SimuSage based simulation of a coal fired boiler

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VORWEG GEHEN

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Mining, power generation, upgrading

Lignite in the Rhineland

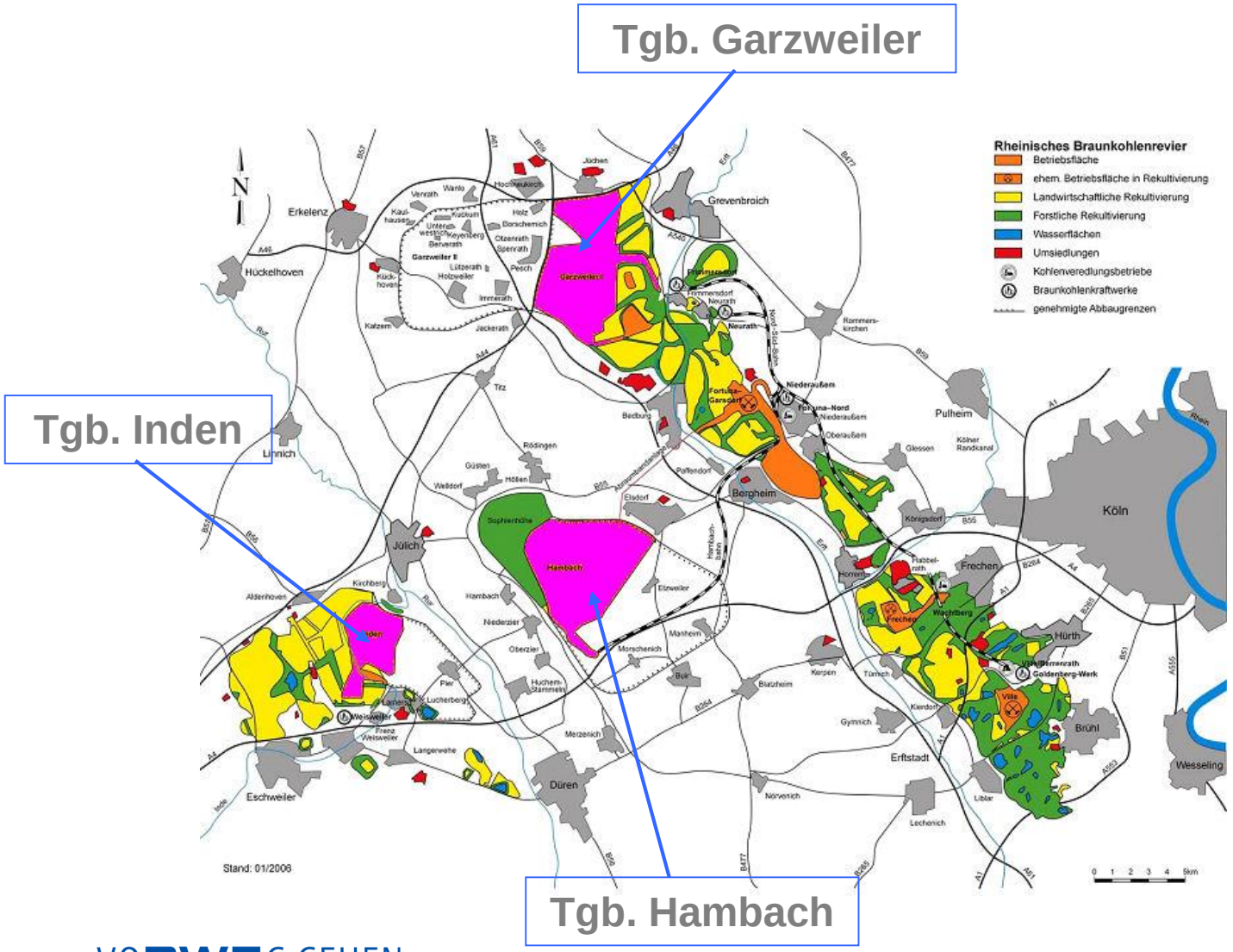
Lignite

Kohlearten				Wasser-gehalt (%)	Energie-gehalt af* (kJ/kg)	flüchtige Anteile waf** (%)
UN-ECE	USA (ASTM)	Deutschland (DIN)				
Peat	Peat	Torf				
Ortho-Lignite	Lignite	WEICHBRAUNKOHLE		75	6,700	
Meta-Lignite		Mattbraunkohle		35	16,500	
Subbitum. Coal	Sub-bituminous Coal	Glanzbraunkohle		25	19,000	
Bituminous Coal	High Volatile Bituminous Coal	Flammkohle	Steinkohle	10	25,000	45
		Gasflammkohle				40
		Gaskohle				35
	Medium Vol. Bitumin. Coal	Fettkohle		Kokskohle 36,000		28
	Low Vol. Bitumin. Coal	Eßkohle				19
Anthracite	Semi-Anthracite	Magerkohle				14
	Anthracite	Anthrazit	HARTKOHLE	3	36,000	10

af * = aschefrei waf ** = wasser- und aschefreie Substanz Quelle: BGR

	Deposit
Origin	in the Tertiary period (12 – 20 mill. years ago) from subtropical vegetation
Volume	55 bn t in the Rhineland
Stripping ratio	4.7 : 1
	Quality
NCV	Ø 8,700 kJoules (= 1/3 tce)
Moisture	50 - 60 %
Ash	1.5 – 8.0 %
Sulphur	0.15 – 0.5 %
Calcium and magnesium	bind gaseous sulphur dioxide in the ash

Rhenish Lignite Mining Area.



Coal classification in the Rhenish Lignite aera.

Tagebau Hambach

Kesselkohle	Brikettierkohle	Kohle, die in den Veredelungsbetrieben eingesetze werden kann.	HBA	für alle Abnehmer auch »pur« in umgebauten Kesseln einsetzbar	Asche / Fe	<	2,5 / 4.000
					K	<	200
					Si	<	1.800
					S	<	0,24
			HBG	»gelorientiert« für Fortuna-Nord und Ville-Berrenrath »pur« in umgebauten Kesseln einsetzbar	Asche / Fe	<	2,5 / 4.000
					K	<	200
					S	<	0,24
	pur - Kohle für Ha-Kessel	Kesselkohle, die in Ha-Blöcken pur eingesetzt werden kann	HKA	eisenarm alkaliarm	Asche / Fe	<	4 / 3.000
					Na / K	<	900 / 200
			HKN	eisenarm alkalireich	Asche / Fe	<	4 / 3.000
					Na	>	900
					K	<	200
					Si	>	4.000
					S	<	0,35
			HKF	eisenreich alkaliarm	Asche	<	4
					Fe	>	4.000
					Na	<	900
					K	<	200
			HKE	eisenreich siliziumarm	Fe	<	10.000
					K	<	200
					Si	<	2.000
	kritische Kohle	Kesselkohle, die nur in dafür freigegebenen Blöcken pur oder nach festgelegten Regeln in Mischung mit Ga- oder Ha-Kohle eingesetzt werden darf	HKR	reich an kritischen Bestandteilen ohne Verunreinigungen aus angrenzendem Abraum	Asche / Fe	> / <	4 / 5.500
					K	<	300
					S	<	0,8
			HKS	reich an kritischen Bestandteilen Verunreinigungen aus sandbetonten Grenzflächen möglich	Asche / Fe	<	7 / 5.500
					K	<	1.000
					S	<	0,8
			HKT	reich an kritischen Bestandteilen Verunreinigungen aus tonbetonten Grenzflächen möglich	Asche / Fe	<	7 / 5.500
					K	<	1.000
					S	<	0,8

