PREDICTION OF THE VOLATILE RECIRCULATION IN CEMENT ROTARY KILNS BY MEANS OF PROCESS SIMULATION

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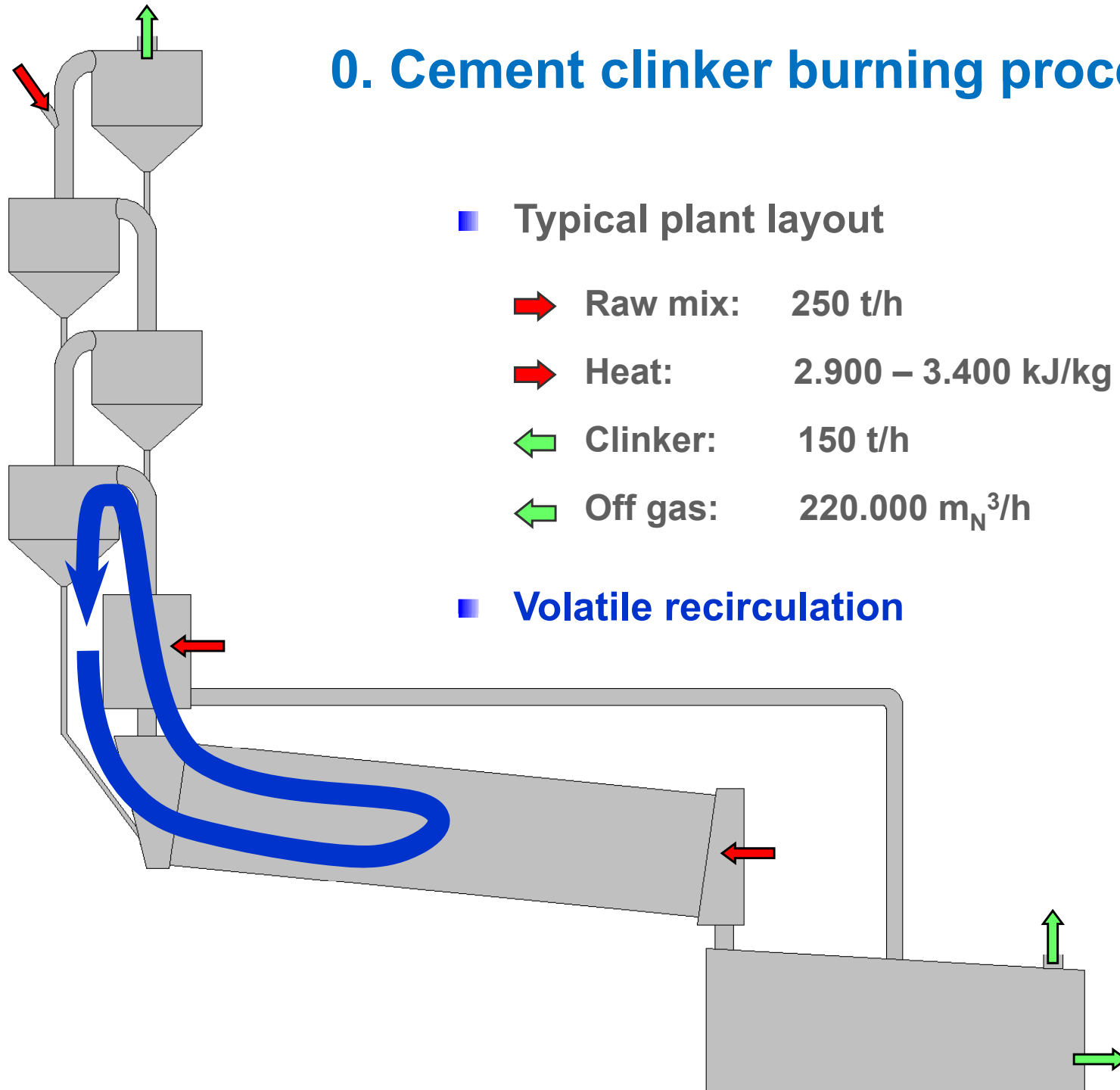
1. Project objectives

