

AES/RE/14-15 Power Plant Mátra. Research to development of a coal quality concept for the lignite deposits Visonta and Bükkábrány, Hungary

18.08.2014 Francien Troost

Confidential, Contains Business Secrets: Copyright RWE Power AG

Title : Power plant Mátra.
Research to development of a coal quality concept for the lignite deposits Visonta and Bükkábrány, Hungary.

Author : Francien Troost

Date : August 2014

Professor : Dr. M.W.N. Buxton
Supervisor : Dr. H. Marx (RWE Power AG)

TA Report number : AES/RE/14-15

Postal Address : Section for Resource Engineering
Department of Geoscience & Engineering
Delft University of Technology
P.O. Box 5028
The Netherlands

Telephone : (31) 15 2781328 (secretary)
Telefax : (31) 15 2781189

Copyright ©2014 Section for Resource Engineering

*All rights reserved.
No parts of this publication may be reproduced,
Stored in a retrieval system, or transmitted,
In any form or by any means, electronic,
Mechanical, photocopying, recording, or otherwise,
Without the prior written permission of the
Section of **Resource Engineering**,
RWE Power AG and **Mátra Erőmű ZRt***

Power Plant Mátra.
Research to development of a coal quality concept for the
lignite deposits Visonta and Bükkábrány, Hungary

Master of Science Thesis

Submitted for degree of Master of Science in Applied Earth Sciences' Resource Engineering
at Delft University of Technology

Francien Troost

August 18th, 2014

This Thesis was written under supervision of RWE Power AG
and in cooperation with Mátrai Erőmű ZRt.
The support of both companies is hereby gratefully acknowledged.

VORWEG GEHEN



MÁTRAI ERŐMŰ ZRT.



Copyright © Delft University of Technology, Applied Earth Sciences (AES).

All rights reserved.

Abstract

By Francien Troost, M.Sc. Mining Engineering at Delft University of Technology

This project stands under supervision of RWE Power AG in cooperation with Mátrai Erőmű ZRt.

This Thesis carried out research towards development of a coal quality concept on geological and mining engineering operational level of Mátrai Erőmű ZRt's Visonta and Bükkábrány open cast lignite mines, with objective to reduce and avoid sub-optimal combustion behaviour at Mátra Power plant. RWE Power AG is the major shareholder of Mátrai Erőmű ZRt (50.9%).

Three improvable sub-optimal combustion behaviours were determined based on power plant performance (2012-2014).

A coal quality handling recommendation was developed for Mátrai Erőmű ZRt based on results of coal quality modelling carried out within this Thesis. Through a coal sort algorithm the Visonta (V) and Bükkábrány (B) coal was divided into *coal sorts* (German: *Kohlesorte*). A programme was written which creates a block model assigned with quality data from geological samples. Subsequently, the coal sorts in the production profile were predicted by modelling the mining of the blocks within the block model. In- and Inter-pit supply strategies and blend ratios were determined to provide an optimal direct coal sort or blend of coal sorts to the Mátra Power plant. A preliminary mine scheduling programme was developed within this Thesis.

The Thesis was performed along the Mátrai Erőmű ZRt operational mining and processing value chain. A technical background introduces the deposit geology, Visonta and Bükkábrány Mine, fuels (i.e. coal and co-combusted biomass) and Mátra Power plant. A theoretical background describes the power plant components of focused sub-optimal combustion behaviour in theory and points out coal quality parameters and operational factors which potentially enhance sub-optimal combustion. The operational procedures at Mátrai Erőmű ZRt were studied on site, i.e.: sampling, geological modelling, mine planning, mining, transporting (logistics, rail supply of Bükkábrány coal and stockpiling facilities), blending and combustion. Historical operational data was used as modelling input, i.e.: geology database, overview on available qualities, technical constraints, blending constraints and acceptance algorithm. The quality modelling consists of determination of a coal quality algorithm (incl. power plant acceptance algorithm), coal quality modelling for the individual coal seams and evaluation of in- and inter-pit supply strategies. Finally, the coal quality handling description summarises the recommendations for the Mátrai Erőmű ZRt operation.

The resulting handling recommendation states the determined coal sorts, cutting technique guideline, power plant supply strategies, stockpile supply schedule and blending strategies.

The significant result from this Thesis is that the coal in Visonta and Bükkábrány Mine can be divided into minable coal sorts for which a standard combustion behaviour can be expected.

