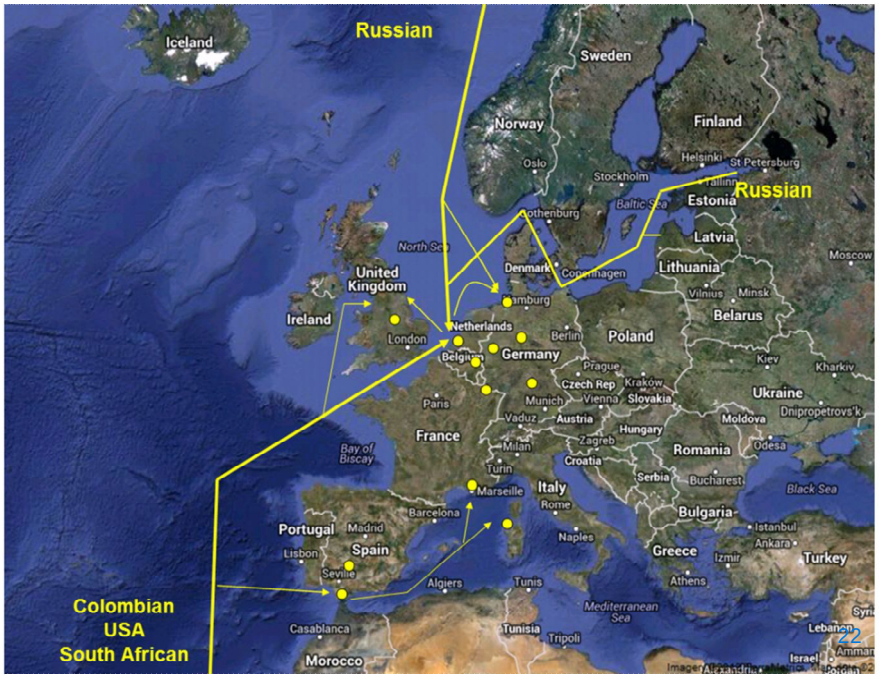
Example Value-in-Use Assessment

Comparison of coal options for a European Power Plant

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

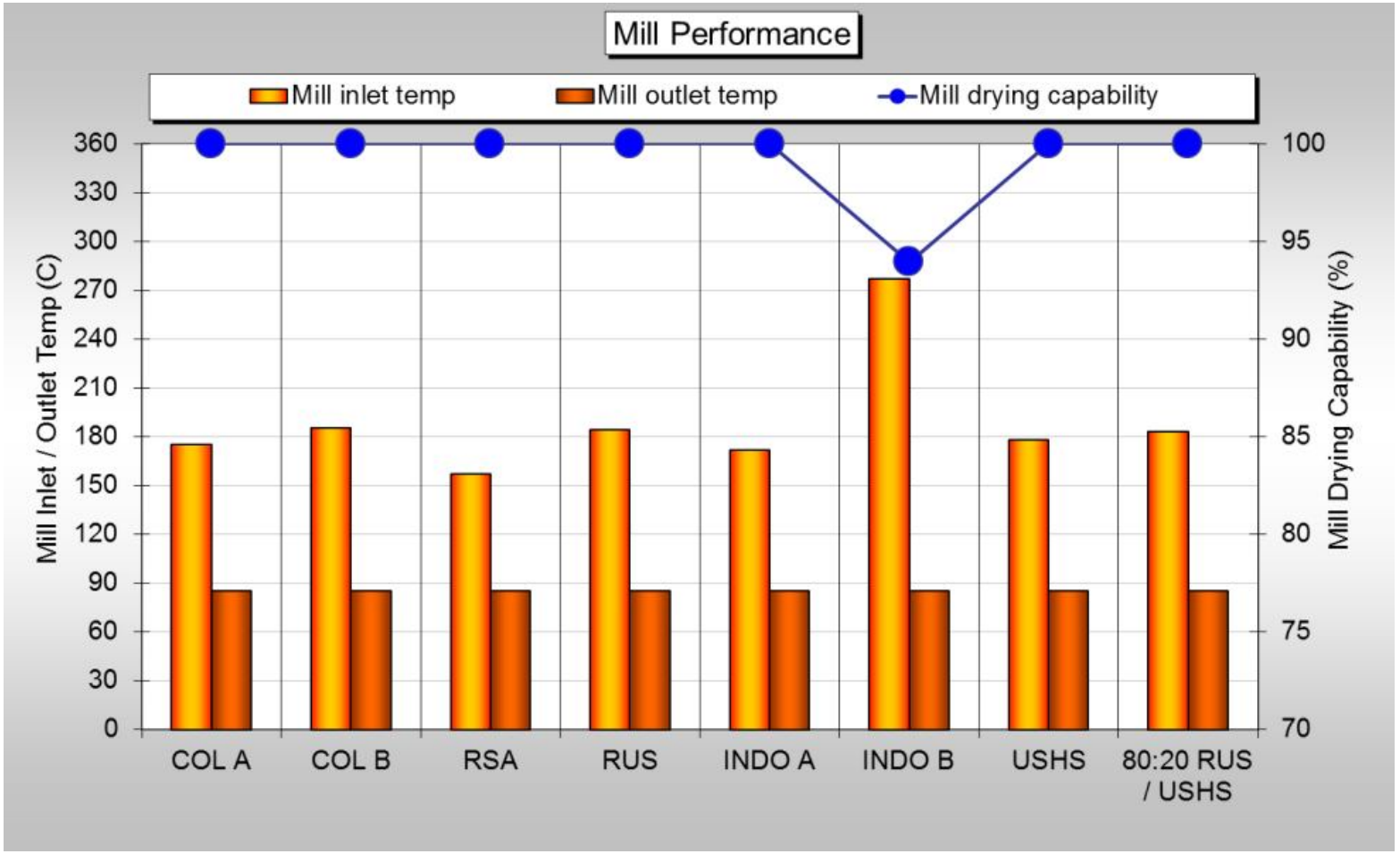
- US high sulphur coals available at price discount
- Colombian / Russian coals close to API#2 (benchmark price for imports into NW Europe)
- S African & Indonesian coals are more expensive to deliver into Europe

