Modelling Coal Quality Impacts on Power Generation Costs

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• Value-in-Use (VIU) Assessment
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We are Uniper

Our operations:

Power Generation
Commodity Trading
Energy Storage
Energy Sales
Energy Services

Where we operate:

40+ countries around the world
4th largest generator in Europe

Employees: 13,000

- Power generation, Storage, Services - Europe
- Power generation - International
- Commodity Trading, Energy Sales

- €1.71bn EBITDA
- 100 years Experience
- 38 GW Total generation

Main activities:

Gas fired plants
Coal fired plants
Energy storage
Gas fields
Gas pipelines and infrastructure
Regasification
Nuclear plants
Hydroelectric plants
Trading
Energy sales (small to large clients, electricity and gas)
Services

Gas fired plants 19.2 GW
Coal fired plants 9.1 GW
Energy storage Gas: 8.5 bn m³
Gas fields
Gas pipelines and infrastructure
Regasification
Nuclear plants 1.9 GW
Hydroelectric plants 3.6 GW
Trading
Energy sales (small to large clients, electricity and gas)
Services

Expertise built on engineering excellence and owner, operator asset experience

We are a **one-stop shop** offering a broad range of services that work closely together, reducing complexity and risk for customers.

Our **background as an asset owner/operator** gives us deep understanding of the energy industry and our customers’ needs.

We are **independent** of equipment and component suppliers, giving us freedom to choose the best solution for customers.

**Expertise based on experience**

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<tbody>
<tr>
<td>Innwerke</td>
<td>UK Central Electricity Generating Board</td>
<td>PLE Pipeline Engineering GmbH</td>
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Uniper’s competencies are being brought to the global stage by Uniper Energy Services

- Front end engineering design
- Commercial evaluation
- Engineering Procurement and Construction tendering and project management
- Construction and site management
- Commissioning

Our core skills
- Owner’s engineer
- Project management
- Environmental management
- Electrical, mechanical and civil engineering
- Digital engineering
- Process engineering
- OEM independence
- Grid and Local energy system solutions

- Outage support
- Production support
- Maintenance and spares optimisation
- Field services
- Workshop services

- Planning, permit and impact assessment
- Decommissioning and dismantling
- Demolition

- Benchmarking
- Asset lifetime assessment & extension
- Asset risk management
- Compliance and standards
- Technical operational excellence

Value proposition

Leading one-stop-shop energy solutions provider with services across the value chain and life-cycle

Leveraging competencies in delivering bespoke customer solutions

Business at a glance

- Expertise across multiple technologies
- Services to more than 600 customers
- Active in more than 40 countries
Coal quality expertise is required along the power generation value chain

<table>
<thead>
<tr>
<th>New Build</th>
<th>Fuel offer</th>
<th>Load/Disport</th>
<th>Delivery</th>
<th>Utilisation</th>
<th>Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab / pilot-scale testing</td>
<td>Coal suitability review / advice</td>
<td>Coal sampling &amp; analysis</td>
<td>Coal sampling &amp; analysis</td>
<td>Full-scale combustion &amp; emissions testing</td>
<td>Data management</td>
</tr>
<tr>
<td>Design coal basket, Specifications</td>
<td>Coal switching and blending</td>
<td>Supplier data challenge</td>
<td>Coal stock management, stock audit</td>
<td>Boiler performance optimization</td>
<td>Emissions monitoring &amp; compliance</td>
</tr>
<tr>
<td>Performance guarantees</td>
<td>Out-of-spec / low cost coals</td>
<td>Portfolio optimization</td>
<td>Coal blending optimization</td>
<td>Problem solving</td>
<td>Emissions Trading</td>
</tr>
</tbody>
</table>

- Value-in-Use (VIU) assessment
Value-in-Use assessment shows the true value of coal to the power plant operator

Coal buyers aim to minimize the coal price delivered to the power plant (e.g. $/kcal)

However, the true value of coal is the cost of generating electricity from the coal ($/MWh)

The best value coals are not necessarily the cheapest

The best value coals are not the same for different power plants
Operational and financial impacts of coal quality can be observed across many power plant systems

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**Cost impacts**

- Fuel price, taxes
- Fuel delivery
- Handling, blending
- Ash handling, disposal
- Emissions (reagents, by-products)
- Unit efficiency
- Maintenance
- Availability

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The diagram shows various processes and their associated impacts:

- **Slagging**
- **Fouling**
- **Erosion and Corrosion**
- **Heat transfer**
- **Carbon burnout, boiler efficiency**
- **Combustion Stability**
- **Self heating**
- **Mills** (Mill power, grind quality, mill wear, coal drying)
- **SCR** (NOx removal)
- **Air Heater**
- **Particulates Removal**
- **ESP**
- **SO2 removal**
- **FGD**
- **Gypsum Quality**
- **Emissions**
For accurate Value-in-Use assessment a dedicated computer model is required

Requirements

A number of inputs are required for VIU assessment

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

More detailed input information (full coal analysis + unit specific models) leads to more accurate VIU results

Expert VIU models

Only two VIU computer programs enable highly accurate unit-specific modelling.

- EPRI’s VISTA coal quality impact model
- Uniper’s Fuel Evaluation Tool

Uniper is able to offer VIU analysis using either tool
Uniper’s Fuel Evaluation Tool (FET)

Background

The FET was developed by Uniper in 2010 to address a need within the business to account for coal quality variation in transactions between coal buyers and power plants.