2. Simulation setup

3. Simulation data

4. Simulation results
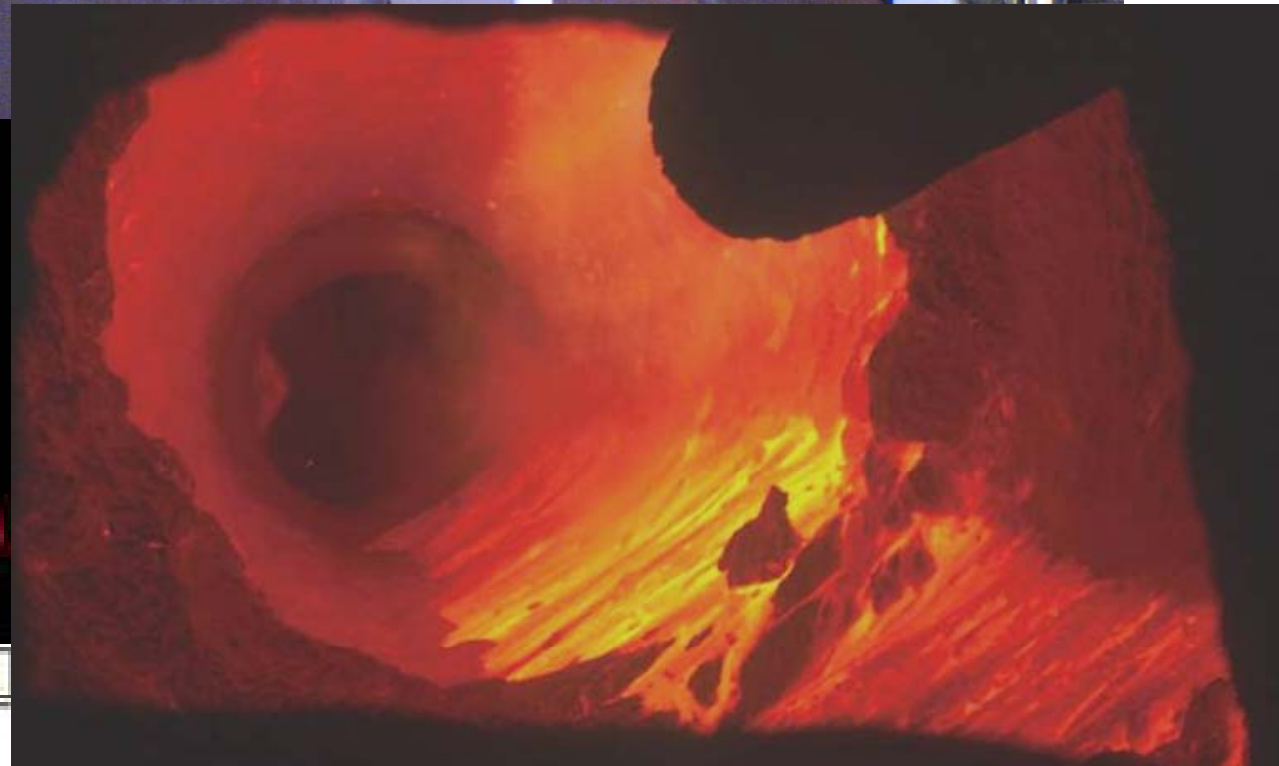
5. Outlook

0. Cement clinker burning process

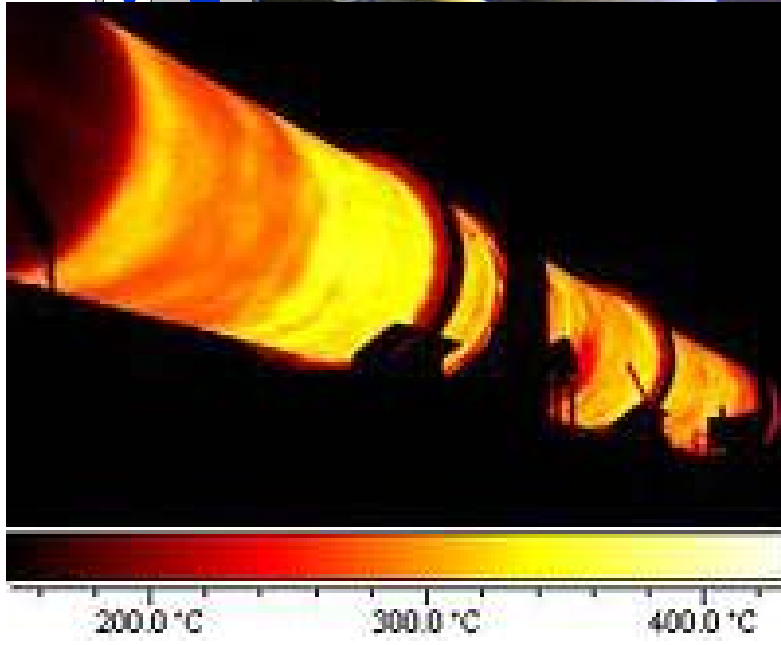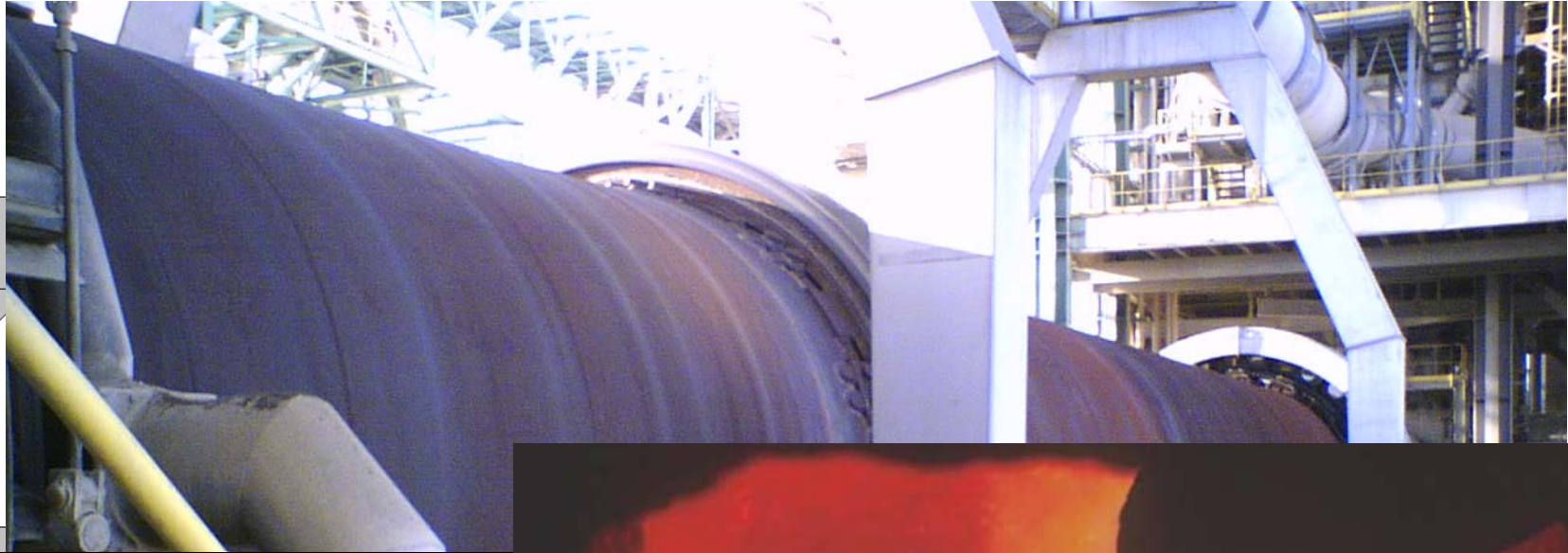■ **Typical plant layout**

