Supplementary Materials to

Water-energy nexus in the Antofagasta mining district: options for municipal wastewater reuse from a nearly energy-positive WWTP

G. Campo, B. Ruffino, A. Reyes, M. Zanetti

SM Table S1. Nomenclature ASM3

Parameters
ASM 3 = Activated sludge model 3
$\mathbf{S_I}$ = Inert soluble organic material (COD)
$\mathbf{S_S}$ = Readily biodegradable organic substrates (COD)
S_{NH_4} = Ammonium plus ammonia nitrogen (NH_4^+-N + NH_3-N)
S_{NO_x} =Nitrate plus nitrite nitrogen (NO_3^- -N + NO_2^--N)
X_I = Inert particulate organic material (COD)
X_S = Slowly biodegradable substrates (COD)
X_H = Heterotrophic organisms (COD)
X_A = Nitrifying organisms (COD)
X_{STO} = A cell internal storage product of heterotrophic organisms (COD)

SM Table S2. Hypothesis on COD partition

COD fraction	Percentage %	Value mg/L
$\mathbf{X_I}$	43.2	293.0
$\mathbf{X_S}$	49.3	334.5
Ss	5.3	35.9
Ss	2.2	14.6
$\mathbf{X_H}$	0.0	0.0
$\mathbf{X_A}$	0.0	0.0
$\mathbf{X_{STO}}$	0.0	0.0

SM Table S3. Technical Data of Sanitaire® Silver Series II Diffusers

Disc materials	Specially blended high-grade EPDM
Disc diameter	178 mm
Effective surface area	0.024 m^2
Orifice size	5 mm
Airflow range per disc	0.8 -6.8 Nm^3/h
Standard Oxygen transfer efficiency	6-8% per m submergence
Standard Oxygen Efficiency	2.5 -6 kg O_2/kWh

SM Table S4. Details concerning the outputs of the used ASM3

	Scenario 0	Scenario 1	Scenario 2	Scenario 3	
	aerobic	aerobic	aerobic	anoxic	aerobic
FSS mg/L	1,380	1,380	529	529	529
X_S mg/L	220	220	105	129	87
Ss mg/L	0.26	0.26	0.24	0.7	0.14
X_I mg/L	6,320	6,320	3,600	3,470	3,440
Total sN mg/L	39	39	44	27	25
X_H mg/L	940	940	548	612	621
X_A mg/L	36	36	38	57	58
X_{STO} mg/L	151	151	82	109	91

1. Field oxygen transfer rate equation

$$\mathrm{OTR_f} = \mathrm{SOTR}\left[\frac{\tau\beta\omega C^*_{\infty 20} - C}{C^*_{\infty 20}}\right][(\theta)^{T-20}]\alpha F$$

SM Equation S1

Where:

- C = average dissolved oxygen concentration within the process water volume, mg/L;
- OTR_f = field oxygen transfer rate estimated for the system operating under process conditions at an average dissolved oxygen concentration, C, and temperature, T, kg O_2 /h;
- SOTR = oxygen transfer rate under standard conditions (20°C, 1 atm, C = 0 mg/L), kg O_2/h;
- T = field temperature;
- C^*_{st} = dissolved oxygen surface saturation concentration at operating temperature, mg/L;
- C^*_{s20} = dissolved oxygen surface saturation concentration at standard temperature (20°C) mg/L;
- τ= temperature correction factor = C^*_{st} /C^*_{s20};
- β=relative DO saturation to clean water = $C^*_{wastewater}$/$C^*_{tap\ water}$;
- P_b = barometric pressure at test site (kPa);
- P_s = standard barometric pressure (101.325 kPa);
- ω= pressure correction factor = P_b/ P_s;
- d_e= mid-depth correction factor; (0.40);
- D_f = depth of diffusers in basins, m;
- $C^*_{\infty,20}$ = saturated dissolved oxygen value at sea level and standard temperature (20°C) for diffused aeration, mg/L. It is higher than C_{st} as it is affected by oxygen transfer from bubbles under pressure in the water column. The value of $C_{\infty,20}$ can be estimated using the following equation:

$$C^*{}_{\infty,20} = C^*{}_{s,20} \times \left[1 + d_e\left(\frac{D_f}{P_s}\right)\right]$$

SM Equation S2

- θ = empirical temperature correction factor,1.024;
- α= relative oxygen transfer rate in process water versus clean water ($K_La_{f,20(wastewater)}$/$K_La_{f,20(tap\ water)}$);
- F = fouling factor.