Which coals offer the best overall value?



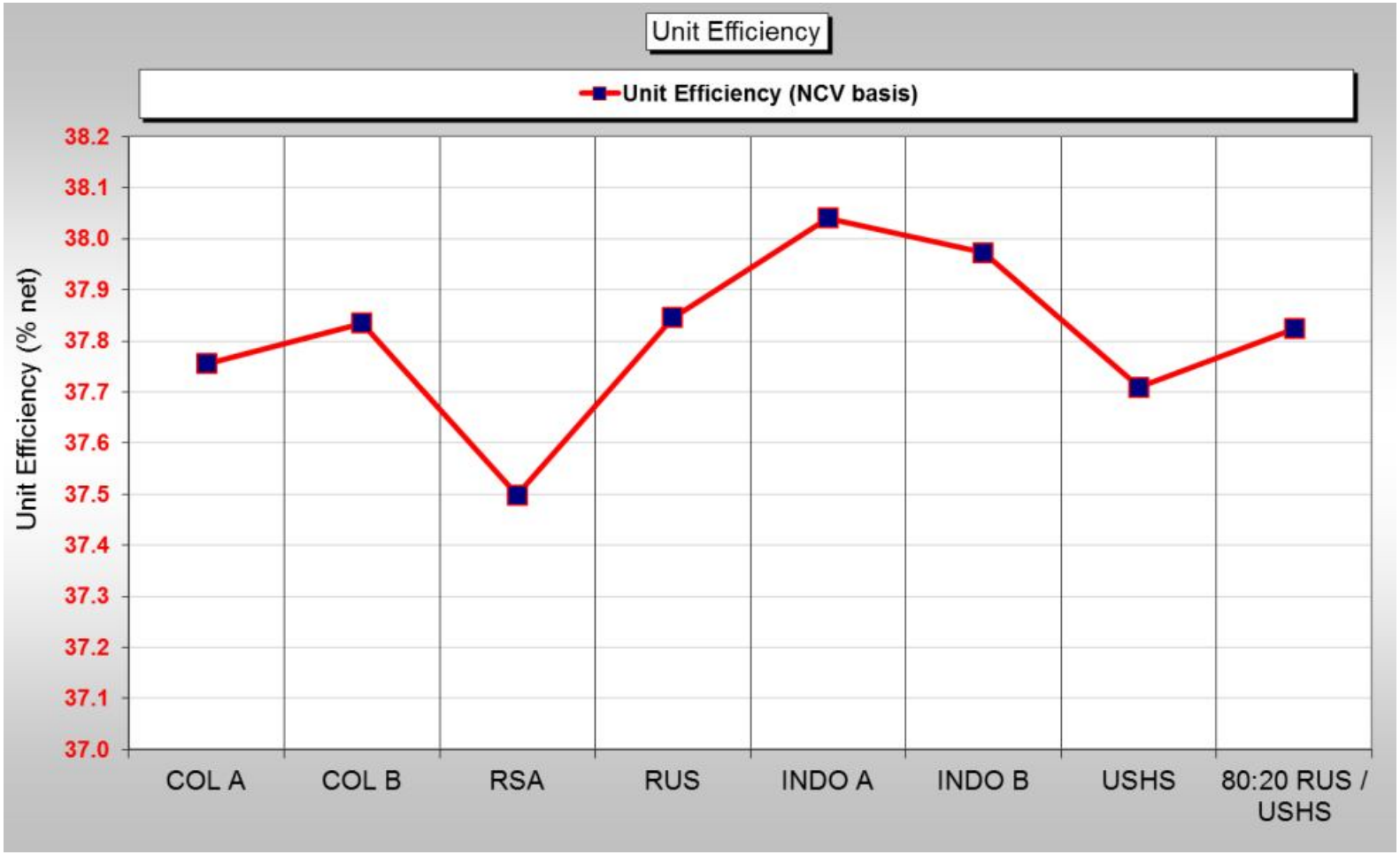
Plant performance impacts

Mill performance