Acknowledgment

With full enthusiasm, I wrote my M.Sc. Thesis:

“Mátra Power Plant. Research towards development of a coal quality concept for the lignite deposits Visonta and Bükkabrany, Hungary”

It was the best and most interesting project I carried out, so far.

I am grateful to thank the following people who supported and helped me in different valuable ways to prepare, structure and improve my M.Sc. Thesis, to answer open questions and to just be around.

Thank you

Mam and Pap
Marijtje and Hester

Dr Mike Buxton
Matthias Zwinge
Dr Harald Marx
Dr Markus Kosma
Dr Carsten Geisler
Anno Loock
Ágnes Meize Kissné

Additionally, I would like to say thank you to all RWE Power AG and Mátrai Erőmű ZRt colleagues in giving me the chance to learn and to my TU Delft Exam Committee for reading and grading my M.Sc. Thesis.

Glückauf

Francien Troost

Köln, July 31st 2014

List of Content

Abstract	i
Acknowledgment	iii
List of Content	iv
List of Figures	ix
List of Tables	xi
1. Introduction	1
1.1 Mátrai Erőmű ZRt: a company overview	1
1.2 The added value of a coal quality sort concept: the Rhenish coal sort concept as example.....	2
1.3 Thesis motivation	6
1.3.1 Project history.....	6
1.4 Problem description.....	8
1.5 Aim and research objectives.....	8
1.6 Research questions	8
1.7 Methodology and Thesis structure	8
1.8 Thesis scope and limitations.....	10
1.8.1 Thesis scope	10
1.8.2 Thesis limitations	12
Section Ia: Technical Background	13
2 Geology	13
2.1 Regional Geology	13
2.2 Local geology	14
3 Mines	26
3.1 Visonta mining operation	26
3.2 Bükkábrány mining operation	29
4 Fuel: Lignite fuel quality statement	32
4.1 Visonta Coal quality statement.....	32
4.2 Bükkábrány Coal quality statement.....	32
5 Biomass co-fuel: Quality statement	33
6 Power plant Mátra	34

Section Ib: Theoretical Background	40
7 Theoretical background on focused sub-optimal combustion behaviour	40
Section II: Operation	48
8 Mátrai Erőmű ZRt operation: extracted model input	48
8.1 Geology database	48
8.2 Available qualities	50
8.3 Technical constraints	51
8.4 Blending constraints	55
8.5 Acceptance algorithm.....	57
Section III: Modelling	61
9 Quality modelling	61
9a Coal quality algorithms: Coal quality sorts	61
9a.1 Acceptance algorithm Mátra Power plant	62
9a.2 Coal sort algorithm Visonta and Bükkábrány coal	63
9b Coal quality modelling	69
9b.1 Block model: Geological data and production profile simulation program	69
9b.1.1 Program description.....	71
9b.1.1.1 Intermediate results	75
9b.1.2 Coal sorts expected in upcoming extraction block: Coalsort spreadsheet – Modelling result	78
9b.2 Quality oriented seam characterisation based on block model considering geology and production profile – Modelling result.....	80
9c Supply strategies	95
9c.1 Production schedule.....	99
9c.2 Result: Supply through quality oriented production schedule	103
Section IV: Coal quality rules	105
10 Handling rules: Coal quality oriented material handling recommendations	108
10.1 Coal sorts.....	108
10.2 Cutting technique guideline.....	112
10.3 Coal supply for domestic end-uses.....	114

10.4 Power plant supply	114
10.4.1 Standard supply schedule	114
10.4.2 Stockpile supply schedule	116
10.4.3 Standard blending strategies.....	116
10.5 Incorrect quality delivery or sudden quality changes	117
11 Discussion	118
11.1 Result discussion: Coal quality rules.....	118
11.2 Suggestions for future improvements.....	126
12 Conclusion.....	127
13 Recommendations	130
13.1 Recommendations towards implementation.....	130
13.2 Recommendations beyond the scope of the Thesis	131
References	137
Appendices	141
Appendix A Description of Mátrai Erőmű ZRt operation	141
A1 Exploration and channel sampling	141
A2 Geological model.....	143
A3 Mine planning.....	145
A4 Mining operation	147
A4.1 Visonta Mine	148
A4.2 Bükkábrány Mine	149
A4.3 Quality oriented bucket chain excavator utilisation	152
A5 Transportation: Equipment and Logistics technical data	154
A6 Operational data.....	155
A7 Blending: Stockpile technical data and material handling procedures	158
A7.1 Visonta Mine Stockpile	158
A7.2 Bükkábrány Mine Stockpile	159
A7.3 Power Plant Stockpile (Kohlenlagerplatz).....	160
A8 Combustion behaviour.....	163
A8.1 Summary of coal quality characteristics and combustion behaviour detected through RWE research.....	167