2. Blower – Power required for adiabatic compression

$$P_w = \frac{wRT_1}{28.97\ n\ e} \times \left[\left(\frac{p_2}{p_1}\right)^n - 1\right]$$

SM Equation S3

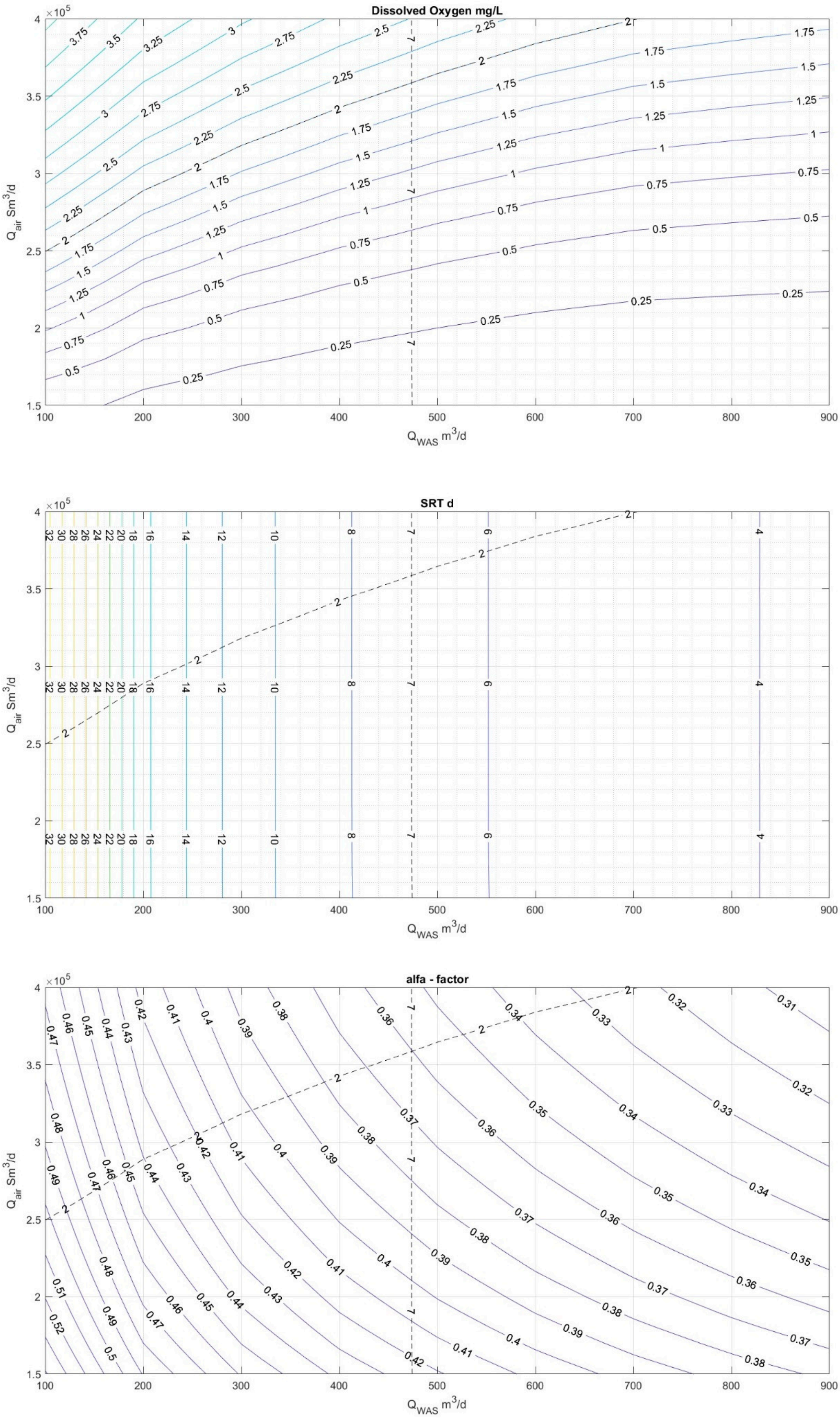
Where

- P_w = power requirement by blowers (kW);
- w =weight of air flowrate (kg/s);
- R= universal gas constant. R= 8.314 (J/mole K);
- T_1= air absolute inlet temperature (K);
- p_1= air absolute inlet pressure (atm);
- p_2 =air absolute outlet pressure (atm);
- n = (k – 1)/k where k is the specific heat ratio. k= 1.395;
- 28.97 =molecular weight of dry air;
- e = blowers efficiency.