Tagebau Garzweiler

Flöz Garzweiler		Kesselkohle, die in Ga-Blöcken oder in Mischung mit Ha-Kohle eingesetzt werden kann	GGA	Flöz Garzweiler aschearm arm an kritischen Bestandteilen	Asche / Fe	<	4 / 4.000
					K	<	200
		Kesselkohle, die in Ga-Blöcken pur oder in Mischung mit Ha-Kohle eingesetzt werden kann	GGS	Flöz Garzweiler aschereich sandig	Asche / Fe	> / <	4 / 4.000
					K	<	200
		Kesselkohle, die nicht ohne weiteres Mischen mit Ga- oder Ha-Kohle eingesetzt werden kann	GGR	Flöz Garzweiler reich an kritischen Bestandteilen	Fe	>	4.000
					und / oder		
					K	>	200
Flöz Frimmersdorf / Morken Ga-Mischkohle		Kesselkohle, die in Ga-Blöcken pur oder in Mischung mit Ha-Kohle eingesetzt werden kann	GMA	Flöz Frimmersdorf / Morken aschearm arm an kritischen Bestandteilen	Asche / Fe	<	4 / 4.000
					K	<	200
		Kesselkohle, die in Ga-Blöcken pur oder in Mischung mit Ha-Kohle eingesetzt werden kann	GMS	Flöz Frimmersdorf / Morken aschereich sandig	Asche / Fe	> / <	4 / 4.000
					K	<	200
		Kesselkohle, die nicht ohne weiteres Mischen mit Ga- oder Ha-Kohle eingesetzt werden kann	GMR	Flöz Frimmersdorf / Morken reich an kritischen Bestandteilen	Fe	>	4.000
					und / oder		
					K	>	200

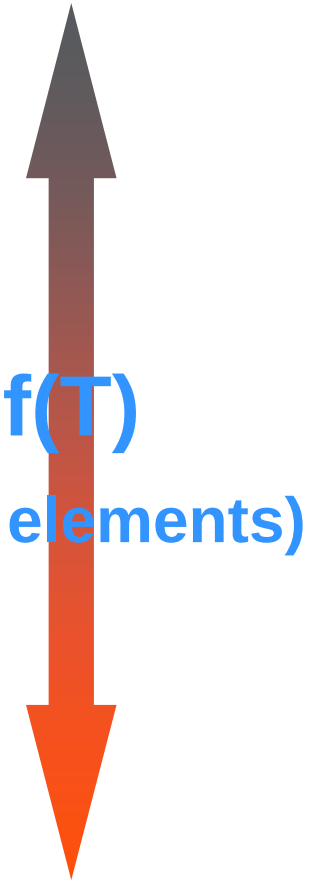
15 Lignite varieties from only two mines: Hambach & Garzweiler

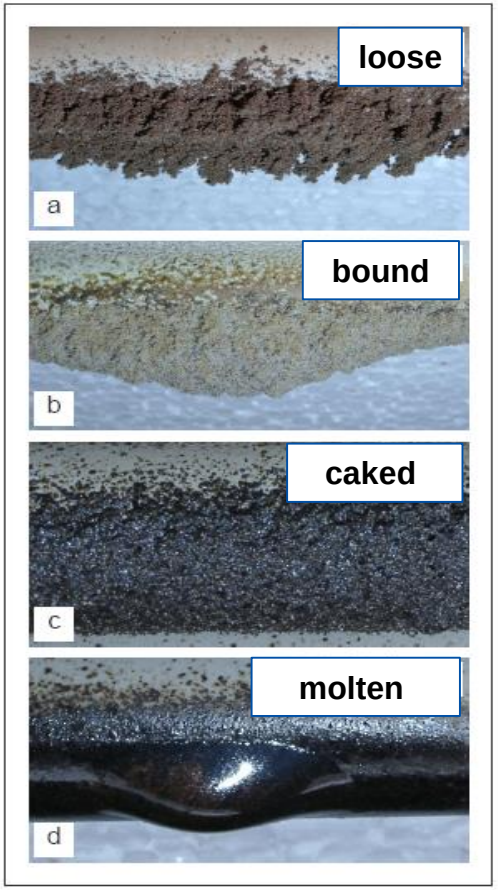
Forms of slagging and fouling

Fouling

Sintering

Slagging





Slagging and Sintering must be technically manageable or preventable

Effects of salts and clay

> Coal minerals exhibiting alkali sulphate salts show a strong tendency to form a salt melt and lead to bound deposits.

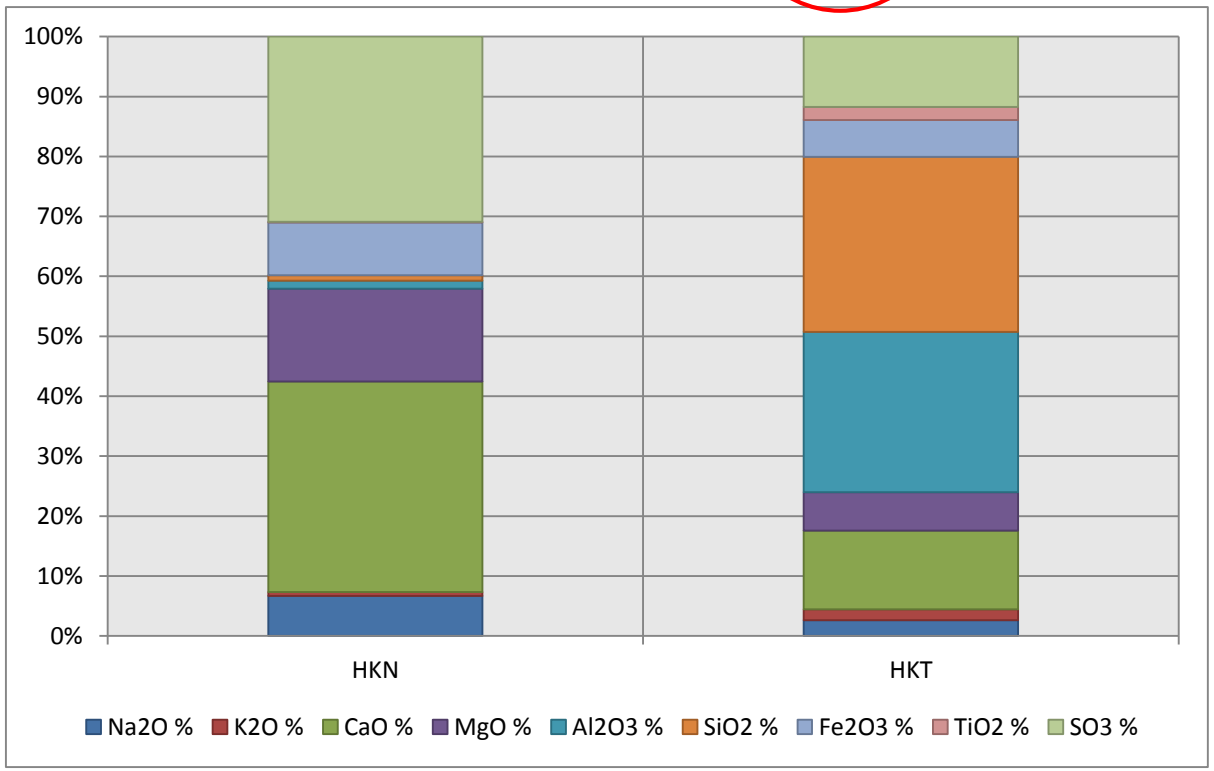
> Clay rich coal minerals show a tendency to form oxid based melts and lead to slagging problems.