➡ **Raw mix:**   250 t/h

➡ **Heat:**   2.900 – 3.400 kJ/kg clinker

⬅ **Clinker:**   150 t/h

⬅ **Off gas:**   220.000 m_N^3/h

■ **Volatile recirculation**
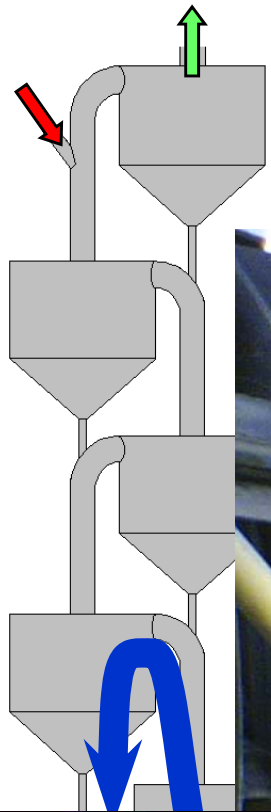
~ 10 m

0. Cement clinker burning process

1. Project objectives
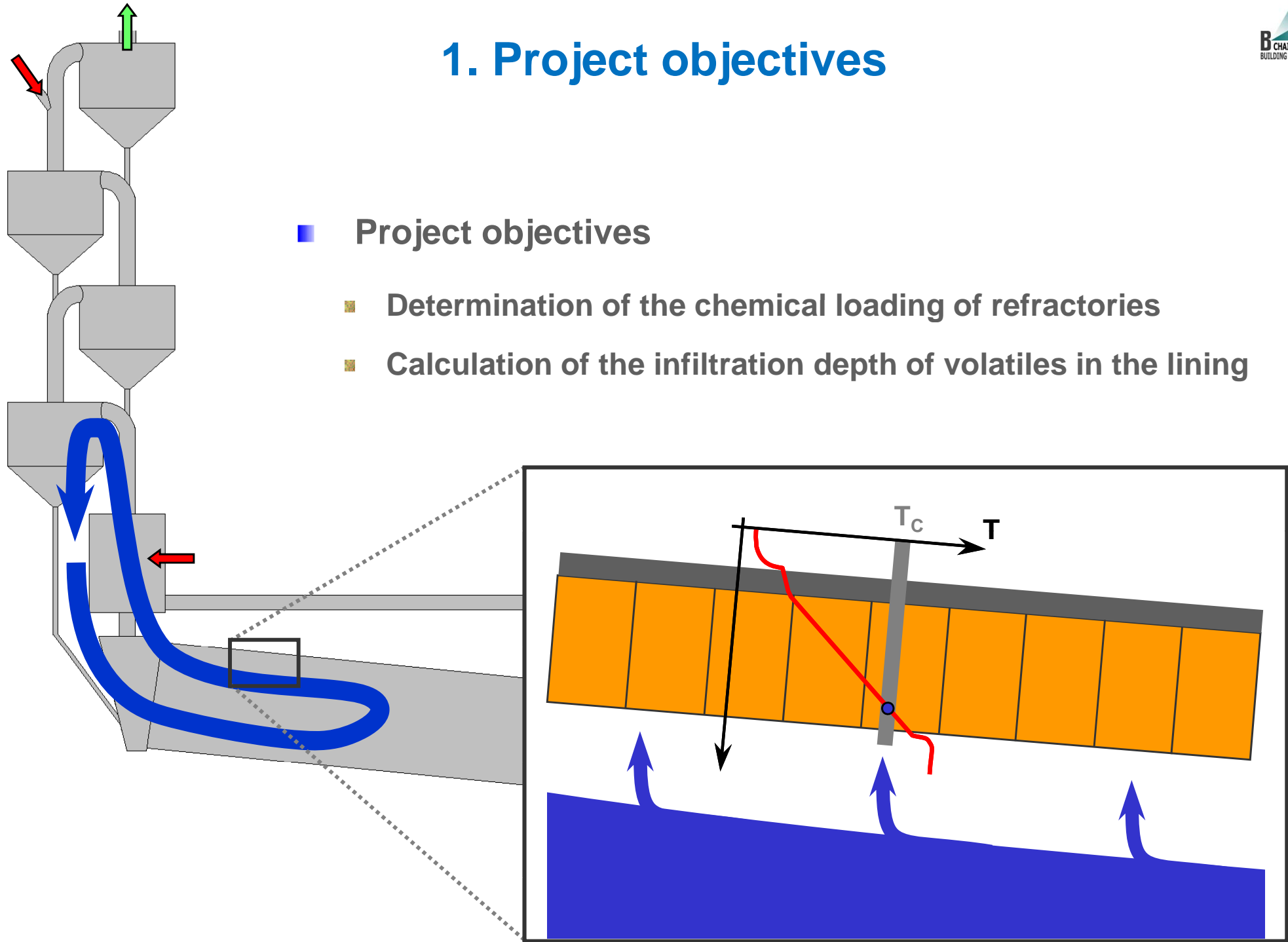
- **Project objectives**

  - **Determination of the chemical loading of refractories**

  - **Calculation of the infiltration depth of volatiles in the lining**

1. Project objectives