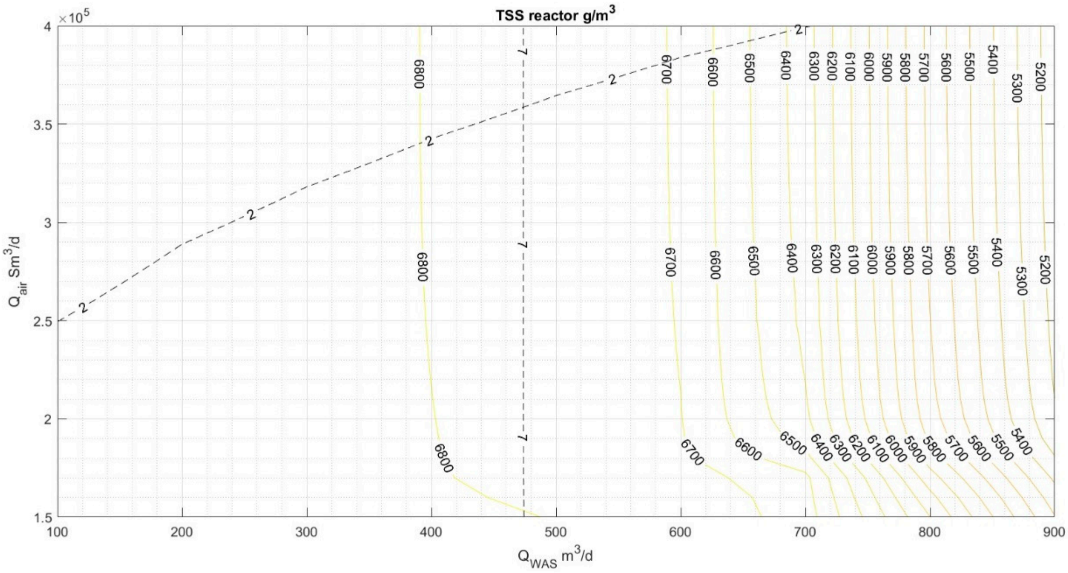
Reference

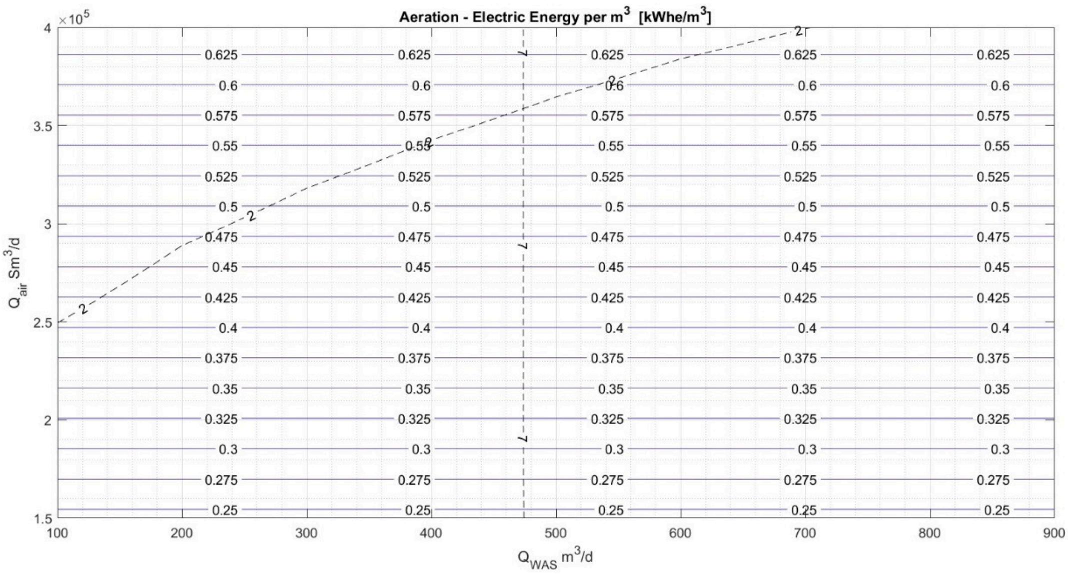
Metcalf & Eddy Inc., Tchobanoglous, G.; Burton, F.L.; Tsuchihashi, R.; Stensel, H.D. Wastewater Engineering: Treatment and Resource Recovery. 