→ HKN coal is rich in alkali sulphates

→ HKT coal is rich in clay minerals

Original Lignite compositions from Hambach as an example for HKN and HKT coals

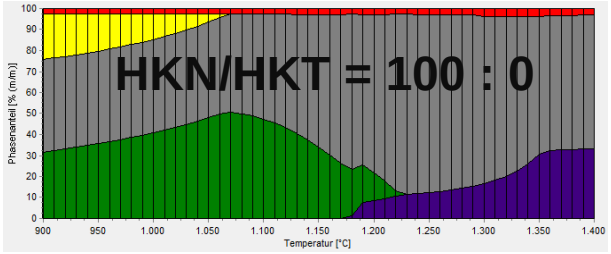
	w (roh)	a (820°C)	S (roh)	Na2O	K2O	CaO	MgO	Al2O3	SiO2	Fe2O3	TiO2	SO3	B/S
	%	%	%	%	%	%	%	%	%	%	%	%	
HKN	50,5	2,01	0,28	7,54	0,69	39,58	17,45	1,53	0,98	9,92	0,16	34,79	28,17
HKT	52,2	5,35	0,26	2,72	1,86	13,63	6,60	27,69	30,19	6,36	2,28	12,14	0,52

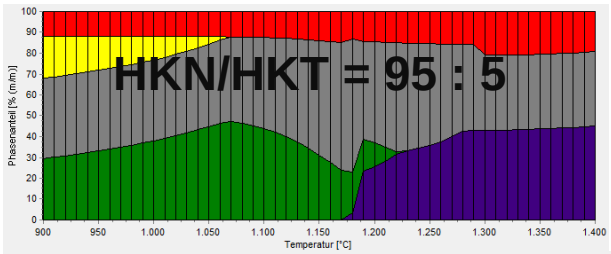


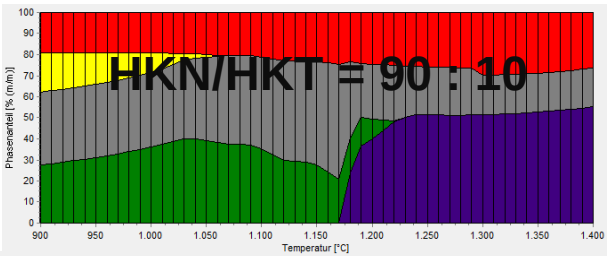
Temperature and composition dependent melt phases

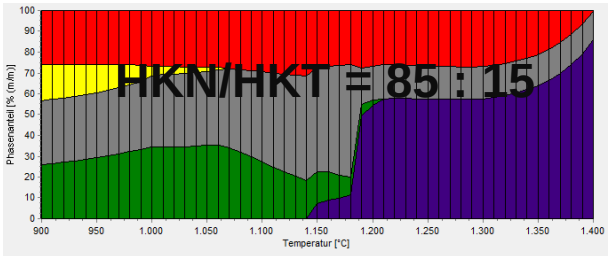
Thermochemical simulation using a SimuSage model

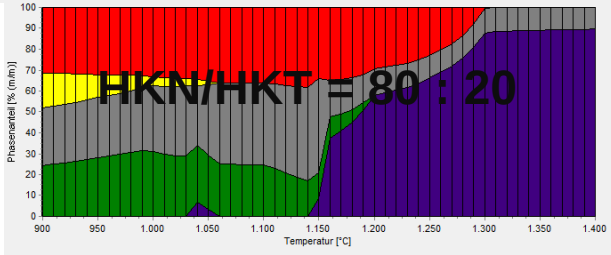
Isothermal mixing of HKN and HKT coal minerals: result overview