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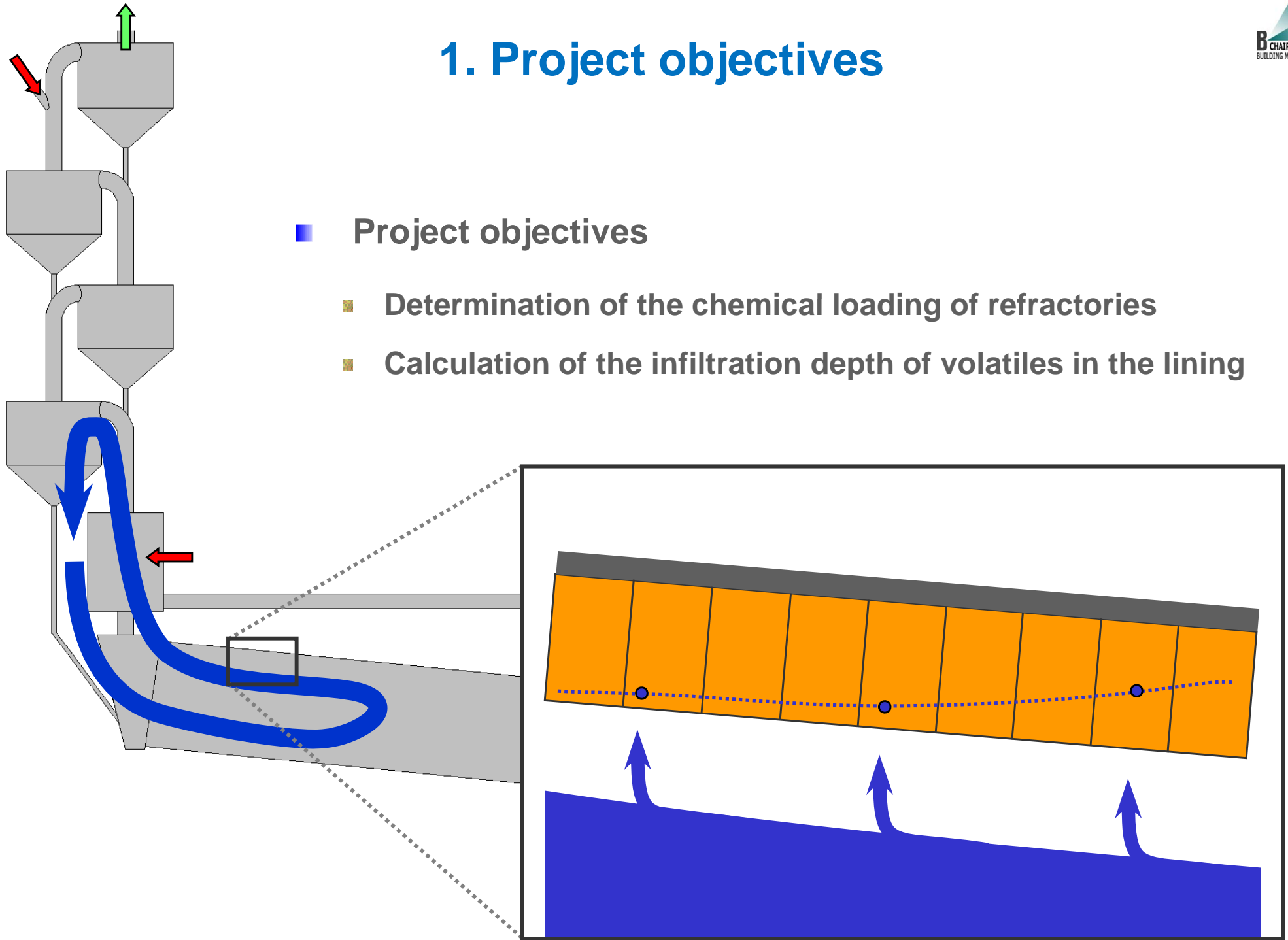
2. Simulation setup
Total process model

■ **Reactors in a total process model**

   ▪ **Preheater stages** .... **4 – 6**

   ▪ **Calciner(s)** .... **0 – 2**

   ▪ **Kiln segments** .... **up to ~ 1/m**

   ▪ **Cooler segment(s)** .... **1 – 300**
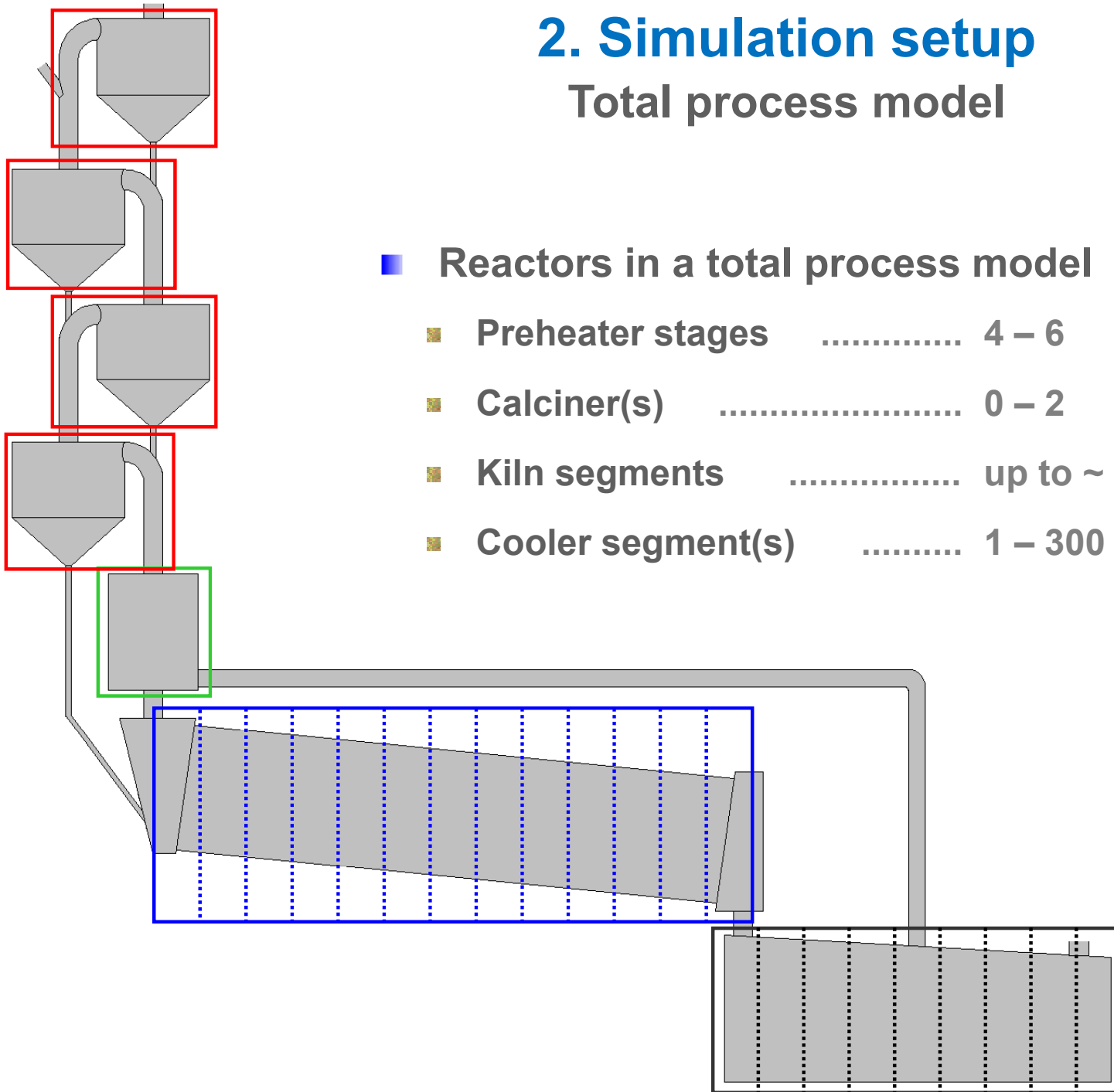
2. Simulation setup
Total process model
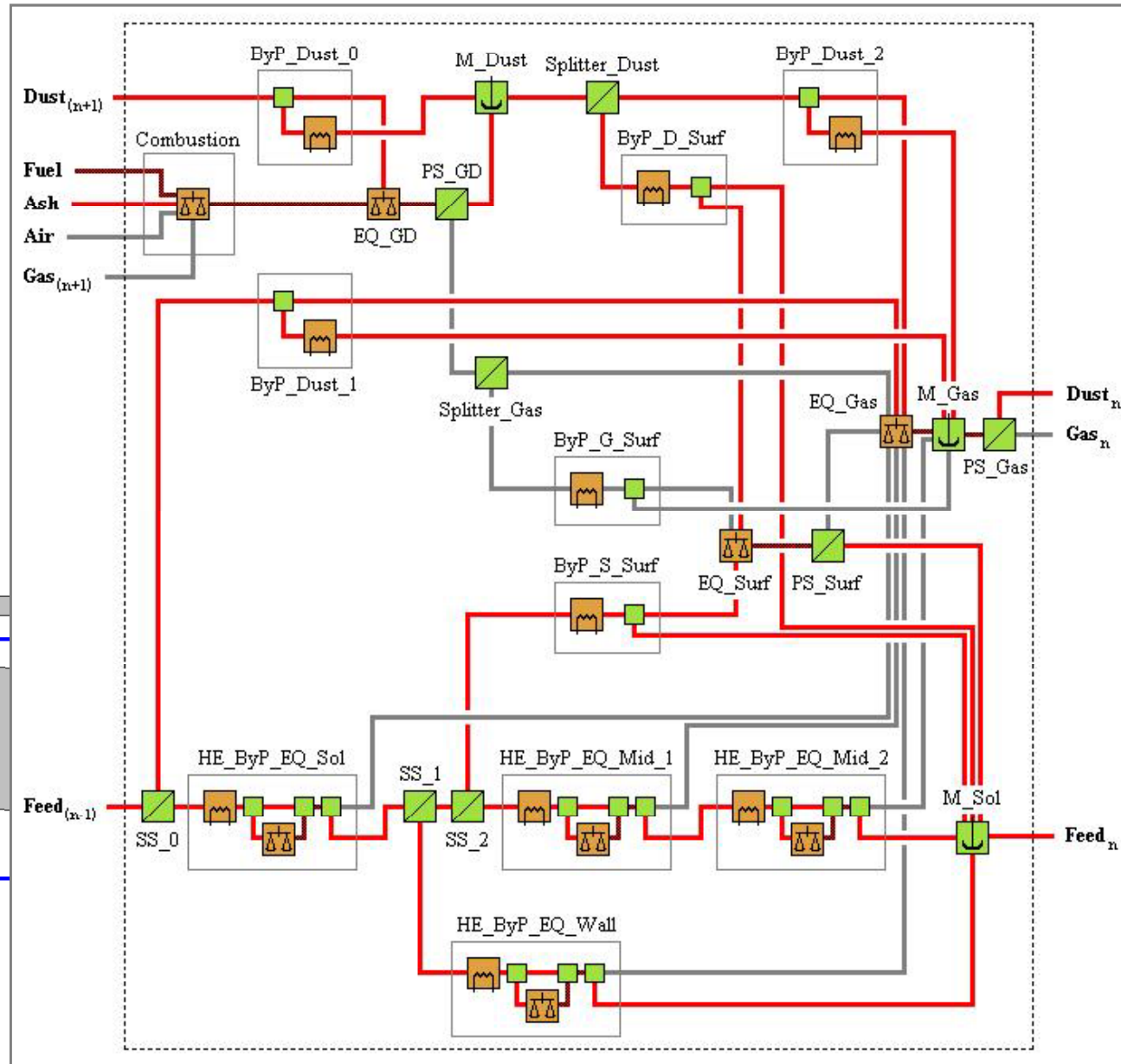
3. Simulation data
Rashadia plant layout – kiln #1