Appendix B Coal Mineralogy	169
Appendix B1 Basic-Acid-ratio Curve	174
Appendix B2 Siliceous multi-component system	175
Appendix B3 Sulphate two phase systems	175
Appendix B4 Potassium and Phosphor two phase system	176
Appendix C Sampling Results.....	177
Appendix C1 Channel Sample Database.....	177
Appendix C2 Ash composition data Seam V0.....	177
Appendix C3 Sampling series Neuroth and Lokay (2012).....	177
Appendix C4 Evaluation difference in coal quality for core drill sample and channel sample	177
Appendix D Contour Maps	178
Appendix D1 Coal quality contour maps: Visonta Mine seams V0, V1 and V2	178
Appendix D2 Coal quality contour maps: Bükkábrány Mine Seams B1928	178
Appendix D3 Thickness contour map of overburden B2829	180
Appendix E Mine Maps	180
Appendix E1a Mine Map Open Cast Mine Visonta.....	180
Appendix E1b Mine Map Open Cast Mine Bükkábrány	180
Appendix E2 Auto CAD Face Cross sections	180
Appendix F Mine Planning.....	181
Appendix F1 Long term mine plan 2013 to 2025	181
Appendix F2 December 2013 production schedule	181
Appendix F3 Week mine production schedule.....	181
Appendix F4 Visonta Mine Belt conveyor shifting schedule 2014.....	181
Appendix F5: Power Plant Stockpile Material Handling Strategy (Phases)	181
Appendix G Production data.....	181
Appendix G1: Daily reports 2013	181
Appendix H Technical data	181
Appendix H1 Technical data of continuous mining equipment	181
Appendix H2 Technical data Visonta belt conveyors	181
Appendix H3 Exemplary production schedule RWE Power AG.....	181
Appendix I Calculations	182
Appendix I1 Script Gather data from daily reports in overview spreadsheet by selecting an x number of daily reports	182
Appendix I2 Script Extraction block (EB), Block Model	185
Appendix I3 Script Quality oriented production scheduling.....	190
Appendix I4 Exemplary preliminary SURPAC block model of Seam V0 assigned with sulphur distribution	196

Vocabulary: English to German	197
Vocabulary: Hungarian to English.....	198

1. Introduction

1.1 Mátrai Erőmű ZRt: a company overview

Mátrai Erőmű ZRt owns and operates two open cast lignite mines: *Visonta Mine* and *Bükkábrány Mine* which supply the power plant *Mátra* near Visonta Mine. *Mátrai Erőmű ZRt* is located in north east Hungary, approximately 90 km east from the capital city Budapest and directly south of the Mátra and Bükk mountain ranges (see Figure 1).