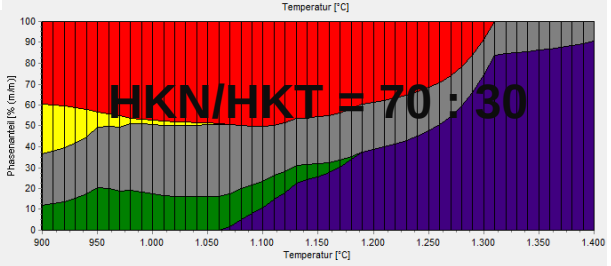


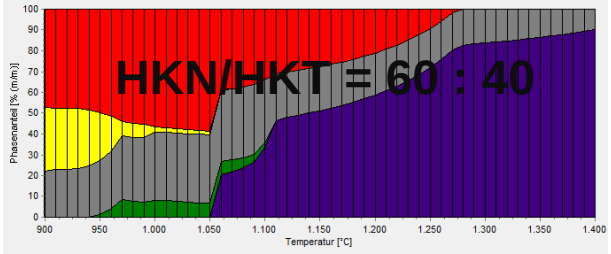


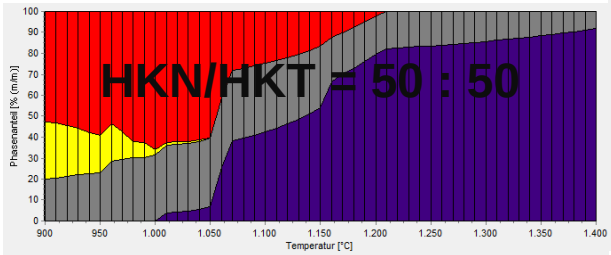


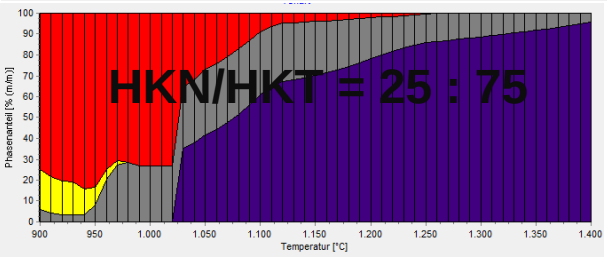


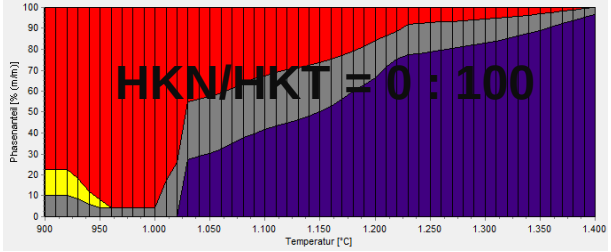