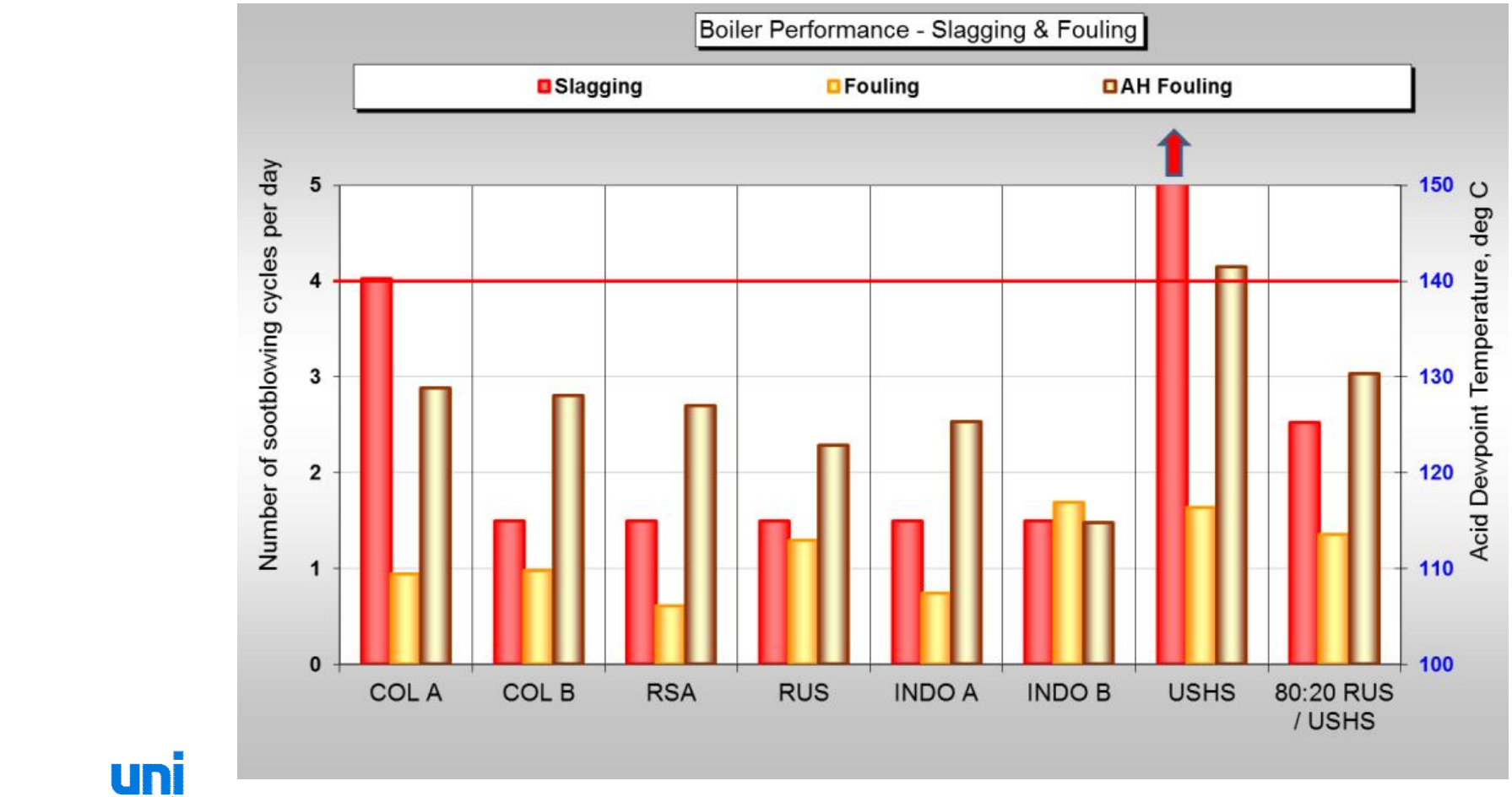
Plant performance impacts

Unit Efficiency



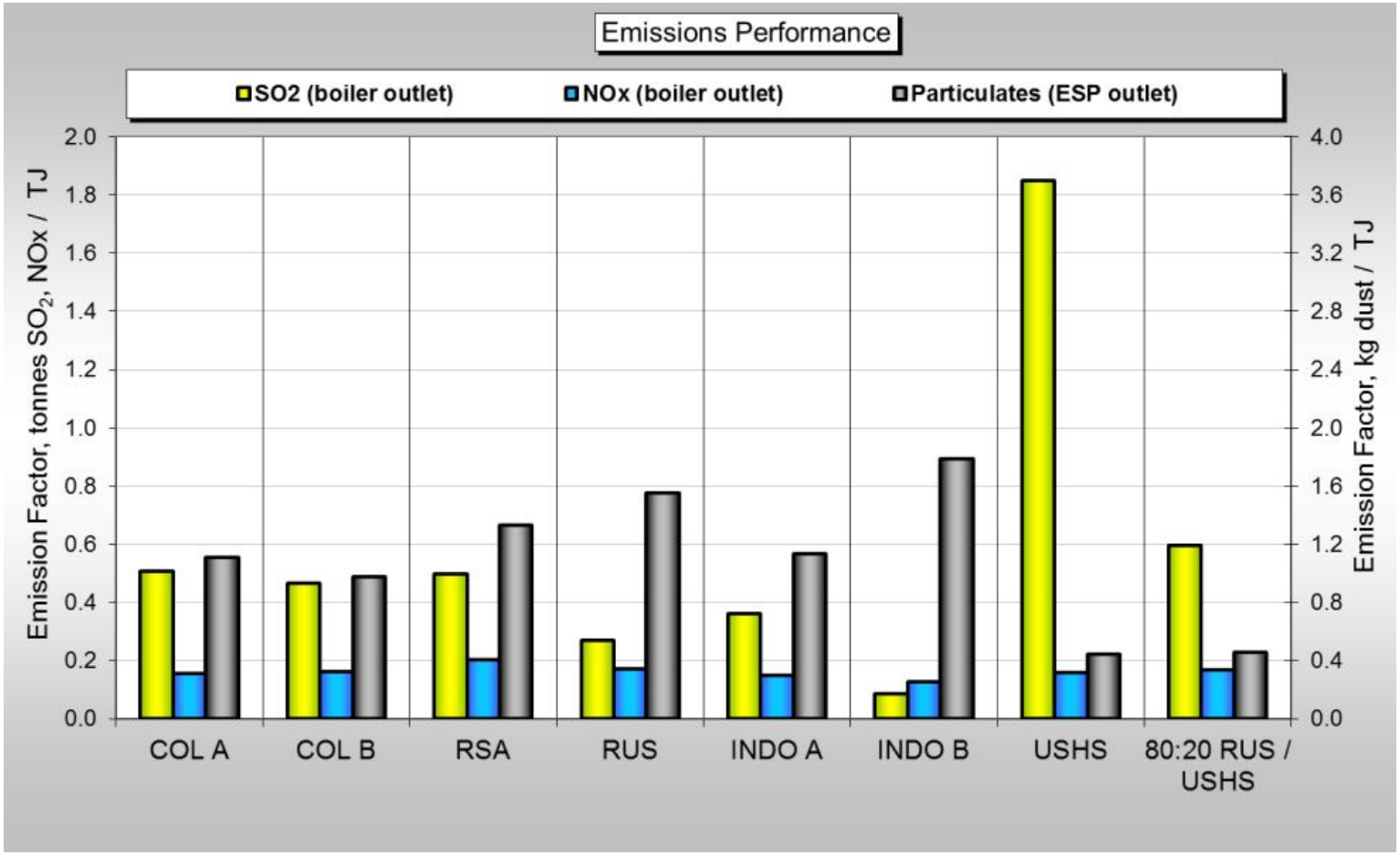
Plant performance impacts