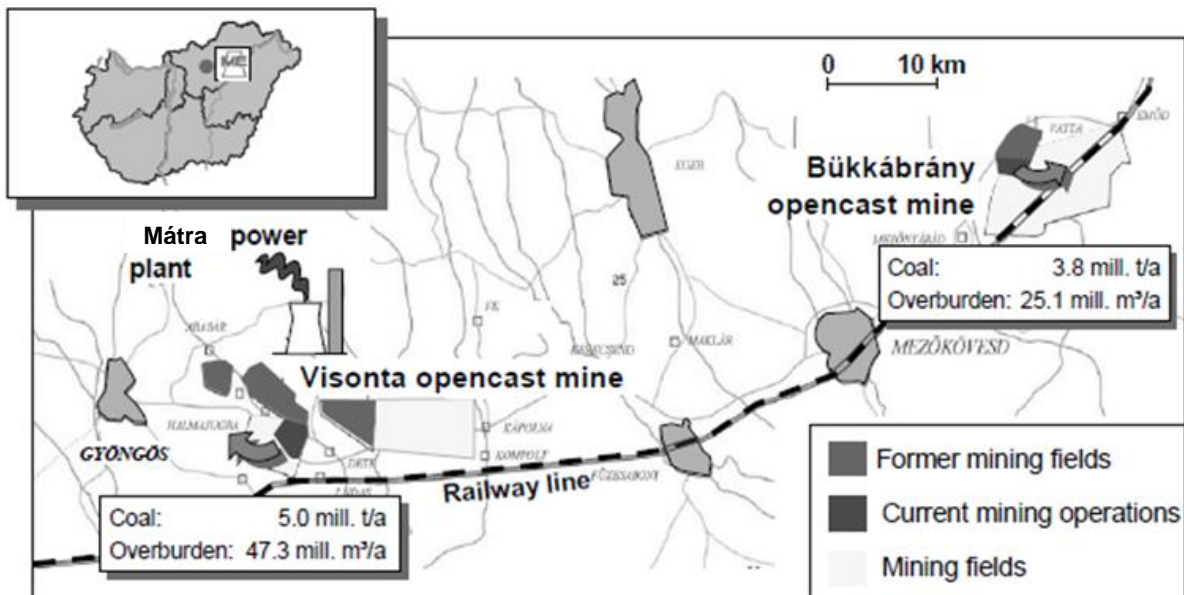


Figure 1 Mátrai Erőmű ZRt aerial overview of Hungary (top left), Visonta Mine, Bükkábrány Mine, railway line and Mátra Power plant (modified after Witzel, 2012)

The open cast mine Visonta and Bükkábrány produce approximately 8.8 Mt of lignite annually. Approximately 5 Mt/a of lignite are produced from the Visonta Mine, of which approximately 75,000 t are sold for Hungarian domestic end use. The Mine has a stripping ratio of 9.4:1 m³/t, overburden to coal ratio. Approximately 47 Mm³ of overburden is handled annually. Visonta Mine is located directly adjacent to the Mátra Power plant and supplies the power plant by belt conveyor. Temporarily storage of approximately 22 kt is possible in the *Visonta Mine Stockpile*. The Bükkábrány Mine extracts approximately 3.8 Mt/a and supplies Mátra Power plant via 60 km rail. Approximately 160,000 tonnes are annually sold for Hungarian domestic end uses or to other external buyers. Temporarily storage of approximately 30 kt is possible in the *Bükkábrány Mine Stockpile*, a stockpiling facility prior to train loading. The mine extracts approximately 26 Mm³ of overburden per year, the overburden to coal ratio is 6.7:1 m³/t. Based on the overburden to coal ratio Bükkábrány Mine may be considered as the mine with higher economic value, lower operating costs. The mineral reserve of lignite coal in Visonta and Bükkábrány is approximately 800 Mt (Mátra-Präs, 2013).

Mátra Power plant consists of five lignite fired blocks, having the following capacities: Block I and II of both 100 MW, Block III with 220 MW and Block IV and V of 232 MW each. Additionally, two gas turbines were installed in 2007, each with a capacity of 33 MW. The total power plant capacity is approximately 950 MW. The overall efficiency of the Mátra Power plant is 50%. The gas turbines have an efficiency of approximately 34%. The gas turbines increase the flexibility of the power plant when peak energy is demanded. The Blocks III to V are supplied with approximately 250 t/h of raw

lignite. In addition to the lignite and gas fuels, approximately 10% of CO₂-neutral biomass is combusted in the power plant. The heating requirement lays around 11500 kJ per produced kWh to produce approximately 224 MWh/h. The power plant is supplied directly from the mines (Bükkábrány coal through railway) or from the power plant adjacent stockpile facility *Visonta Mine Stockpile* or *Power Plant Stockpile* (German: *Kohlenlagerplatz*). The planned operational life of the Mátra Power plant units is outlined as followed: The annual operating hours of the two 100 MW blocks will be reduced to 1550 hours per annum (~17%) up 2020, towards shut down of these units in 2020. The remaining three blocks (III, IV and V) and gas turbines and supplying mines will be shut down in 2025. (MERT-GP, 2013).

A potential future project at Mátrai Erőmű ZRt is the building of a photovoltaic installation with a capacity of 15 MW. The photovoltaic facility would be built on top of the reclaimed ash waste pond north-west of the power plant (MERT, 2013).