Key Features

- Evaluation of **complete coal analysis**: CV, proximate, ultimate, ash composition, HGI, FSI, size, trace elements.
- **Detailed power plant models** (~200 inputs). Unit calibration and unit-specific calculations. Default data can be used.
- **All aspects** of power plant operation affected by coal quality are evaluated. Full technical reports accompany VIU results.
- Model is **highly flexible** and is regularly updated to reflect issues at power plants.

The model is routinely used by Uniper’s coal buyers to optimise purchasing decisions for our European power plant fleet.
Advanced calculations are used within the FET model to deliver accurate evaluations

Example: Boiler Slagging Risks
- Ash Fusion Tests have poor reproducibility, hence are unreliable
- Standard industry slagging indices (e.g. base/acid) not applicable for many coal types fired around the world

Technical Investigation
- A detailed study by Uniper showed that two types of boiler slagging are experienced: iron-induced slagging and calcium-induced slagging
- Uniper has developed very accurate predictions for both types of slagging, based on standard ash composition analysis
- These complex equations are applied within the Fuel Evaluation Tool. The susceptibility of each type of slagging differs between power plants – this is part of the Unit Design & Calibration Data
Significant reduction in boiler slagging risks achieved by using the VIU modelling techniques

Uniper site
- Heyden power station in Germany
- 875 MW, Benson boiler, Comm. 1987
- Import coals (main supply is Russia)

Problem
- Major slagging problems are experienced with some Russian coals
- Historic problems: 3-day forced outage, boiler cleaning costs, ongoing boiler derates

VIU in action
- FET used to evaluation blending options and scenarios
- Result: Optimised coal blending strategy to avoid slagging problems at lowest possible cost

Case study: Germany
- Uniper site
  - Heyden power station in Germany
  - 875 MW, Benson boiler, Comm. 1987
  - Import coals (main supply is Russia)
Risks are also managed using a Coal Blending Tool and On-line Condition Monitoring

**Slagging Risk Tool**
- A simple Tool has been provided to the power plant to enable optimization of coal blending when South African coal is not available.

**On-line Condition Monitoring**
- Algorithms have been developed to provide early-warning of potential slag build-up in the boiler – early warning enables the coal blend to be switched, or forces overnight load reduction.
Value-in-Use can show benefits of coal cleaning

The benefits of Coal Washing
- Improve calorific value / reduce ash content
- Avoid transportation of inert material
- Improve power plant performance

Value-in-Use Study
- Is coal cleaning cost-effective?
- What level of cleaning should be undertaken?

Case study: India

<table>
<thead>
<tr>
<th>Coal Composition</th>
<th>Coal Matter</th>
<th>Ash</th>
<th>Moisture</th>
<th>GAR kcal/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unwashed Coal (G-13)</td>
<td>43%</td>
<td>34% Ash</td>
<td>26%</td>
<td>7000</td>
</tr>
<tr>
<td>Partially Washed Coal (G-10)</td>
<td>34%</td>
<td>26% Ash</td>
<td>5%</td>
<td>6500</td>
</tr>
<tr>
<td>Fully Washed Coal (G-9)</td>
<td>26%</td>
<td>26%</td>
<td>5%</td>
<td>6000</td>
</tr>
<tr>
<td>Advanced Coal Cleaning (G-2)</td>
<td>5%</td>
<td>26%</td>
<td>26%</td>
<td>5500</td>
</tr>
</tbody>
</table>
Several aspects of Plant Performance are improved when firing washed coal
Cost savings are realised in Transportation, Tax and Power Plant Operations

**Transportation Costs**
- Delivery costs per kcal are reduced
- 15 $/tonne is used in this study

**Coal Tax**
- Coal tax is paid per tonne – increasing coal calorific value reduces tax liability
- 400 Rs/tonne (6 $/t) used in this study

**Power Plant Variable Costs**
- Higher plant efficiency
- Lower ash disposal / handling costs
- Reduced maintenance costs
- Higher plant availability
- Improved emissions (costs not included in this example)
The study shows that coal washing can deliver significant savings in total power generation costs.
Summary

• Uniper has extensive experience in all aspects of coal supply and power plant operation

• Value-in-Use assessment is a powerful tool to deliver added value to generation assets
  • Identify best value coals from supplier offers
  • Predict or characterize coal-related plant performance problems
  • Optimize coal blending strategy
  • Optimize coal washing / preparation
  • Determine coal quality price adjustments (sulphur, ash, moisture etc)
  • Evaluate fuel flexibility requirements for new build plant
  • Evaluate low-cost / off-spec fuels
Uniper & India Power have formed a strategic partnership to develop and service the power sector

India Uniper Power Services
- 50:50 joint venture in power plant services
- A value-based service provider
- Offering a broad range of flexible and customised services
- Headquartered in Kolkata

The joint venture will combine strengths of strong partners with complementary scope and portfolio. Key service offerings:
- Plant operations and maintenance,
- Asset monitoring software and analytical tools,
- Fuel evaluation and optimisation
- Increasing flexibility of units; Lifecycle extension,
- Supply and integration of pollution control equipment and systems, etc.

Please visit our stand in the Exhibition Hall
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