5th ed. New York, NY: McGraw-Hill Professional, 2013. ISBN-10:9780073401188

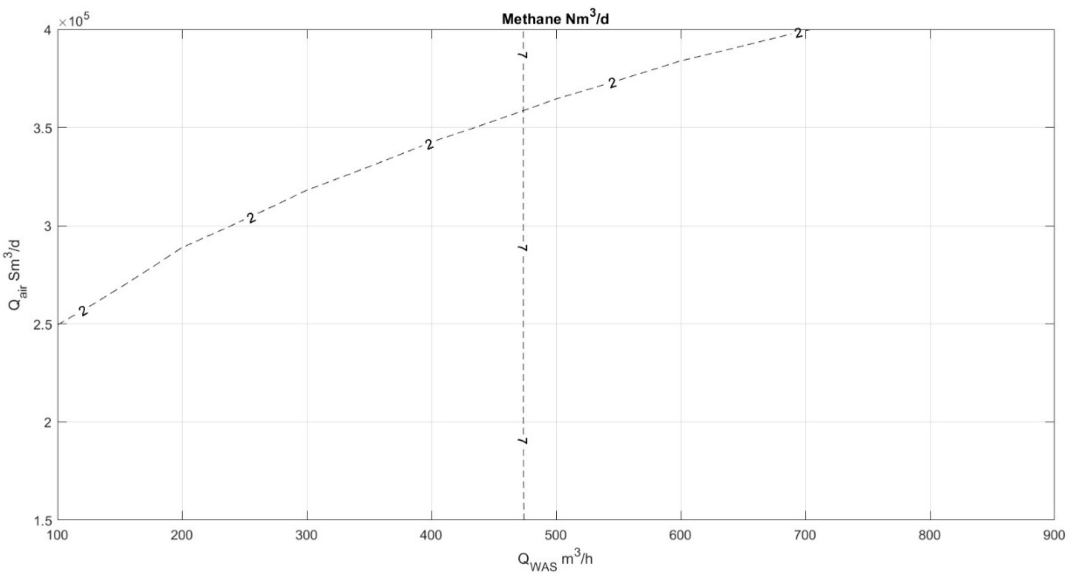
SM Figure S1a. Scenario 0 *Process parameters, a function of Qwas (WAS flow rate) and Qair (air flow rate)*