Mátra Power plant contributes 5536 GWh, or 15% to the Hungarian energy market (2011). Mátrai Erőmű ZRt is owned by three major shareholders, i.e. RWE Power AG (50.9%), Magyar Villamos Művek (MVM) (26.2%), EnBW (21.7%) and 1.2% other owners. The company generated an income of 62 M€¹, from which 13 M€ are generated from exports (20%), considering financial year 2012 (MERT-Präs, 2013).

1.2 The added value of a coal quality sort concept: the Rhenish coal sort concept as example

Throughout the past 15 years RWE Power AG achieved a reduction of ore loss and an increase of power plant availability after introduction and development of a coal quality based *lignite coal sort concept*. The special coal quality parameters per lignite deposit were described by narrowly conceived definitions, the so called: *coal sort algorithm*.

The *Hambach* and *Garzweiler* Mine of RWE supply approximately 100 Mt/a of lignite coal to the power plants and factories, to produce a rough 74 TWh of energy and about 4 million tonnes of briquettes per year (RWE, 2013). The developed coal quality management systems integrate following key systems: geological model, excavation techniques, stockpiling facilities at the mines, rail transport, power plant stockpiling facilities and power plant block specific combustion characteristics.

An extensive amount of knowledge about the deposits geology, mining operations and the operational behaviour of power plant's individual boilers is needed to be able to divide the lignite in economically reasonable *coal sorts*.

Coal sort (German: *Kohlesorte*): (In situ) lignite coal for which one or multiple quality parameters (e.g. ash, sulphur, potassium content) lies within specified ranges so that by combustion of this coal a particular combustion behaviour can be expected.

In this Thesis the term “coal sort” was chosen over “coal type” or “coal kind” because of the logic parallel to the German word, i.e.: “Kohlesorte”. NB. Coal sort should not be confused with “to sort” coal or “sorted” coal.

¹ Exchange rate: 1 EUR = 294.715 HUF (= Hungarian Forint) (2013-10-17)

Deposit geology

The thick lignite seam in open cast mine *Hambach* is covered with a thick overburden layer which results in high calorific values (or low moisture content). In the southern area of the *Hambach* Mine siderite-layers are enclosed in the coal containing a high amount of iron. The lignite in the northern part of the mine contains high sodium concentrations. The sodium oxide content in the coal ashes varies approximately between 3 and 8%. This corresponds with ash contents between 4 and 2%, respectively. Dilution of coal commonly occurs throughout the entire deposit through co-extraction of clay, silt or sand rich sediments from the hanging and footwall sediments of the coal seams, also sediment inclusions dilute the coal (Lokay, 2013).

Garzweiler Mine consists of three by interburden separated coal seams, each having specific coal quality features: *Seam Garzweiler* has a strongly varying thickness. The lignite is poorly consolidated and has a high moisture content. The lignite partially has Xylit-rich structures and sporadically high iron content. *Seam Frimmersdorf* is a sand-rich coal with high sulphur content (i.e. 0.6 – 1.4 %). *Seam Morken* has a poor sulphur and ash content and is there with an excellent blending component to homogenise outlier qualities in *Seam Frimmersdorf* (Lokay, 2013).

Open cast mine *Inden* is not directly included in the coal quality sort concept because it supplies its own *Power plant Weißweiler*.

Coal combustion behaviour

Based on experience of RWE Power AG in combustion of sub-optimal coal (or coal sorts) hypothetical combustion behaviour statements can be made (Neuroth, 2013a). The operational behaviour of a boiler is strongly dependent on the air supply, temperature profile and residence time of the coal dust in the boiler. Air is the major initiator of the combustion- and oxidation processes. Insufficient air supply could cause incomplete combustion and oxidation of the carbon-compounds into carbon monoxide, which could encourage fouling and delayed combustion in the boiler. Furthermore, insufficient air supply could slow down the formation of sulphates in the flue gas due to which the dust in the flue gas is deposited on the heat exchangers and further reacts to form sinter. Slagging could be improved because of Fe^{2+} -formation with low melting temperatures. On the contrary, a surplus of air supply mainly avoids slagging in the boiler, however could lead to increased temperatures and NO_x formation. The temperature influences the melting process of coal dust and condensation processes. High temperatures influence the stability of particular mineral phases, like Anhydrite (CaSO_4) and encourage potential fouling and slagging processes.