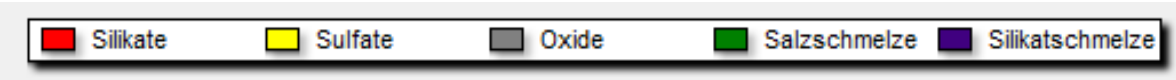




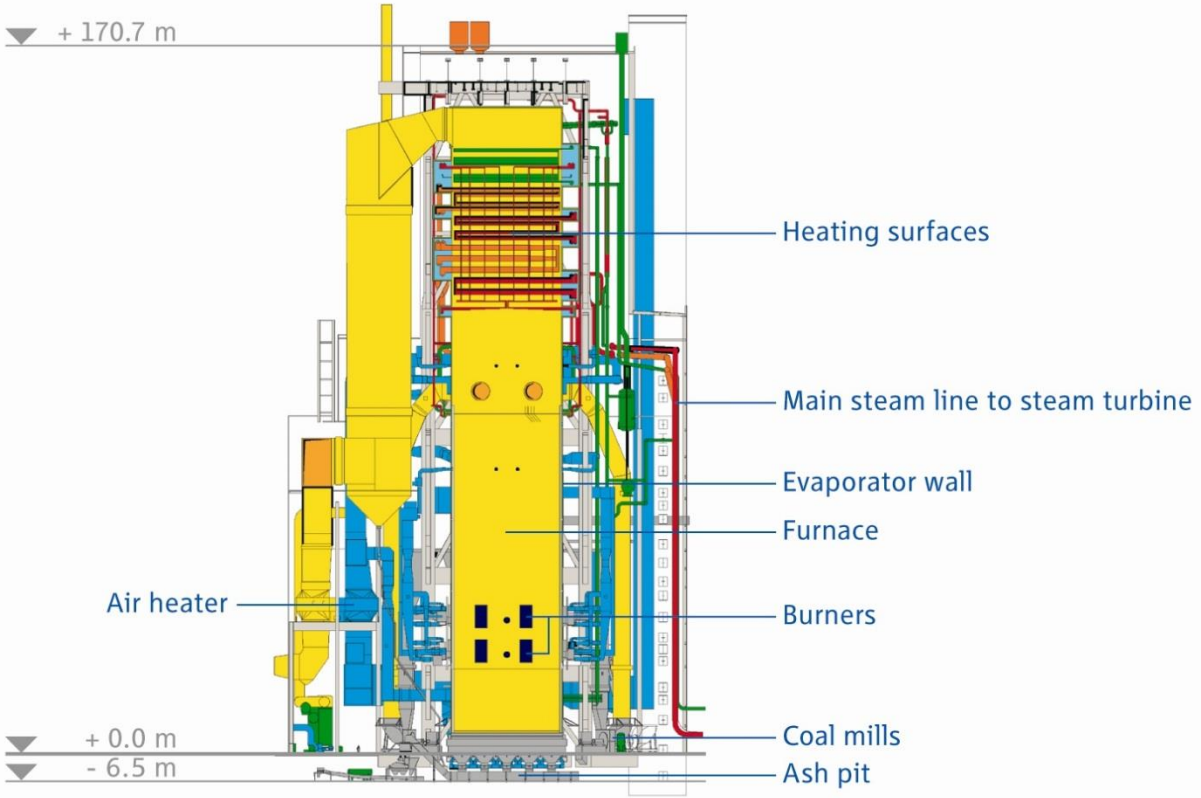




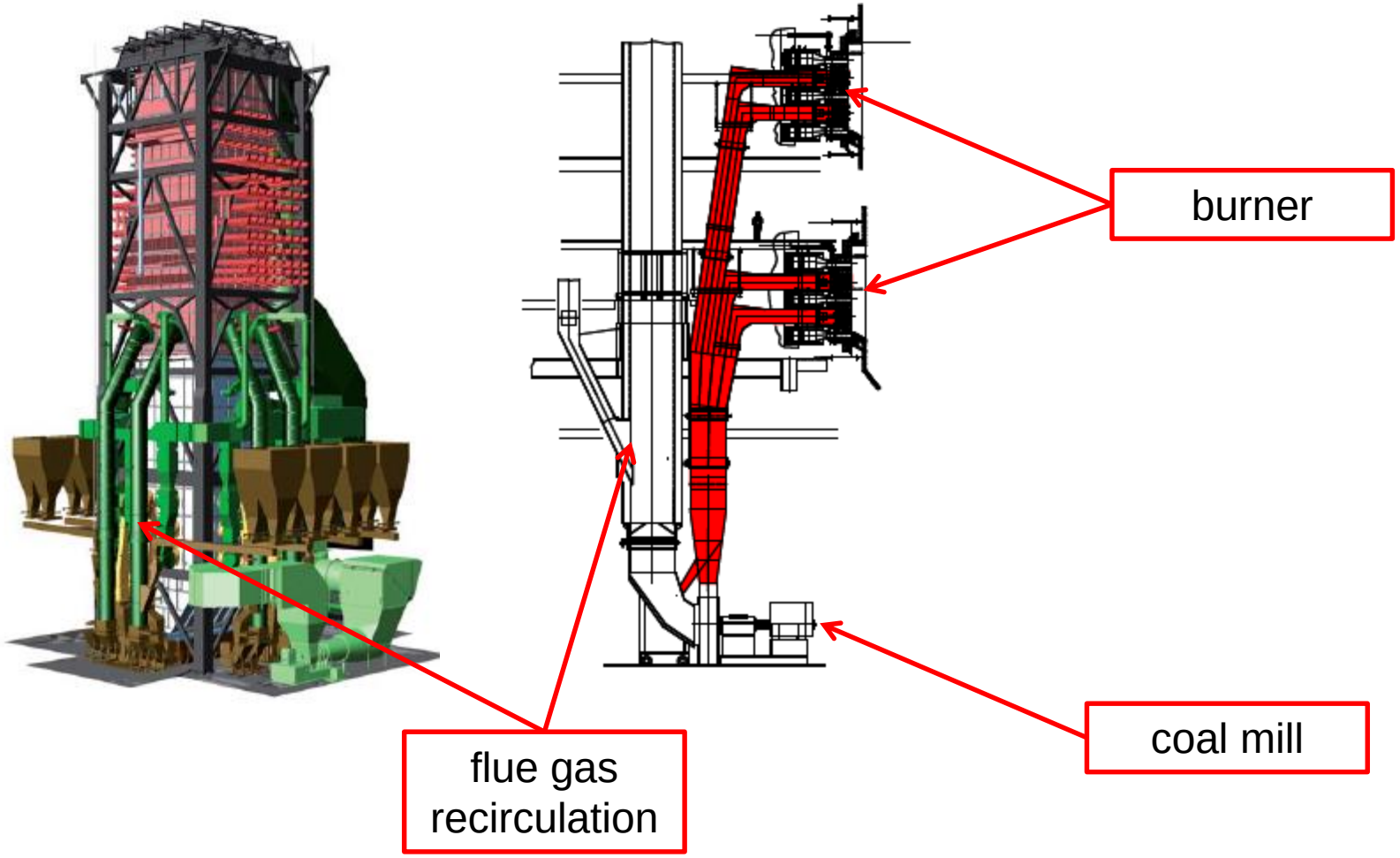




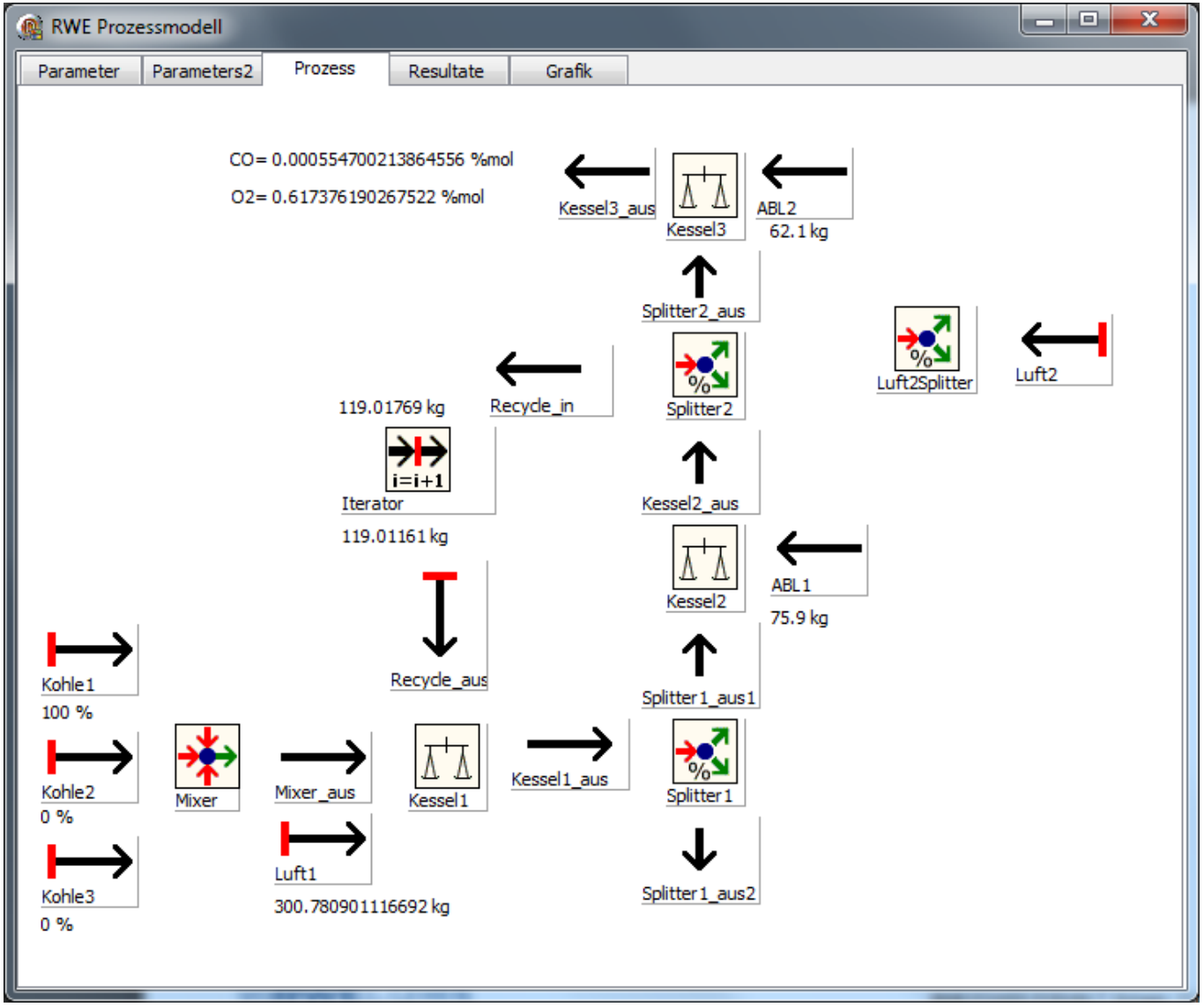
Furnace chamber model
Lignite Boiler – Dust Combustion