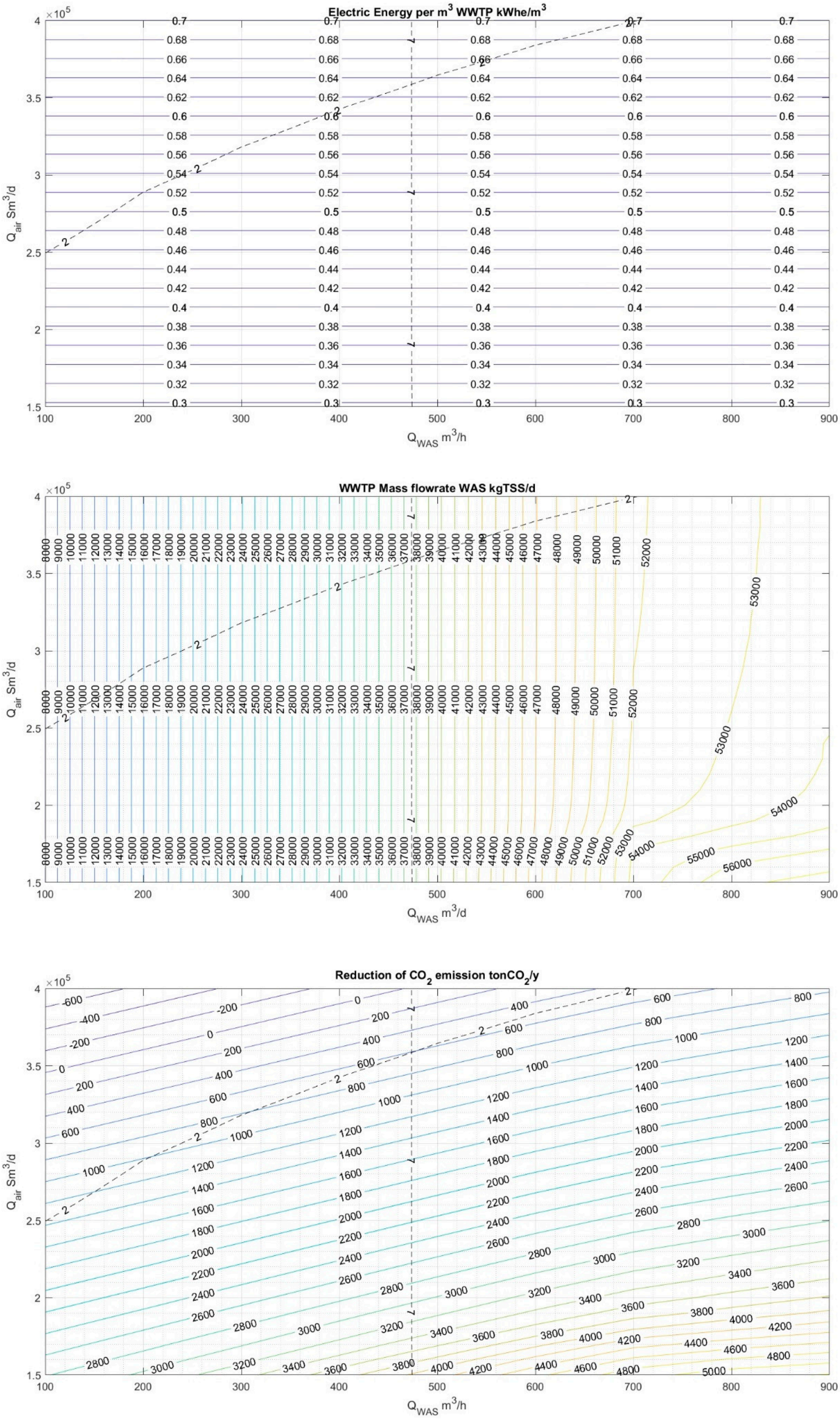
SM Figure S1b. Scenario 0 *Process parameters, a function of Qwas (WAS flow rate) and Qair (air flow rate)*