The following chemical elements could have a high influence on the slagging *potential* of Rhenish lignite blends: silicon, aluminium, iron, calcium, magnesium, sodium, potassium and sulphur. Sulphur, iron and calcium for example occur either organically or inorganically bound. For example: In Rhenish lignite sulphur can occur as Pyrite (FeS_2). In the Mátrai Erőmű ZRt lignite deposits also Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) is a commonly occurring mineral (Frerix et al., 2013), see Chapter 9B.2. The sulphur which is not bound in ash minerals reacts to SO_2 and is transported in the flue gas to the flue gas desulphurisation (FGD) plant. Calcium in combination with sulphur can cause sulphate caking and fouling on the heat exchangers. Dependent on the amount of sodium, temperature and residence time these fouling-coats could become extremely hard. Combustion of sulphur-rich lignite contaminated with clay could result in formation of aluminosiliceous-slugs. High sodium contents in the lignite could increase slagging, sintering and fouling potential in the burning chamber and at the heat exchangers because of its melting point decreasing function against silicates and sulphates. Potassium mainly occurs in the lignite in combination with aluminium-rich clay minerals and feldspars and could

trigger slagging because of its melting point reducing function. In alumino-siliceous systems calcium and magnesium have a melting point reducing characteristic, which might increase the slagging potential. Silica is the key parameter when considering slagging potential, it increases the melting temperature in silica-rich ash systems and decreases melting temperatures when occurring in combination with calcium-magnesium-, or iron-rich combustion systems. Silica (in form of coarse-grained quartz sand) has a cleaning function against fouling on the heat exchangers, however causes extra abrasive wear on the equipment. Iron is mainly present in lignite inorganically bound as siderite (FeCO_3) or pyrite (FeS_2) but could also occur biogenically bound. Iron is uncritical against slagging in low ash environment (no reactants, for example silica, present), however in combination with silica strong slagging processes could occur.

Slagging can be avoided by taking operational measures. For example: spontaneous silica slagging can be prevented by combustion of critical coal qualities at low temperatures (fluidized bed combustion chambers or other boilers with low thermal heating chamber conditions) and by avoiding sub stoichiometric conditions at the exit of the burning chamber. Furthermore, it is prohibited to combust coals with low melting eutectic ash compositions at low temperatures because of their extremely critical slagging potential (dependent on basic-acid-ratio²). Sulphate-sintering is a very slow fouling process. To prevent boilers from this fouling type the following operational measures were suggested: frequent cleaning with shoot-blowers or increase of the ash content (abrasive self-cleaning behaviour). Combustion of lignite with high calorific value, sulphur content and sodium content at the same time must be avoided. Also, a high temperature at the burning chamber exit point must be avoided.

Rhenish coal sorts

The Rhenish coal sorts are defined taking into account boundary conditions for ash content and multiple chemical elements: sulphur, iron, silicon, sodium and potassium. The coal sorts firstly divide the lignite deposits into briquette and boiler coal, based on the ash content. Briquette coal has an ash content lower than 2.5% and is only available in the *Hambach* Mine. The briquette coal is further divided in two coal sorts based on the amount of gel in the coal, i.e. HBG for Hambach Briquette coal Gel which might have a gel amount greater than 50%, and HBA for Hambach Briquette coal Poor (German: *arm*) with a maximum gel amount of 50%. The boiler coal in *Hambach* is divided into seven coal sorts, and *Garzweiler* coal in six. The *Hambach* boiler coal is divided into normal coal which can be used in every *Hambach*-boiler of the Rhenish power plants and sand/clay-rich coal which are preferably fed into the power plant boilers after blending with normal *Hambach* coal or *Garzweiler* coal. The normal *Hambach* coal is additionally subdivided based on iron and alkali (Na and K) enrichment. *Hambach* boiler coal that does not fit in any of these descriptions is called HKR: Hambach Boiler (German: *Kessel*) coal Rich. This coal is subjected to combustion trials before further classification to a particular coal sort. *Garzweiler* boiler coal is divided in coal from Seam *Garzweiler* with minimal amount of critical components iron and potassium (GGA), rich of critical components (GGR) and sand-rich coal (GGS); and blends of *Seams Frimmersdorf* and/or *Morken*, similarly named: GMA, GMS, GMR, also characterized by the amount of iron, potassium and ash (Jaetzel, 2013).