- **Setup of reactors**

  - **4 Preheater stages**

  - **1 Calciner**

  - **35 Kiln segments (à 2 m)**

- **Facts and figures**

  - **complexity similar to FE-simulations**

  - **~ 8 000 SimuSage components**

  - **~ 4.2 · 10^{15} floating point operations**

  - **~ 600 000 calculated equilibria**

LAFARGE CEMENT

Rashadiya kiln #1 (Jordan) – Kiln audit 08/07

3. Simulation data

Rashadia input streams

Raw mix

83°C	267,4 t·h^{-1}
43,40%	CaO
13,16%	SiO$_2$
3,24%	Al$_2$O$_3$
2,11%	Fe$_2$O$_3$
1,69%	MgO
0,43%	K$_2$O
0,07%	Na$_2$O
0,20%	SO$_3$

3. Simulation data

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Heavy oil

100°C	8,5 t·h^{-1}
H$_i$	39.011 kJ·kg^{-1}
80.91%	C
12,88%	H
0,59%	N
2,93%	S
0,29%	O
2,40%	H$_2$O

Heavy oil

100°C	4,5 t·h^{-1}
H$_i$	39.011 kJ·kg^{-1}
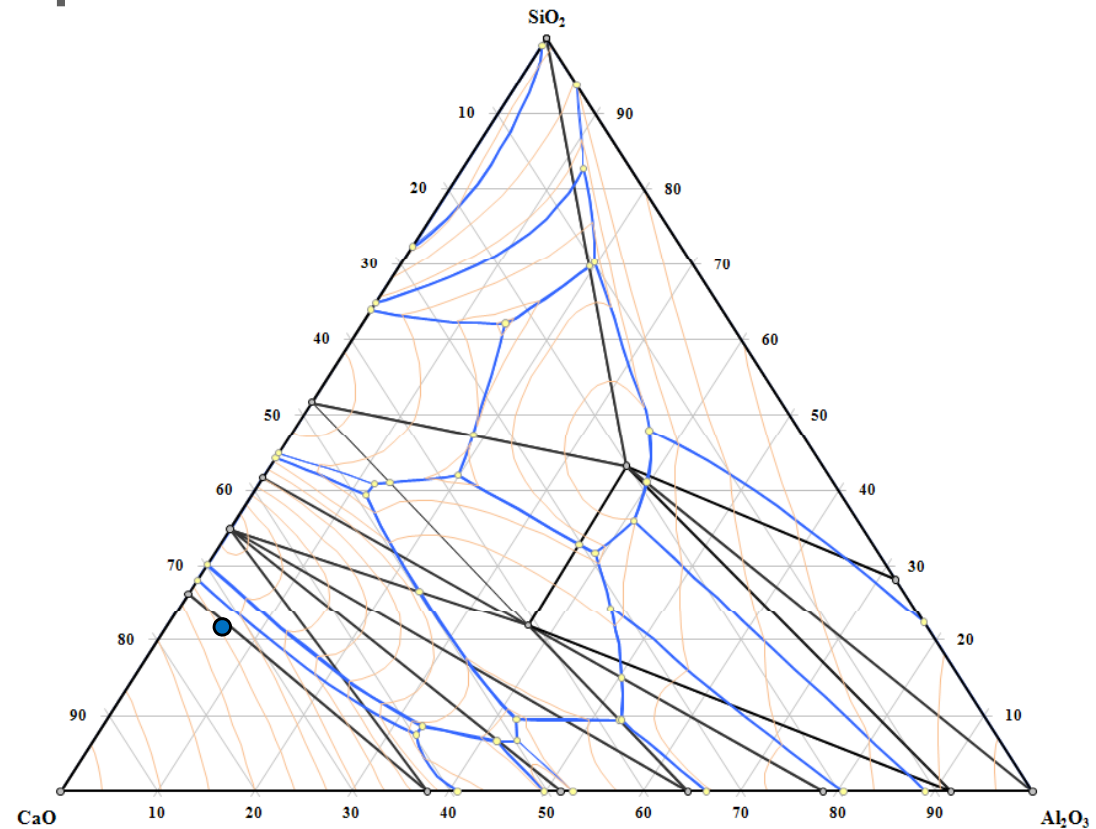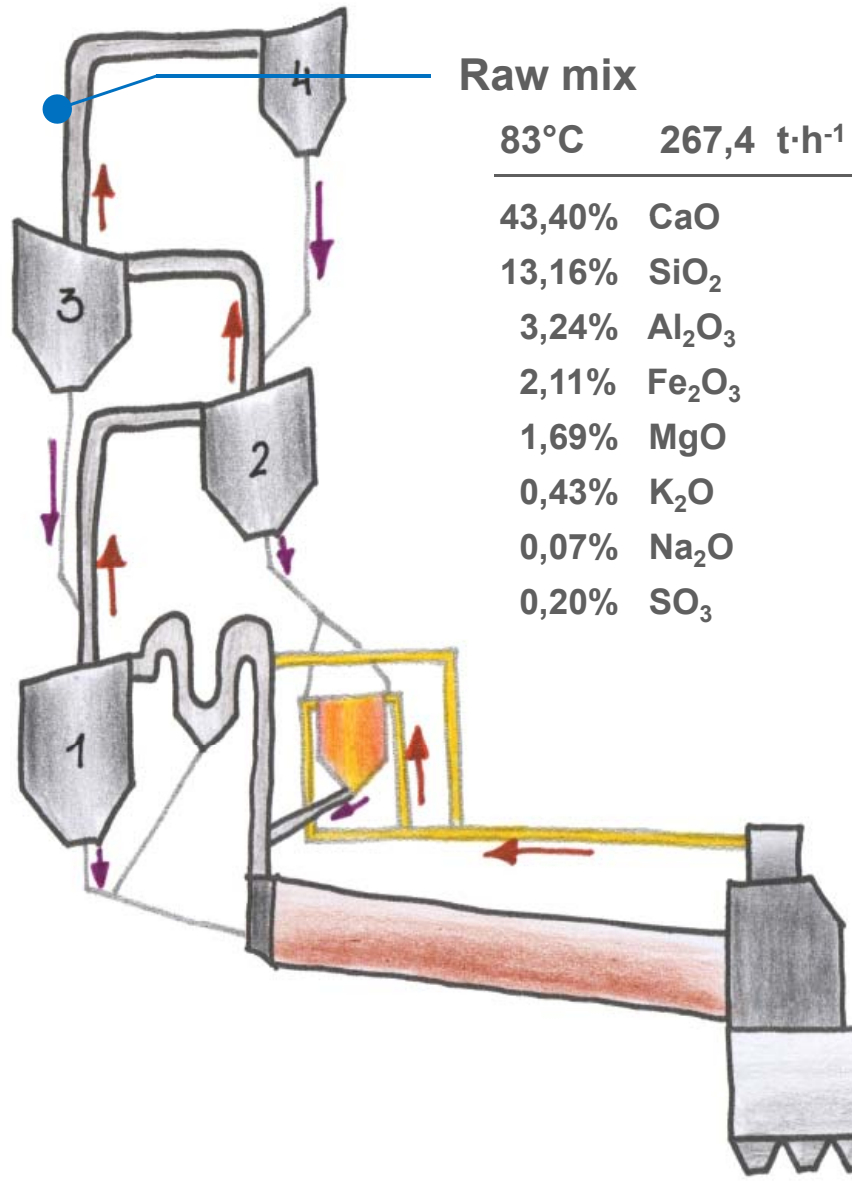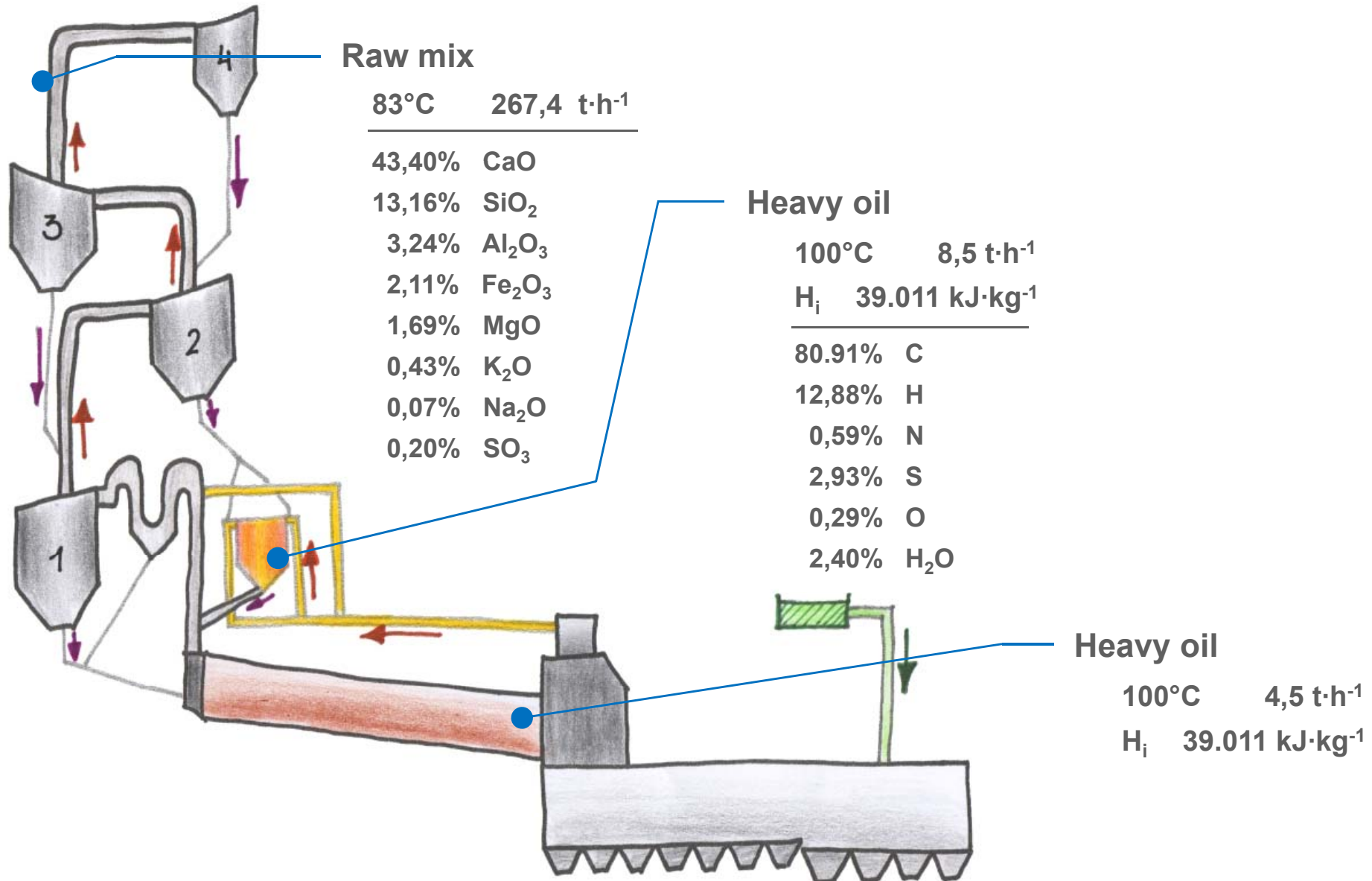
4. Simulation results