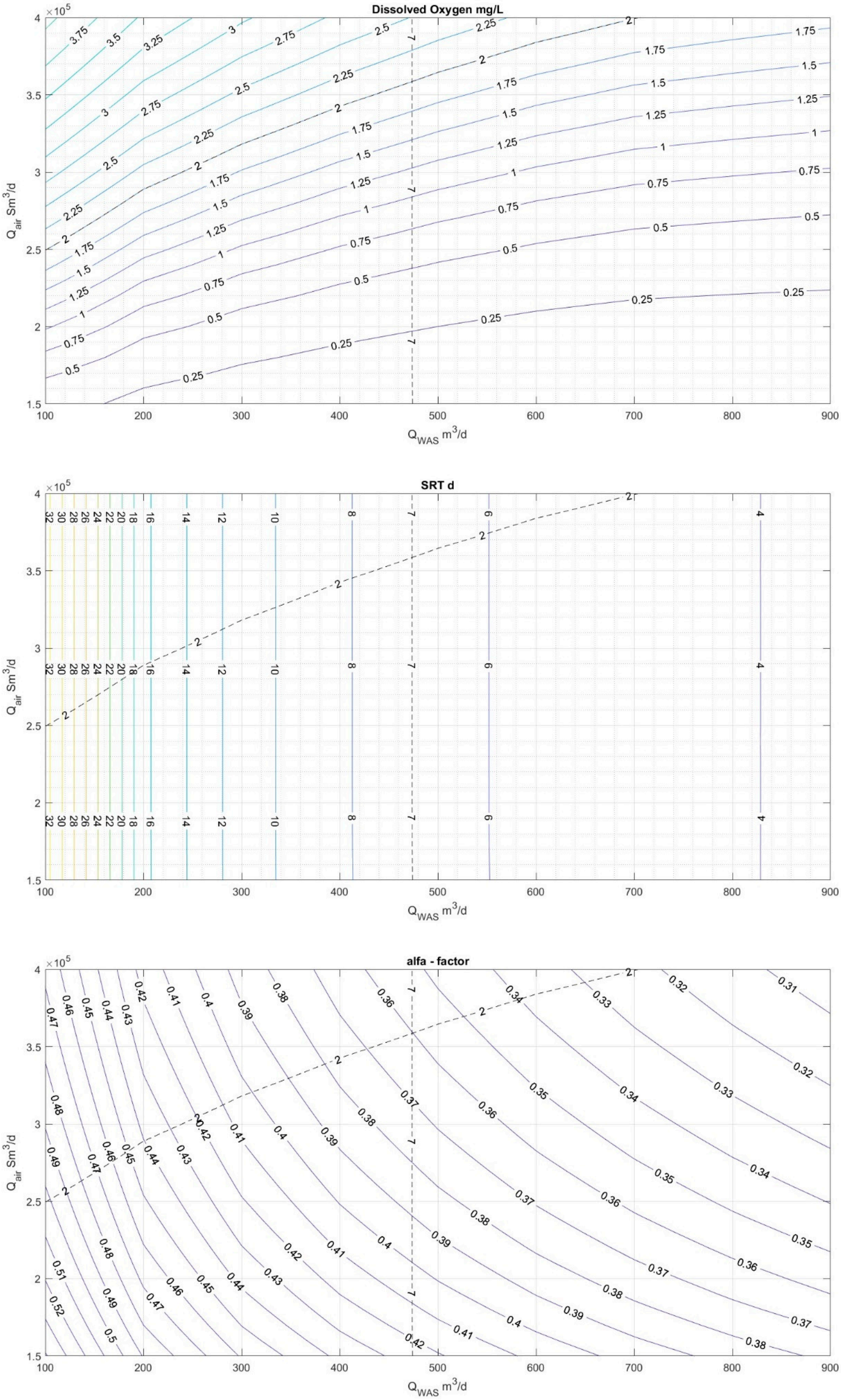




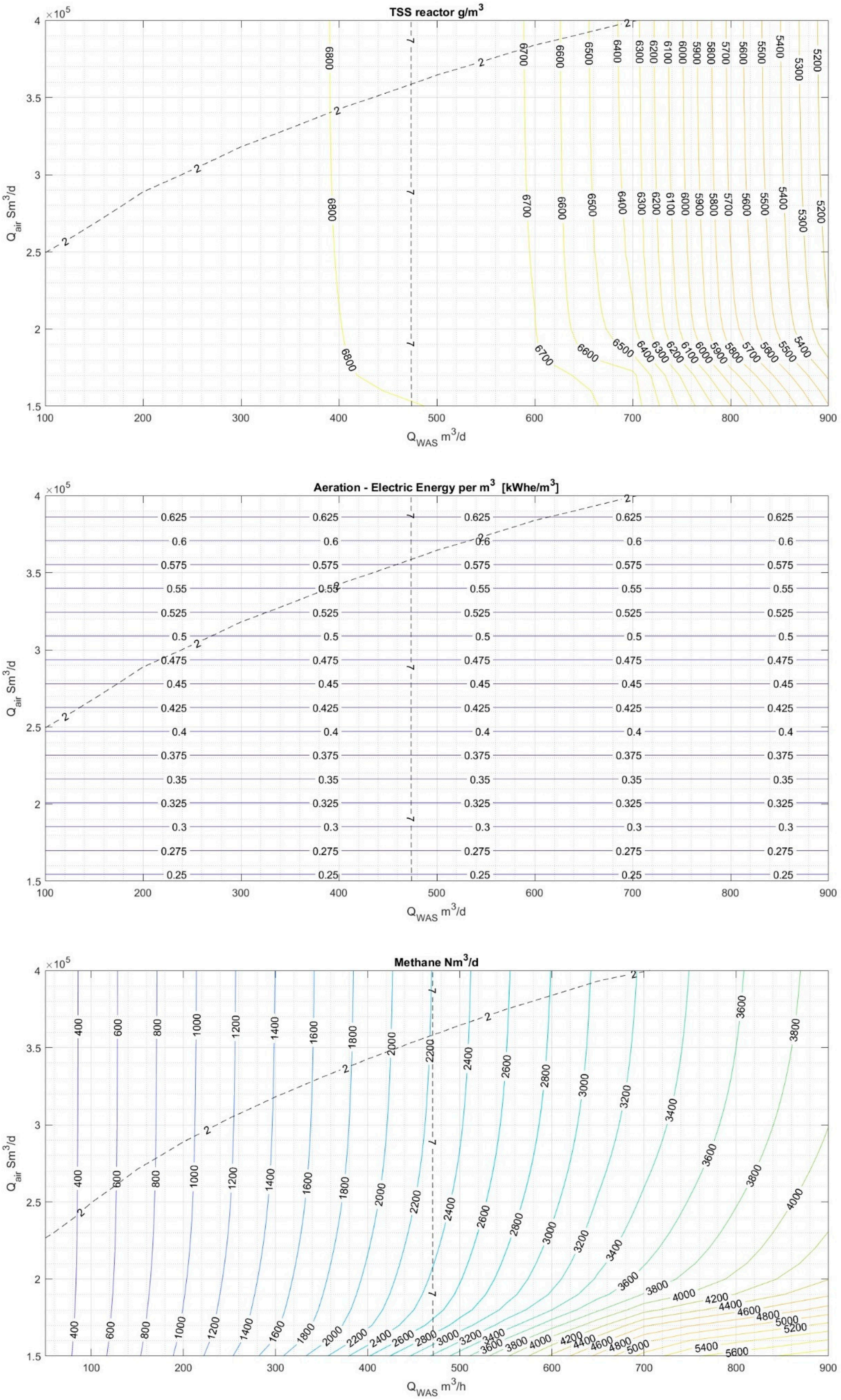
SM Figure S1c. Scenario 0 *Process parameters, a function of Qwas (WAS flow rate) and Qair (air flow rate)*