Coal quality management

From an economic perspective it is of equal importance that the mine extracts the lignite without capacity loss or delay in overburden extraction and that the power plant operates widely without un-

²Basic-Acid Ratio: $(\text{Na}_2\text{O}+\text{K}_2\text{O}+\text{CaO}+\text{MgO}+\text{Fe}_x\text{O}_y):(\text{SiO}_2+\text{Al}_2\text{O}_3+\text{TiO}_2)$, see Chapter 7.1

planned standstills or performs under capacity. Intensive cooperation between the mines and the power plant, supported by a sophisticated digitalised logistics system, is needed to make the coal sorts economically viable (Rosenberg, 2003 and Hagenbrock, 2013). Figure 2 schematically shows the simplified coal quality management system used at RWE Power AG.

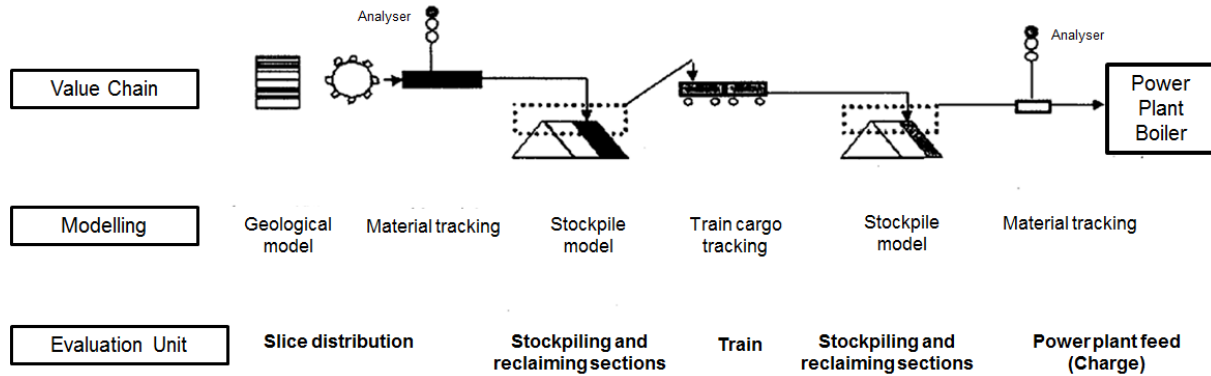


Figure 2 Schematic visualization of the coal quality management system at RWE Power AG (modified after, Hagenbrock, 2013)

The in-situ coal quality descriptions (LAVA geology database and geological model) is divided into by Bucket-Wheel-Excavator (BWE) minable slices, after mining each slice is characterized with this coal quality description, or Quality ID (IKOLA). Automated on-belt sampling proves the coal quality ID. The quality ID consists of all relevant information: which BWE, extraction position, quality description, mass and time. After extraction the coal slice is stored in the stockpile facility. The material in the stockpiles is simulated per slice based on the quality IDs (QUABUS). The stockpiles are used for homogenisation of the extracted coal sorts, to reduce extreme coal quality outliers (e.g. sulphur outliers). From the mine's stockpile the train wagons are filled with blend qualities of the different slices, each wagon gets a new Blend Quality ID (IBUKOM). Per wagon the coal is charged into the power plants stockpiles. A blend quality of wagons is finally reclaimed from the power plant stockpile and fed into the target power plant boiler or factory. Potential reactions between lignite and mineral sediments in the boiler were assessed, as well as caking potential of particular coal sorts (as described earlier). Based on these assessments each power plant and factory got their own lignite blend schedules which are described in the coal quality strategy rules (Hagenbrock, 2013). All material handling rules, coal sorts, blend rules, stockpiling strategies are described in a coal quality handling recommendation (German: *Handlungsempfehlungen*) (Jaetzel, 2013).

Summary

Summarising the components contributing to the coal quality sort concept currently practiced in the Rhenish Mining District by RWE Power AG, i.e.:

- Extensive knowledge on the geology of the lignite deposits (to determine coal sorts)
- Target-aimed (power plants or refining factories) plant feed allocation and delivery
- Utilisation of both mine and power plant capacity (high equipment availability)
- Understanding of the power plant operational behaviour for the particular coal sorts
 - Power plant performance and efficiency
 - Slagging and fouling behaviour of coal sorts, based on B/A-ratio, calorific value, ash melting behaviour and sediment contaminations (or other sub-optimal combustion behaviours)
- Technical operation limitations of mines, logistics, stockpiling facilities and power plant