Output streams

Tower exit gas

350°C	223.635 $m_N^3 \cdot h^{-1}$
57,70%	N_2
28,02%	CO_2
12,03%	H_2O
2,20%	O_2
334 ppm	SO_3

354°C	223.309 $m_N^3 \cdot h^{-1}$
58,6%	N_2
27,5%	CO_2
11,6%	H_2O
2,4%	O_2
209 ppm	SO_3

Clinker

134°C	152,3 $t \cdot h^{-1}$
70,97%	C_3S
6,93%	C_2S
8,04%	C_3A
10,25%	C_4AF
2,36%	C_{free}
1,45%	$CaSO_4$

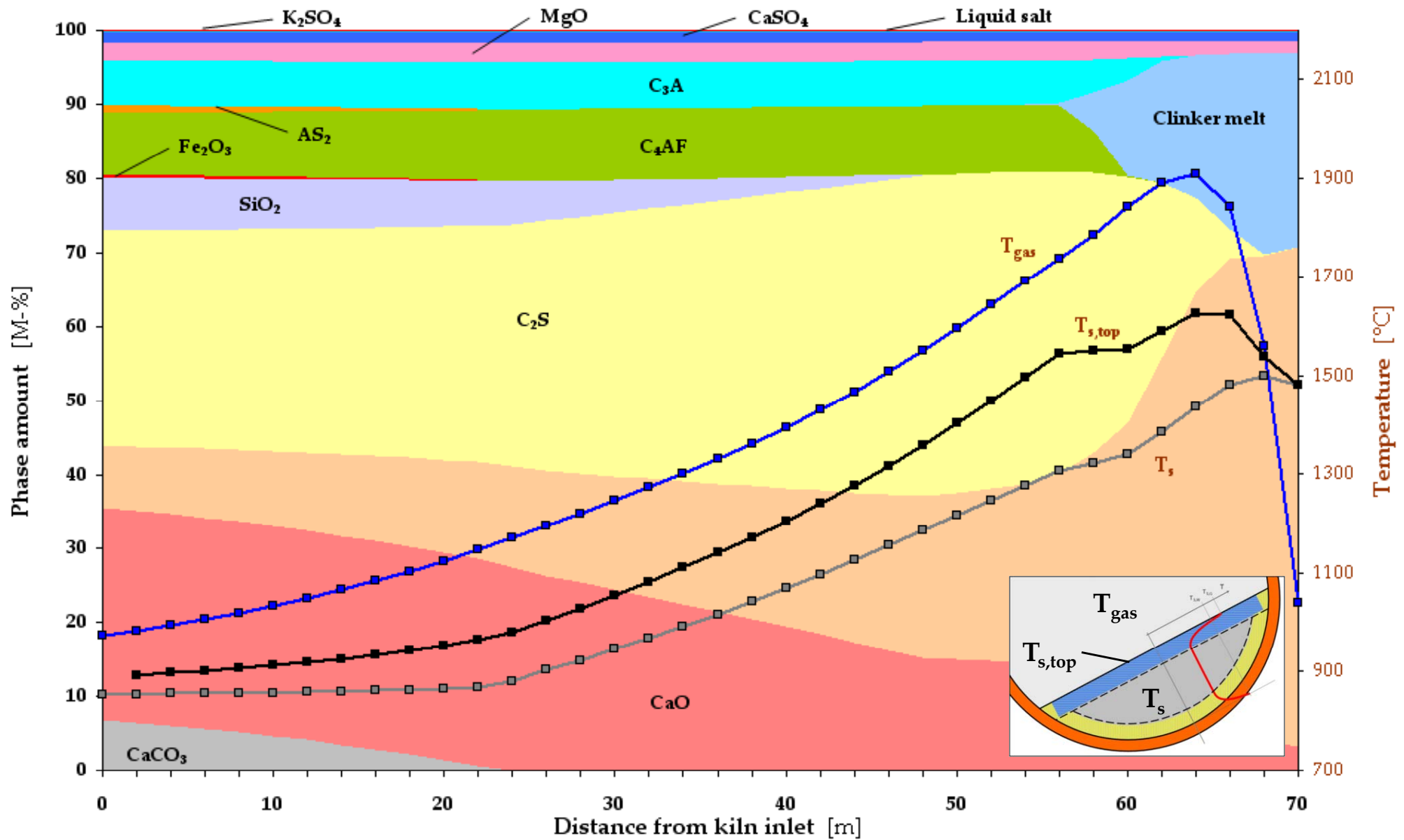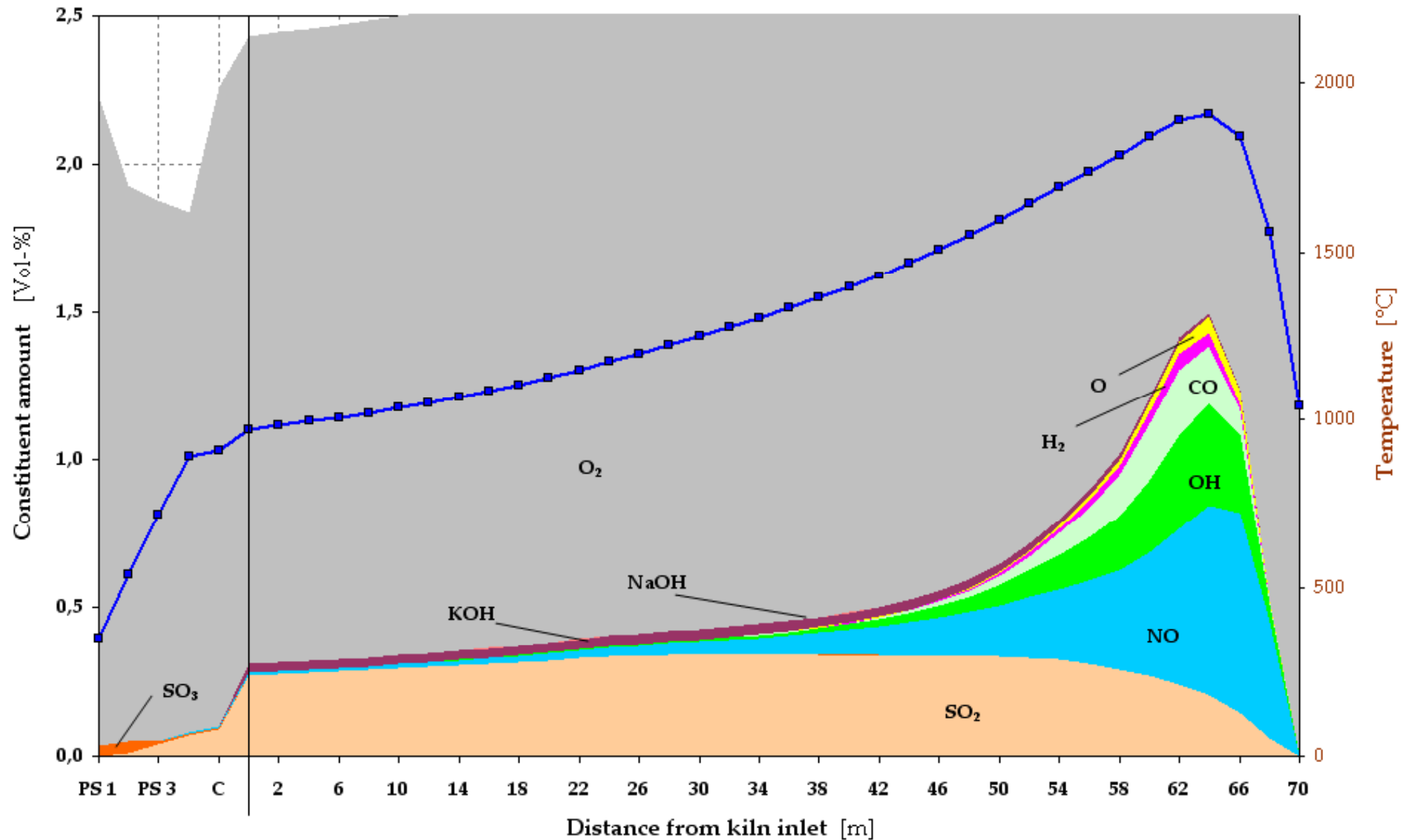| 134°C	152,3 $t \cdot h^{-1}$
69,27%	C_3S
6,43%	C_2S
5,93%	C_3A
11,47%	C_4AF
2,86%	C_{free}
1,13%	$CaSO_4$
0,19%	$K_3Na(SO_4)_2$
0,06%	K_2SO_4
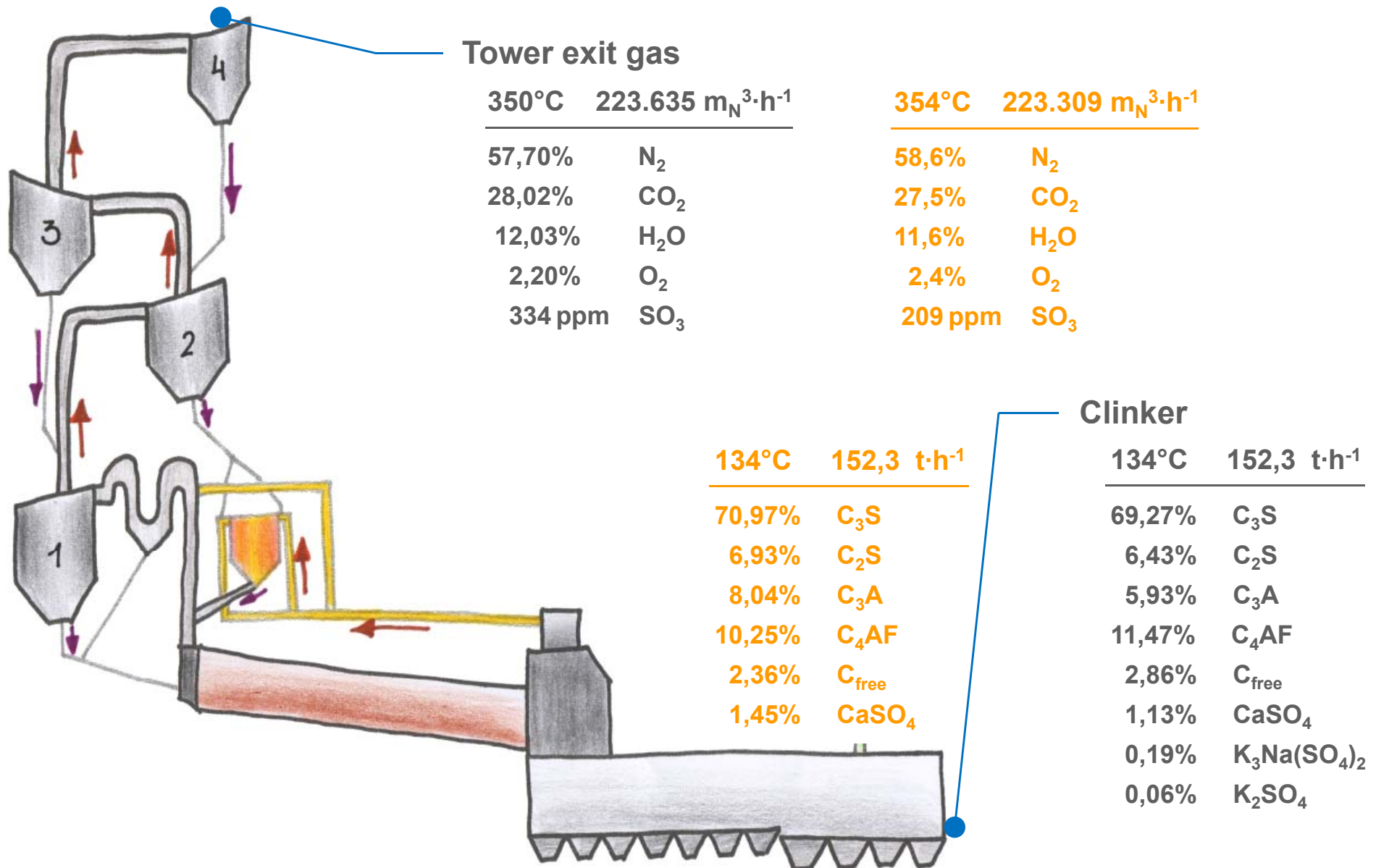
4. Simulation results
Preheater tower – Gas
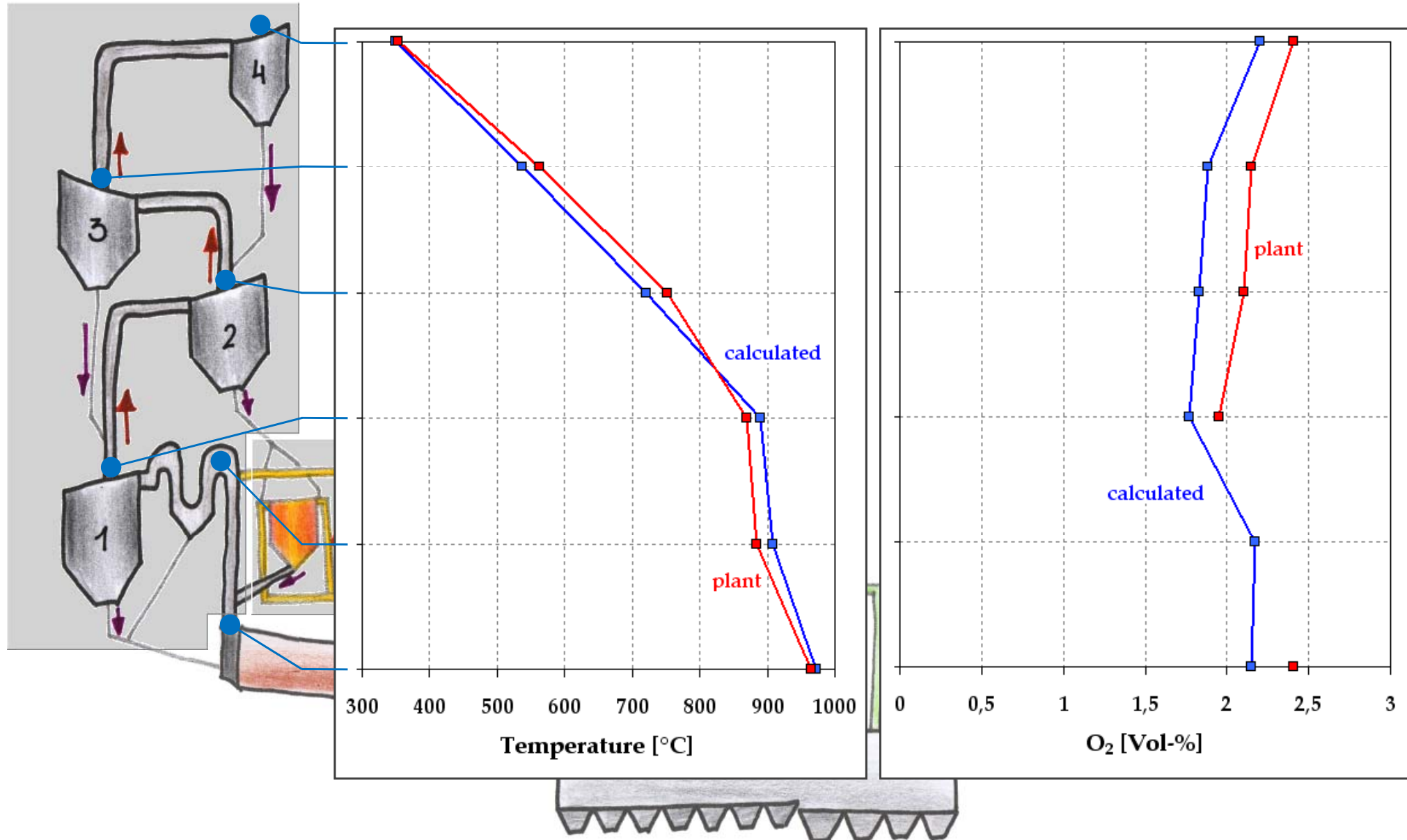
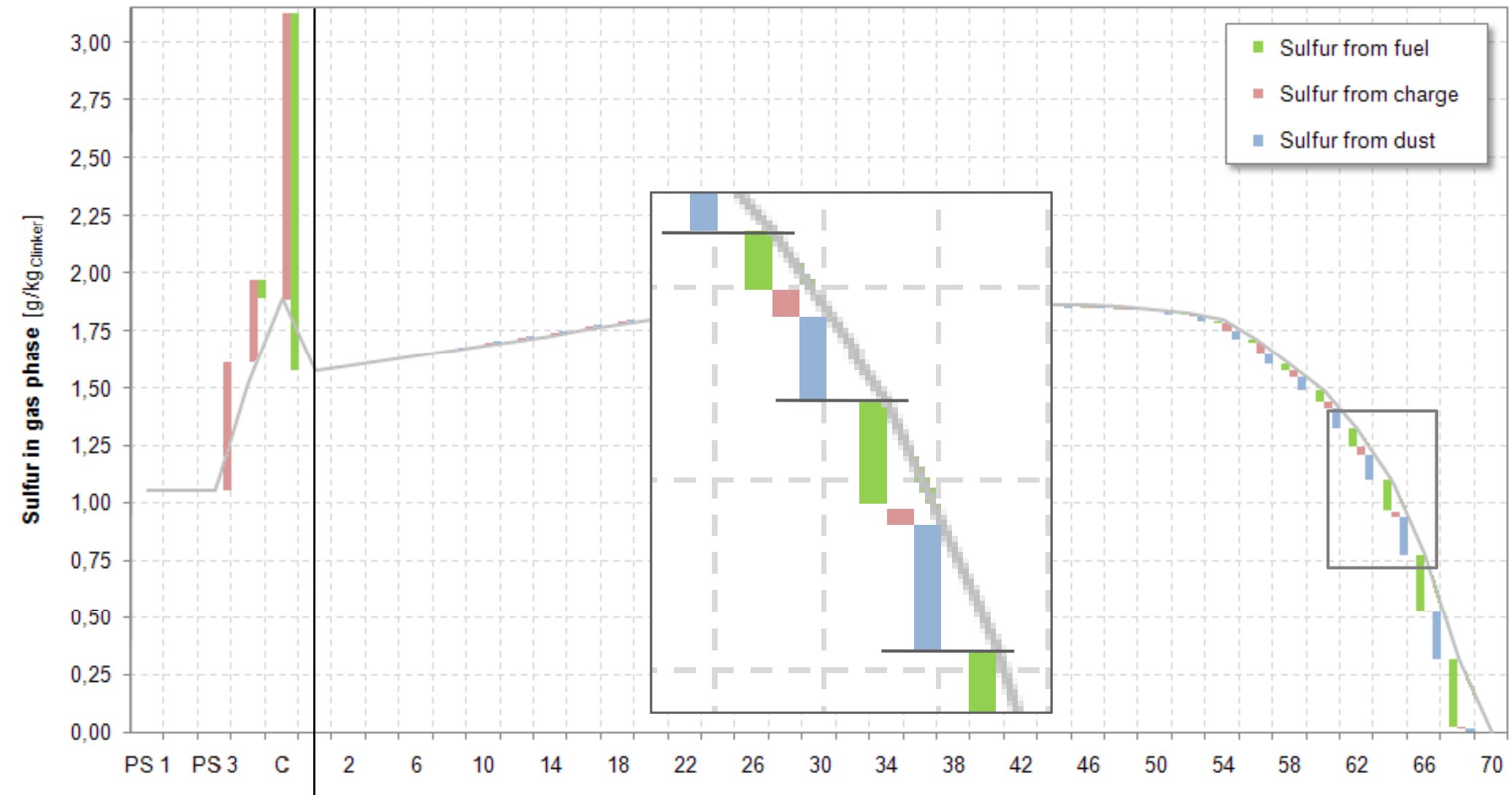# 4. Simulation results