Lignite Boiler – Dust Combustion in Detail

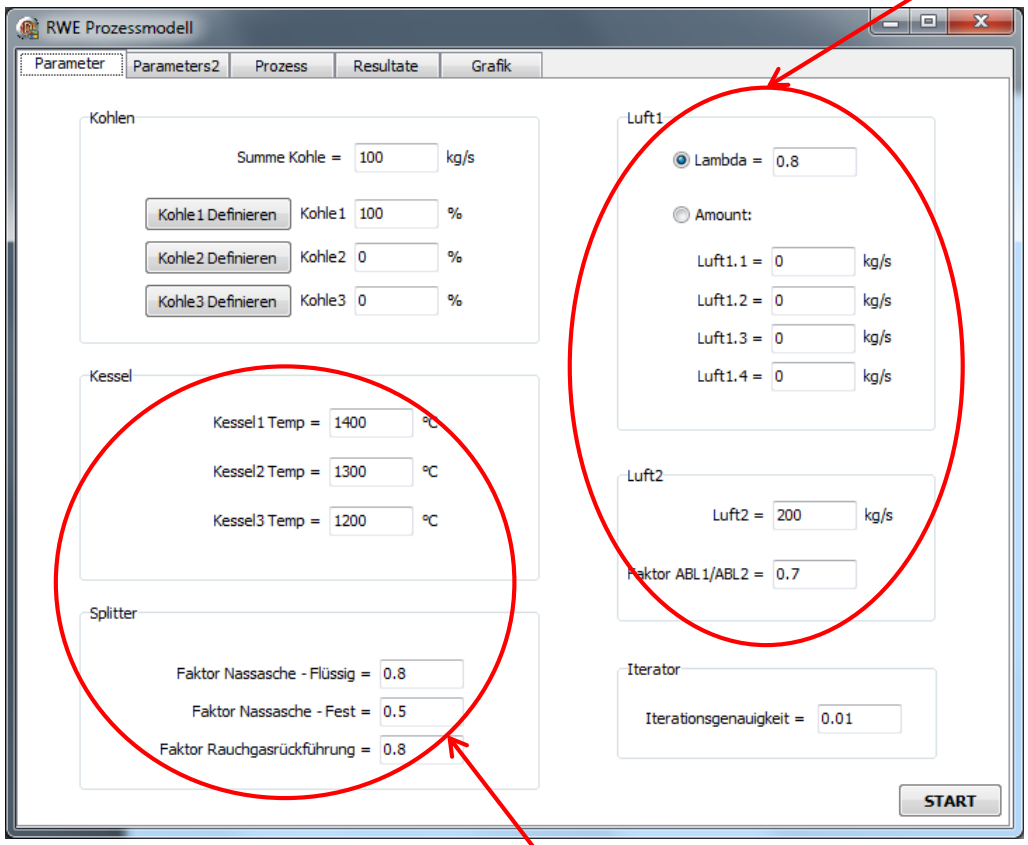


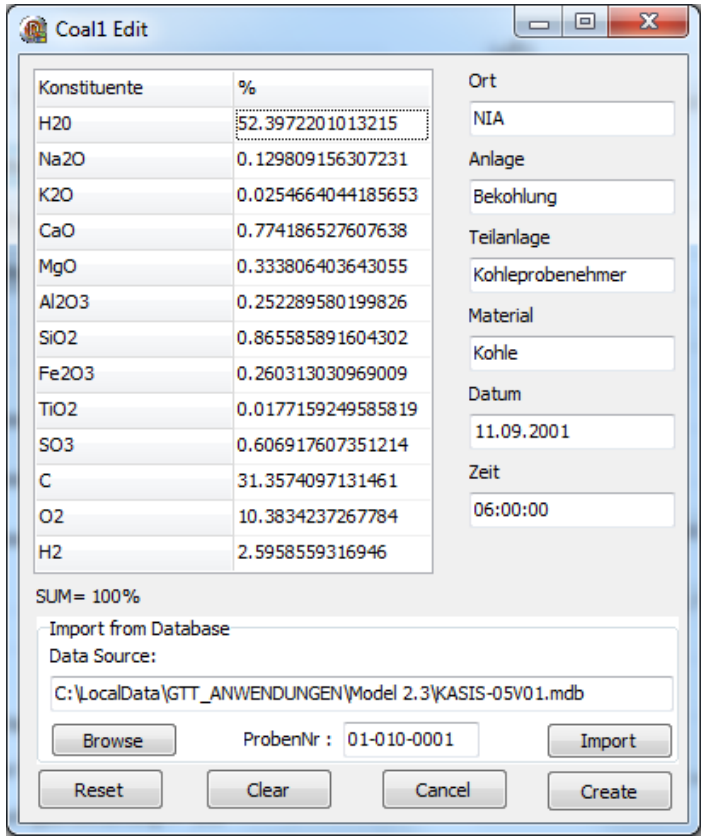
Furnace chamber: SimuSage model



Furnace chamber model: User interface I

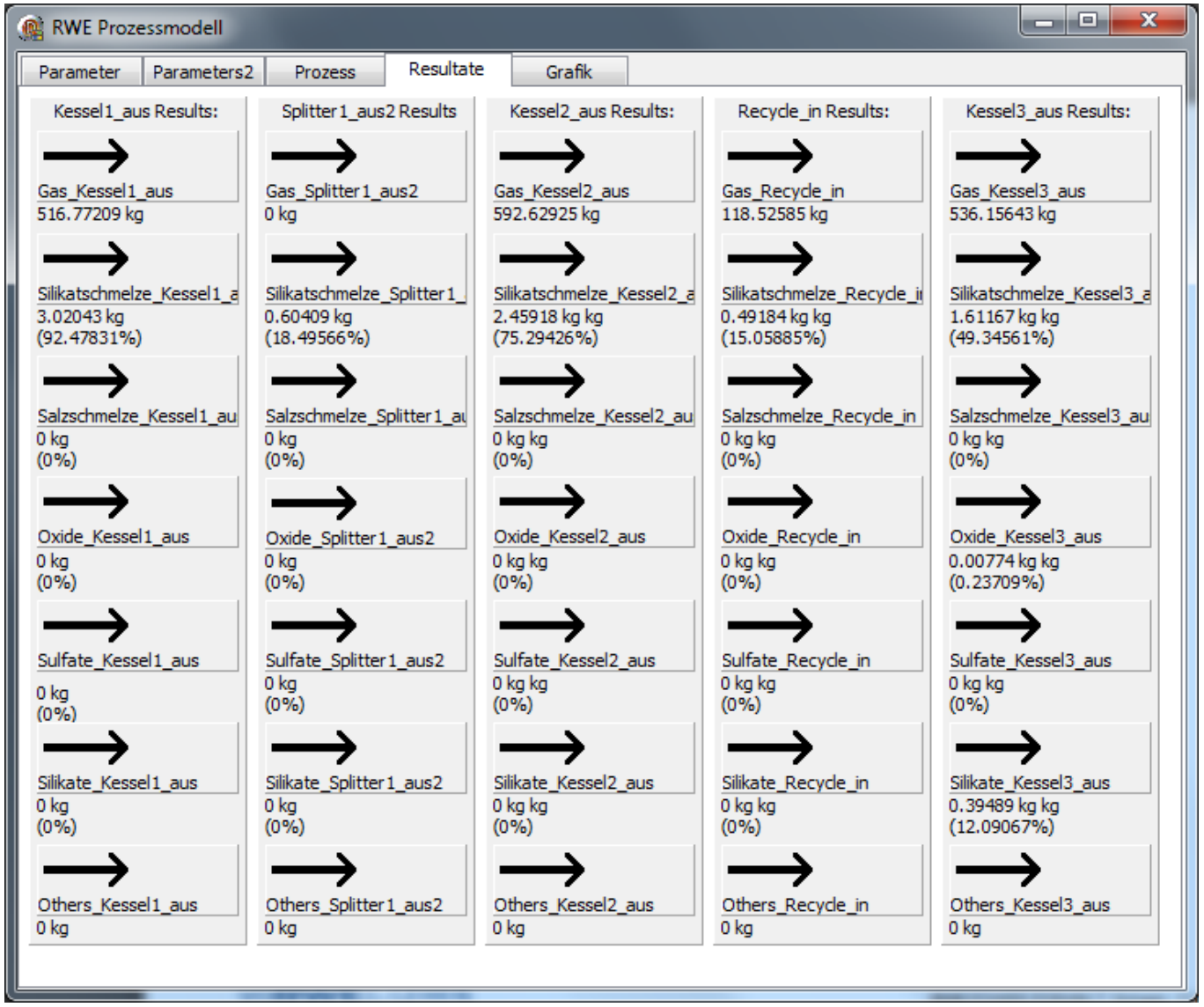
Air supply:
On average or partitioned in four areas





Temperatur in combustion chamber partitined in three areas
Proportion of fluid / solid wet ash
Proportion of flue gas recirculation

Furnace chamber model: Results I

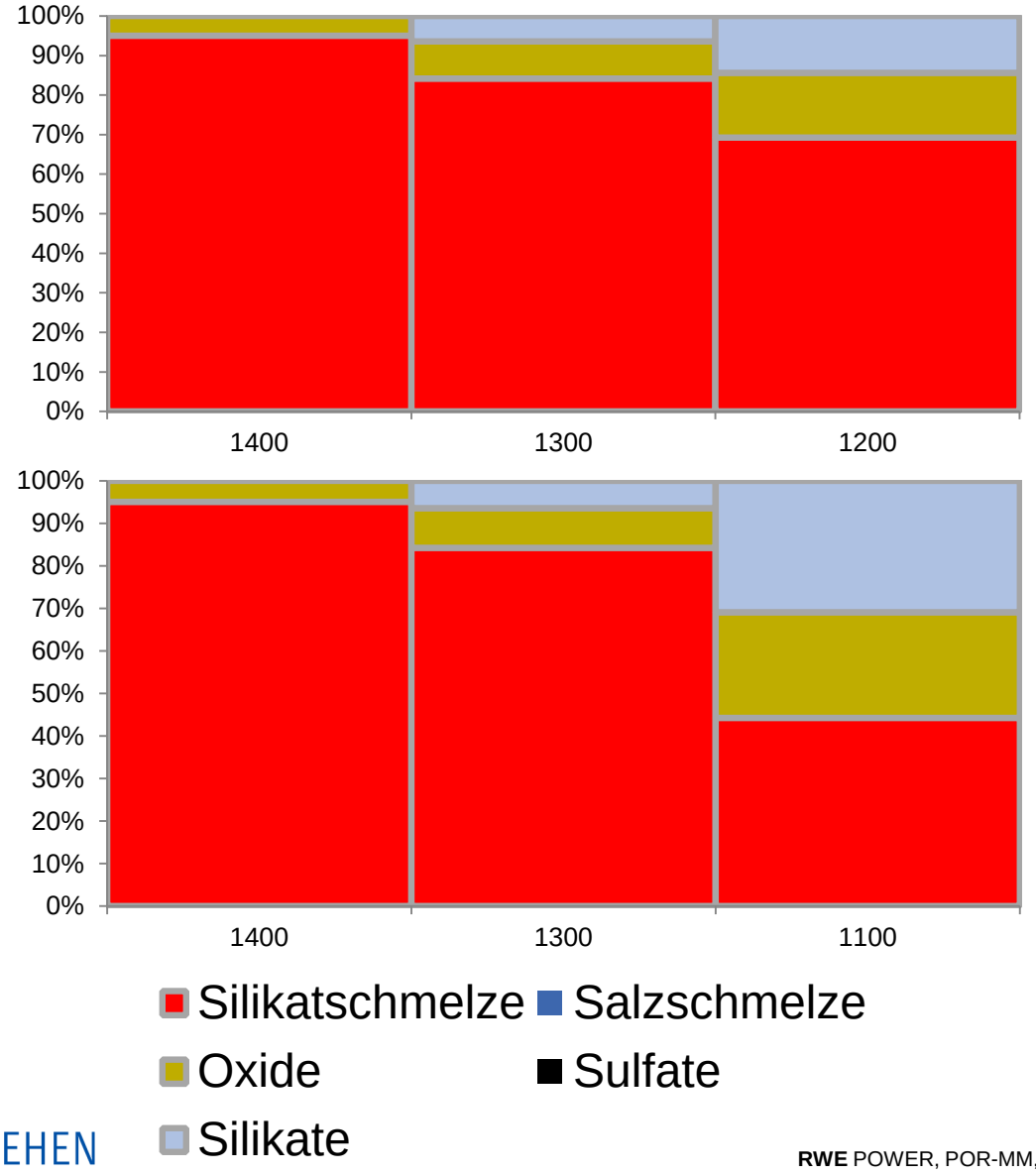


Phases are compiled in characteristic groups:

Silicate melt
Salt melt
Solid oxides
Solid sulphates
others

Furnace chamber model: Results II

Influence of chamber end temperature on phase formation

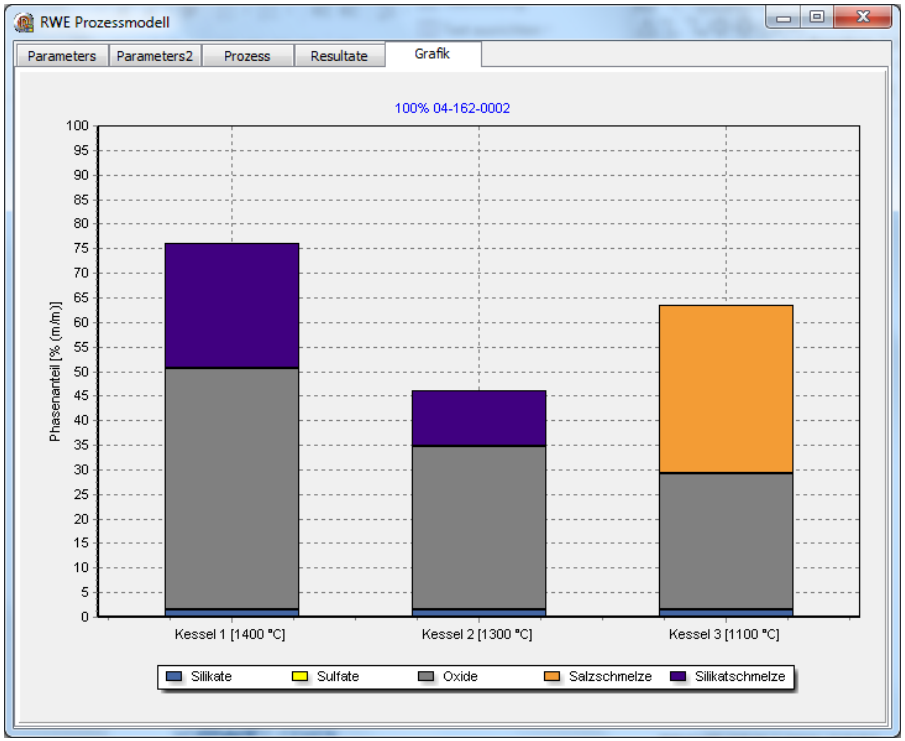


HKT coal

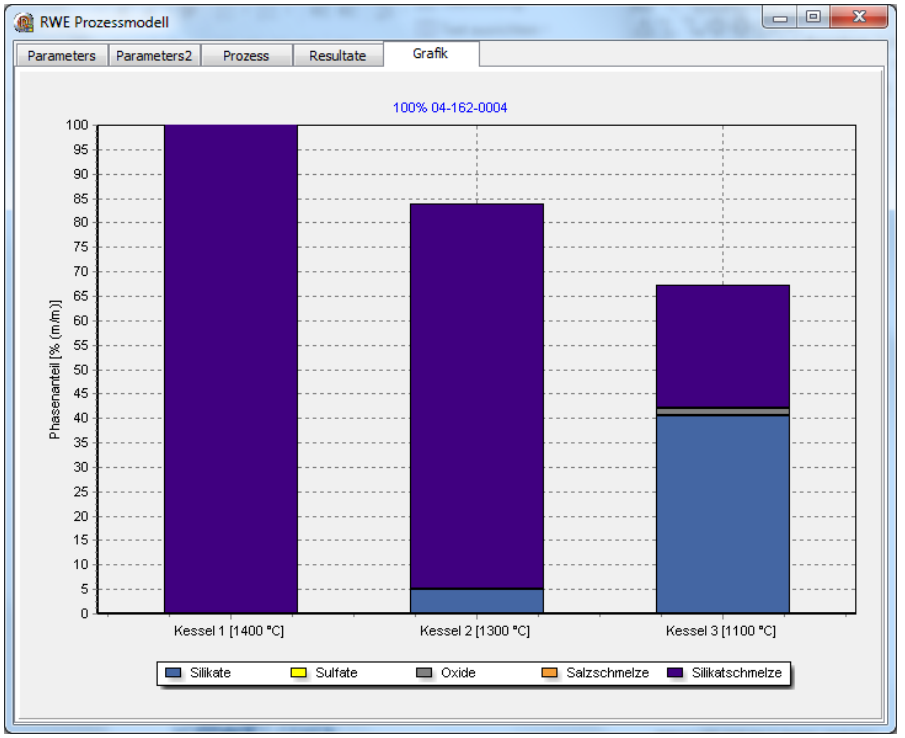
Furnace chamber model: Results III

Influence of coal blends on phase formation

100% HKN

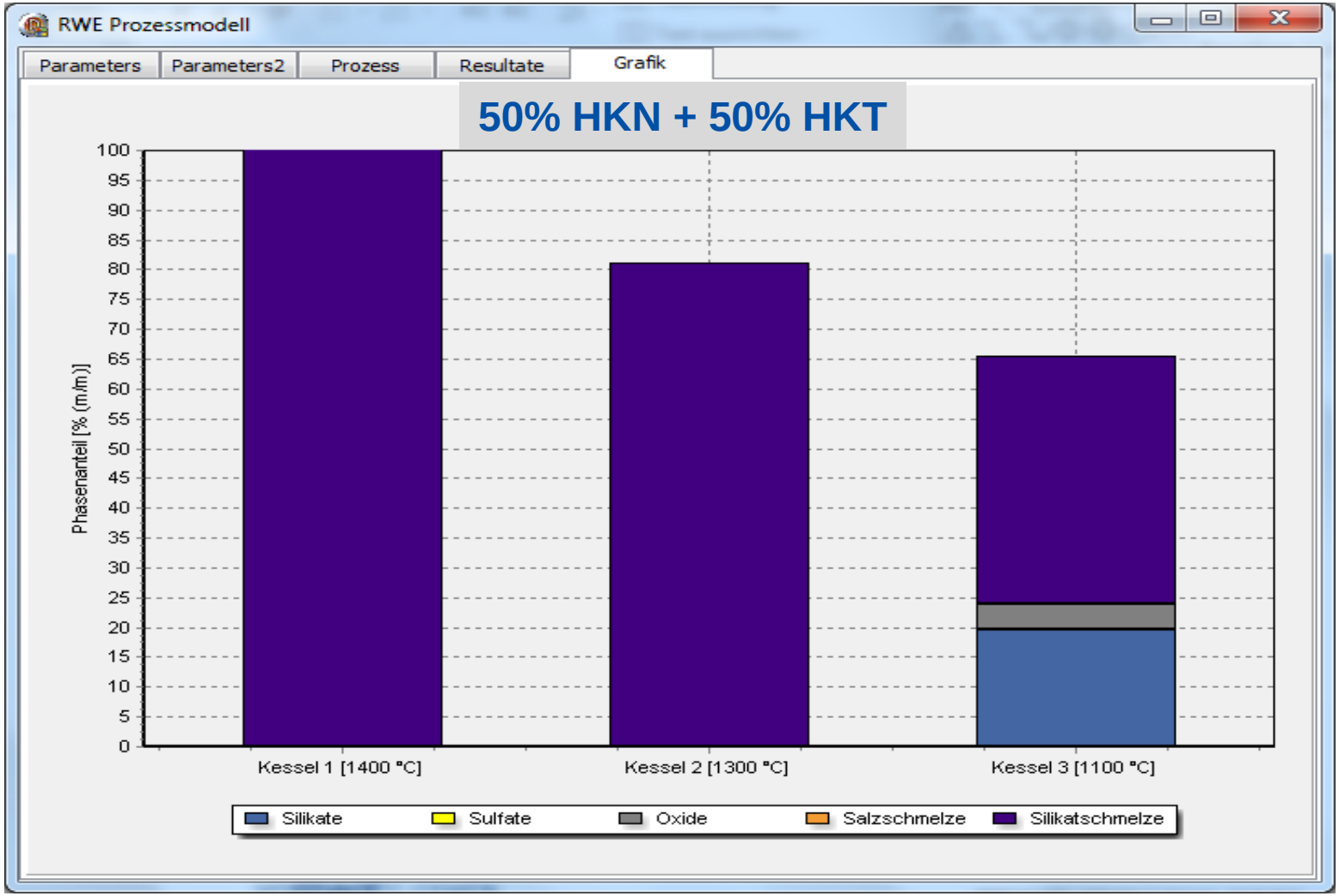


100% HKT



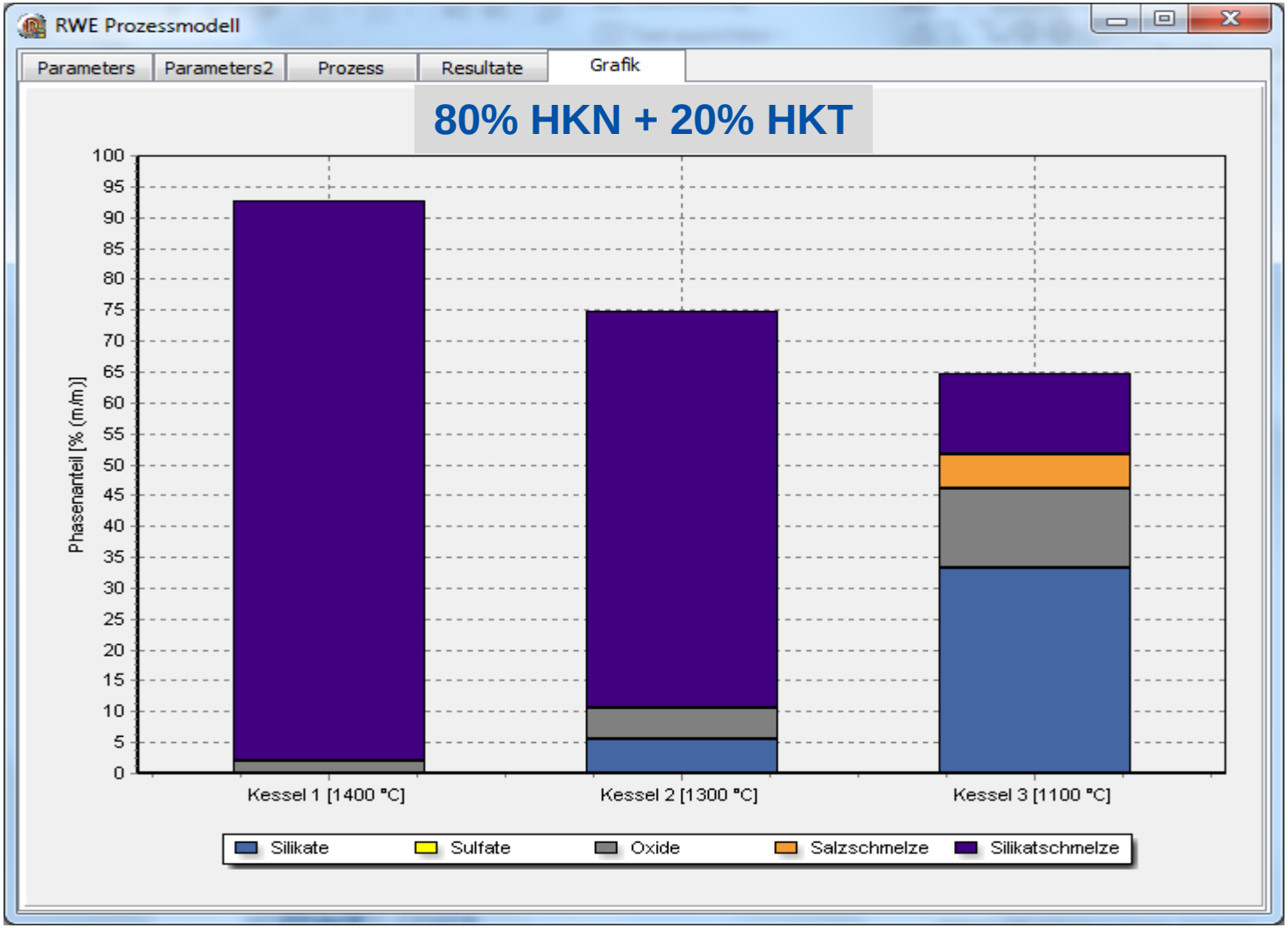
Furnace chamber model: Results III

Influence of coal blends on phase formation



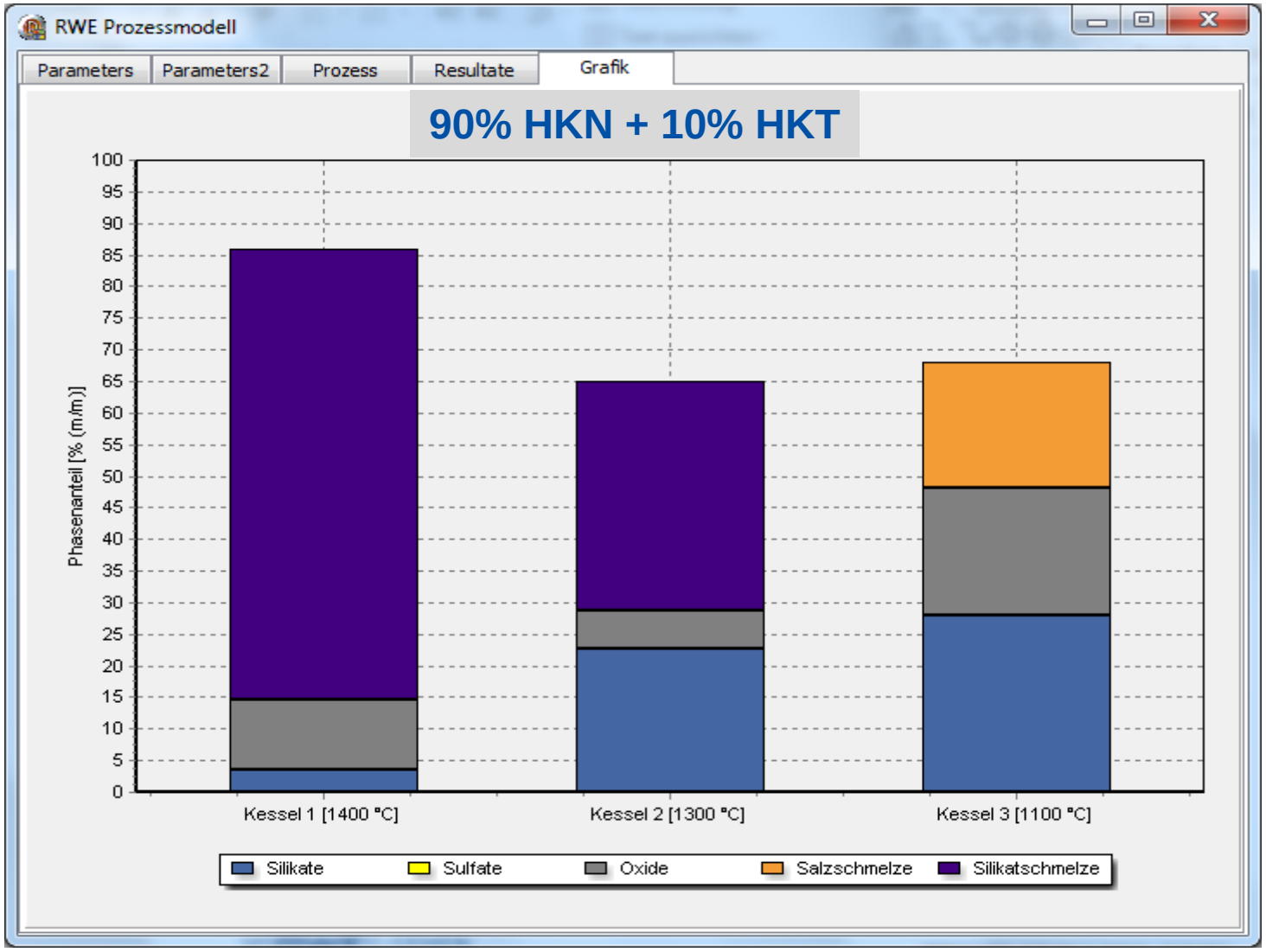
Furnace chamber model: Results III

Influence of coal blends on phase formation



Furnace chamber model: Results III

Influence of coal blends on phase formation



Summary and Outlook

SimuSage based model using interlinked local equilibria

→ Furnace chamber model with interactive user interface and direct access to RWE mineral analyses database

→ First step into development of a proper process model for coal fired power plant

→ Furnace chamber with recirculation of flue gas and input option for coal blends

→ To come: ***Optimisation*** calculations for coal blends as well as ***extension into boiler range*** and ***deposit modelling*** (→VerSi project)

THANK YOU VERY MUCH FOR YOUR ATTENTION !

VORRWEG GEHEN