Slagging & Fouling



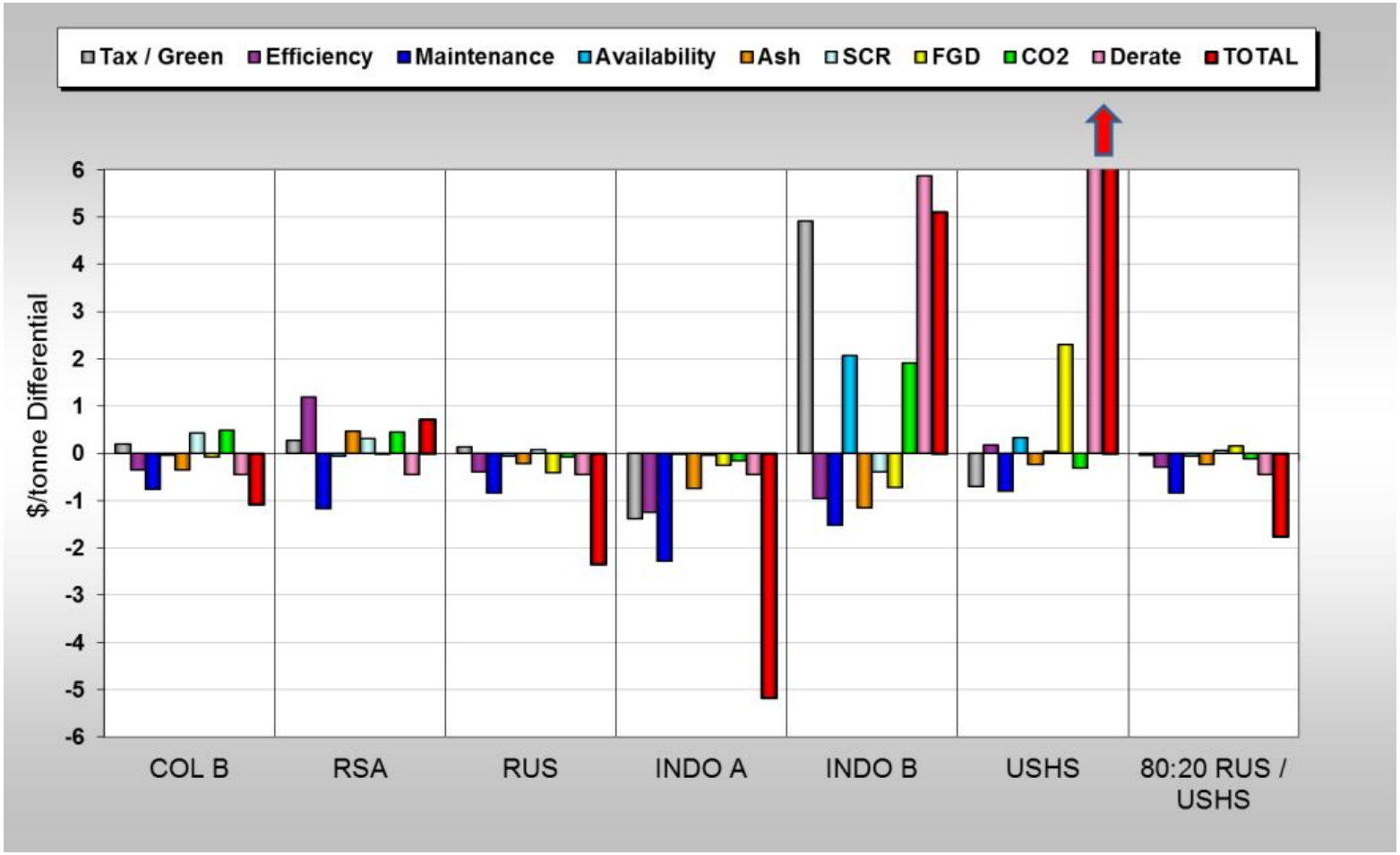
Plant performance impacts

Emissions



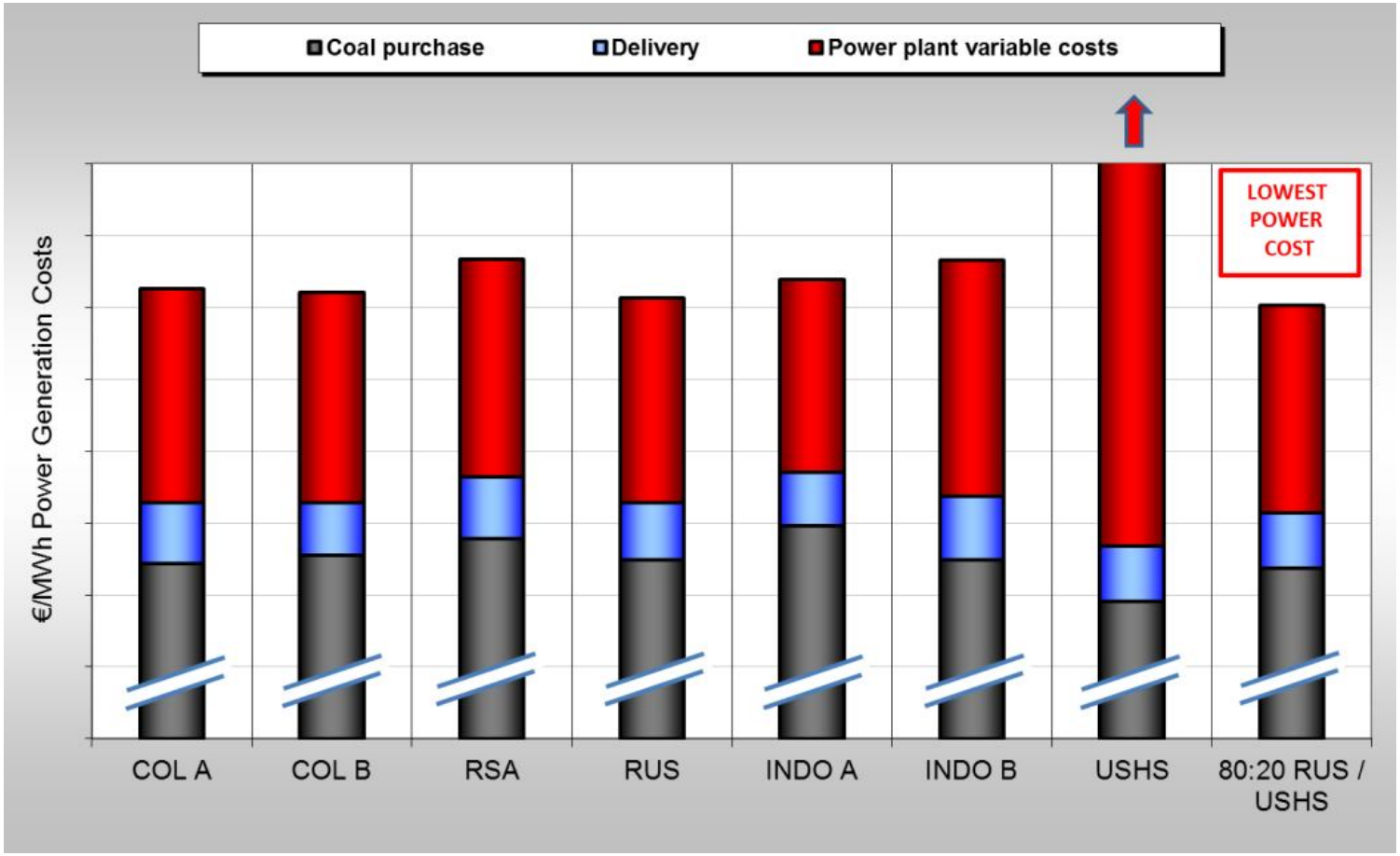
Value in Use Results

Differential Plant Operating Costs



Value in Use Results

Total Power Generation Costs



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 CO_2 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 indicies etc. in line with coal

Thanks for listening !