Kiln phase composition – Material bed

4. Simulation results
Kiln phase composition – Gas
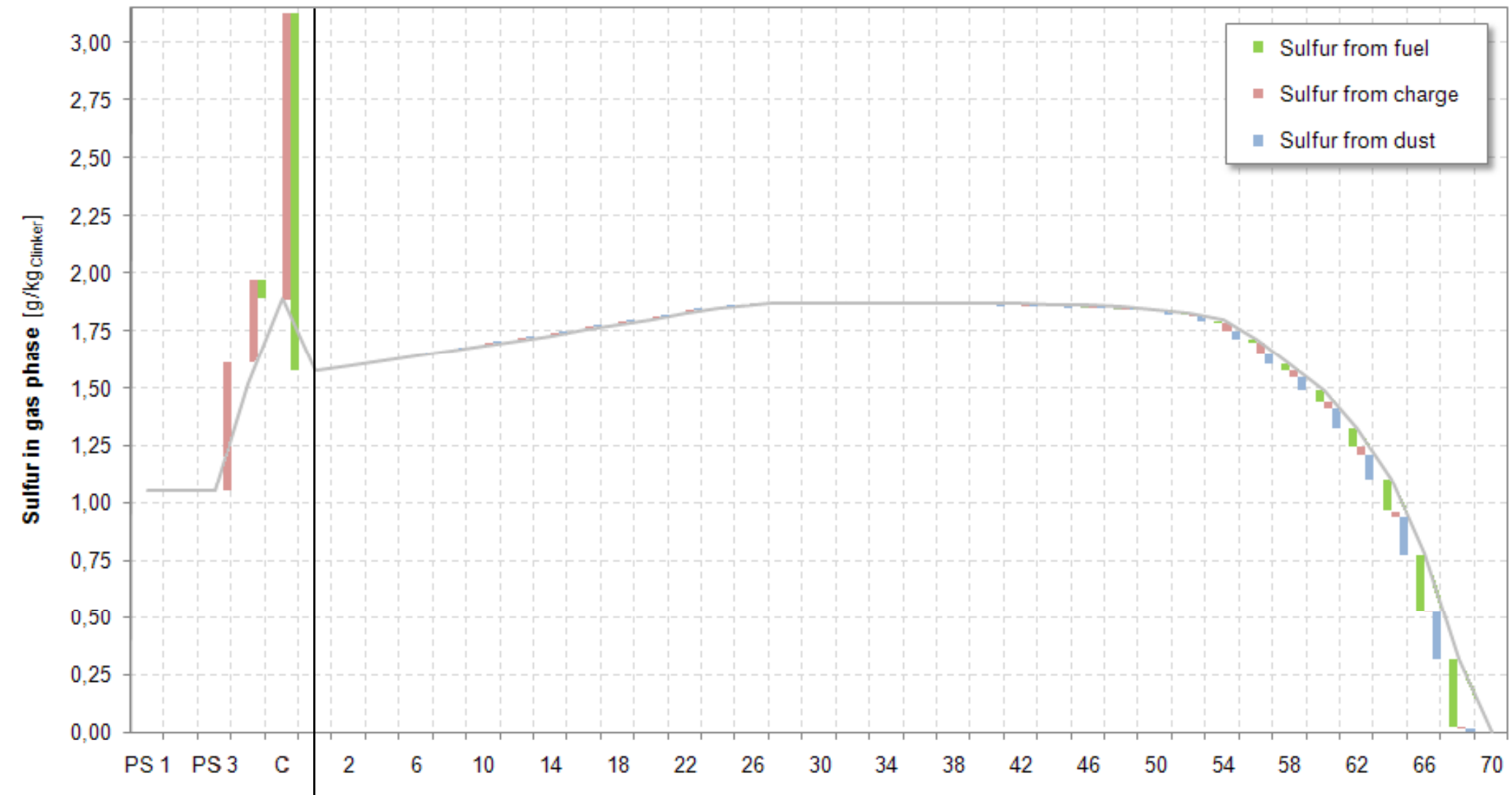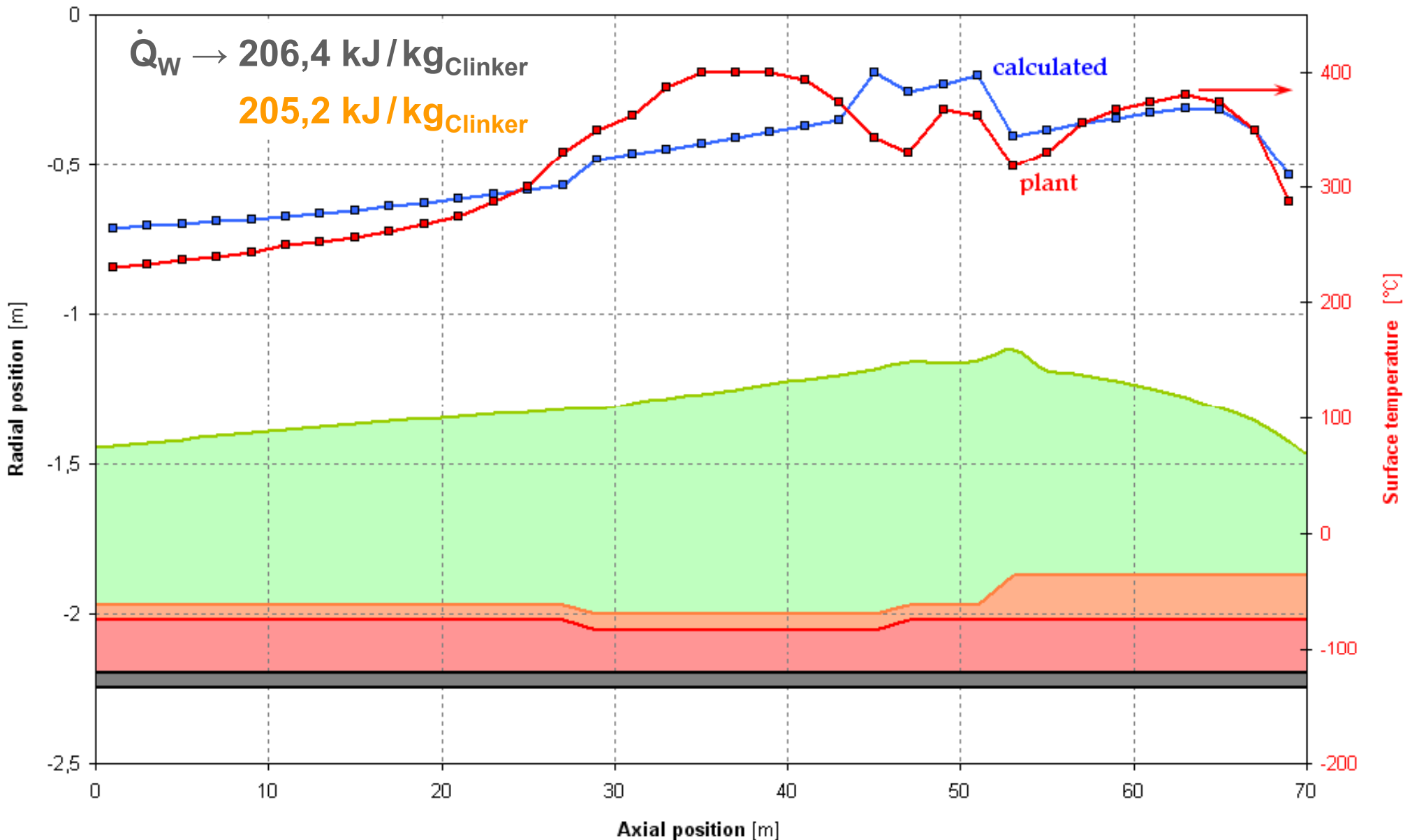
4. Simulation results
Kiln phase composition – Sulfur in gas

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Kiln phase composition – Sulfur in gas

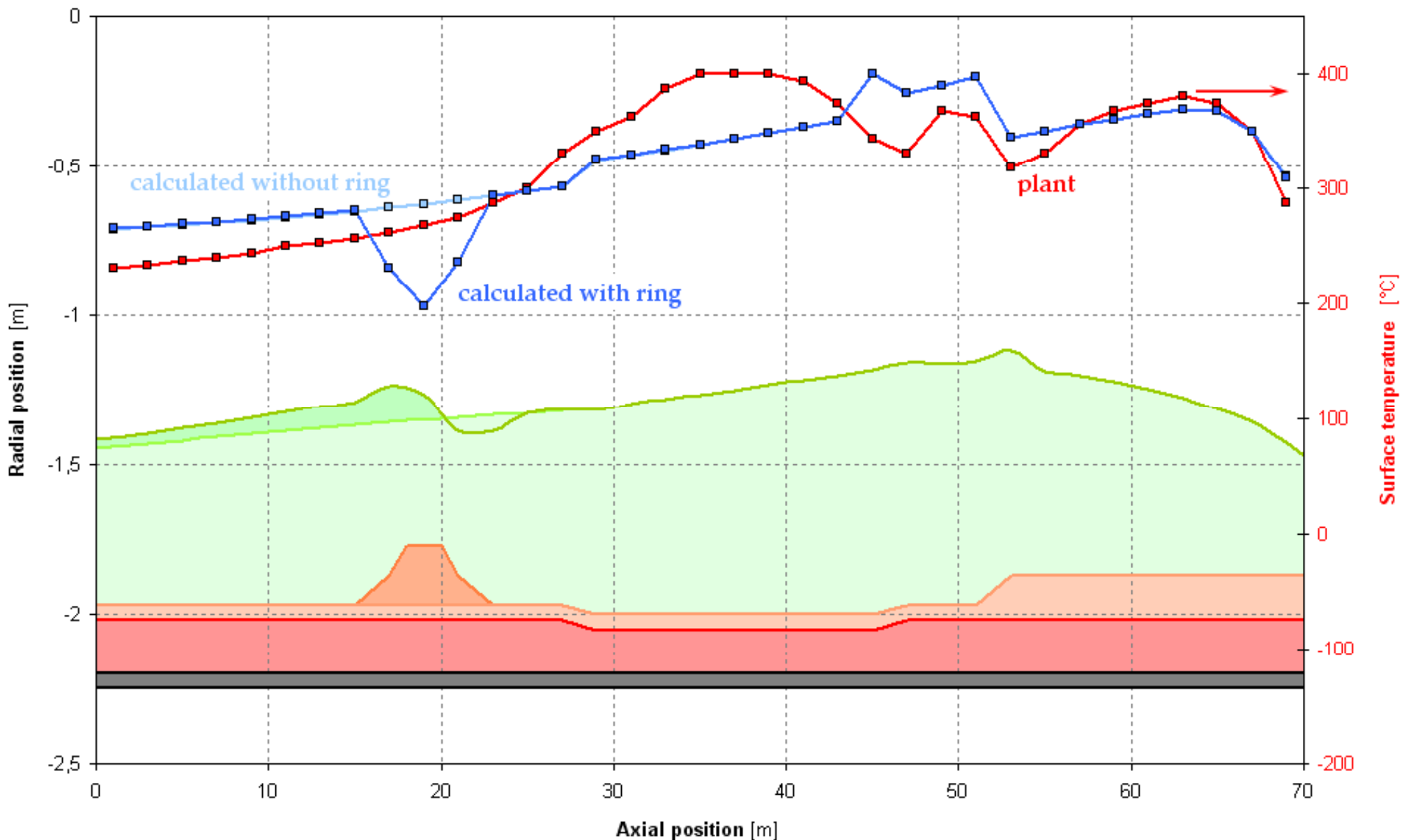# 4. Simulation results
Kiln material height profile

$\dot{Q}_W \rightarrow$ **206,4 kJ / kg**$_{Clinker}$

205,2 kJ / kg$_{Clinker}$

calculated

plant

4. Simulation results

Kiln material height profile – Ring formation near kiln inlet

4. Simulation results

Selected data – Ring formation near kiln inlet

Tower exit gas

350,4°C	350,5°C
334 ppm SO$_3$	335 ppm SO$_3$

Kiln

30,47 s	Time through kiln	30,61 s	Time through kiln
206,4 kJ/kg$_C$	Wall heat loss	201,9 kJ/kg$_C$	Wall heat loss

Clinker at kiln exit

1481,99°C		1484,55°C	
3,219%	CaO	3,318%	CaO
67,52%	C$_3$S	67,11%	C$_3$S

Kiln exit gas

972,89°C	977,29°C
240,8 g S	241,4 g S

5. Outlook

3/09   **6/09**   **9/09**   **12/09**

Further improvement of the total process model

Further simulations:

Plant with higher amount of volatiles

Complex plant setup

User interface

Infiltration profiles

Corrosion profiles