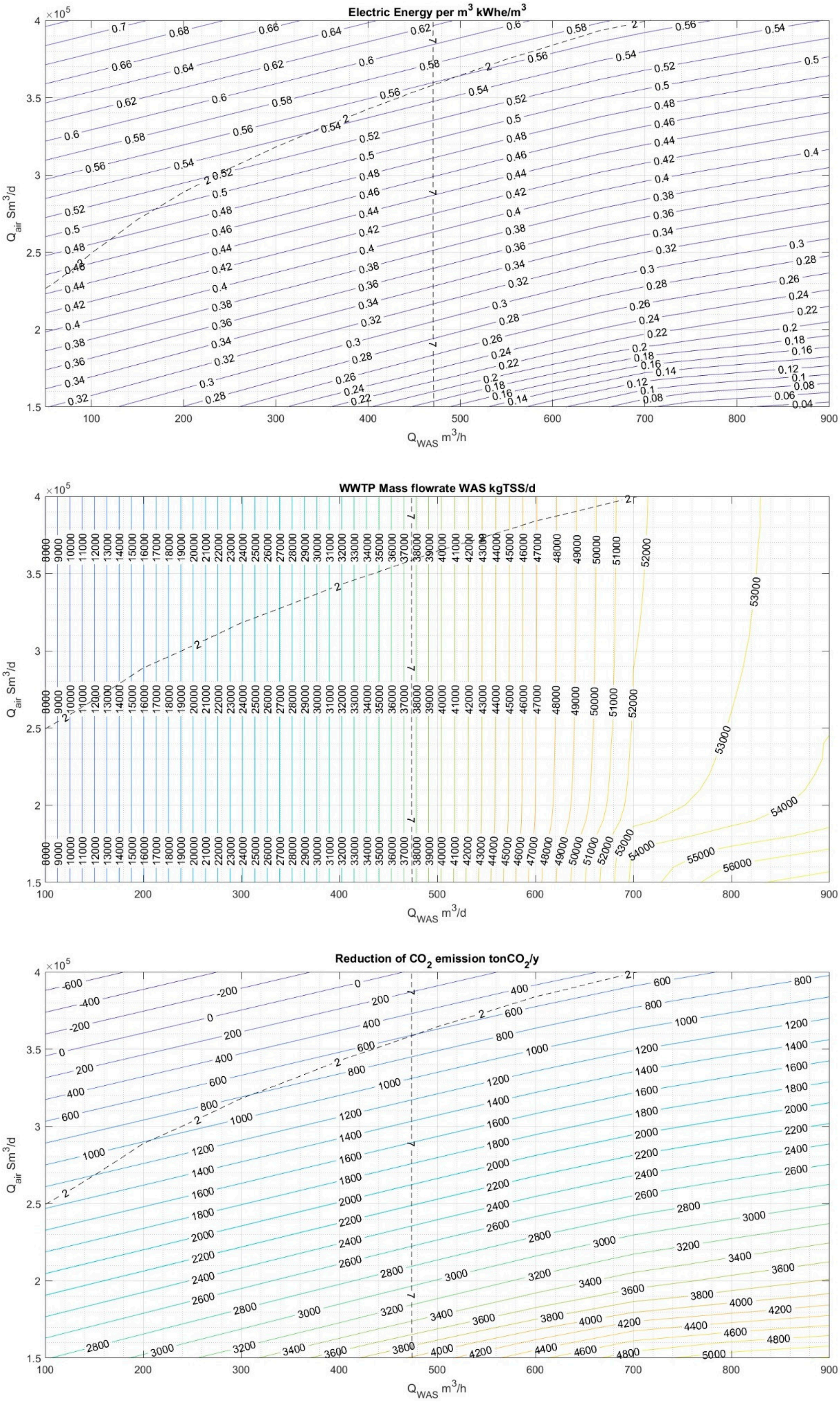
SM Figure S2a. Scenario 1 Process parameters, a function of Qwas (WAS flow rate) and Qair (air flow rate)



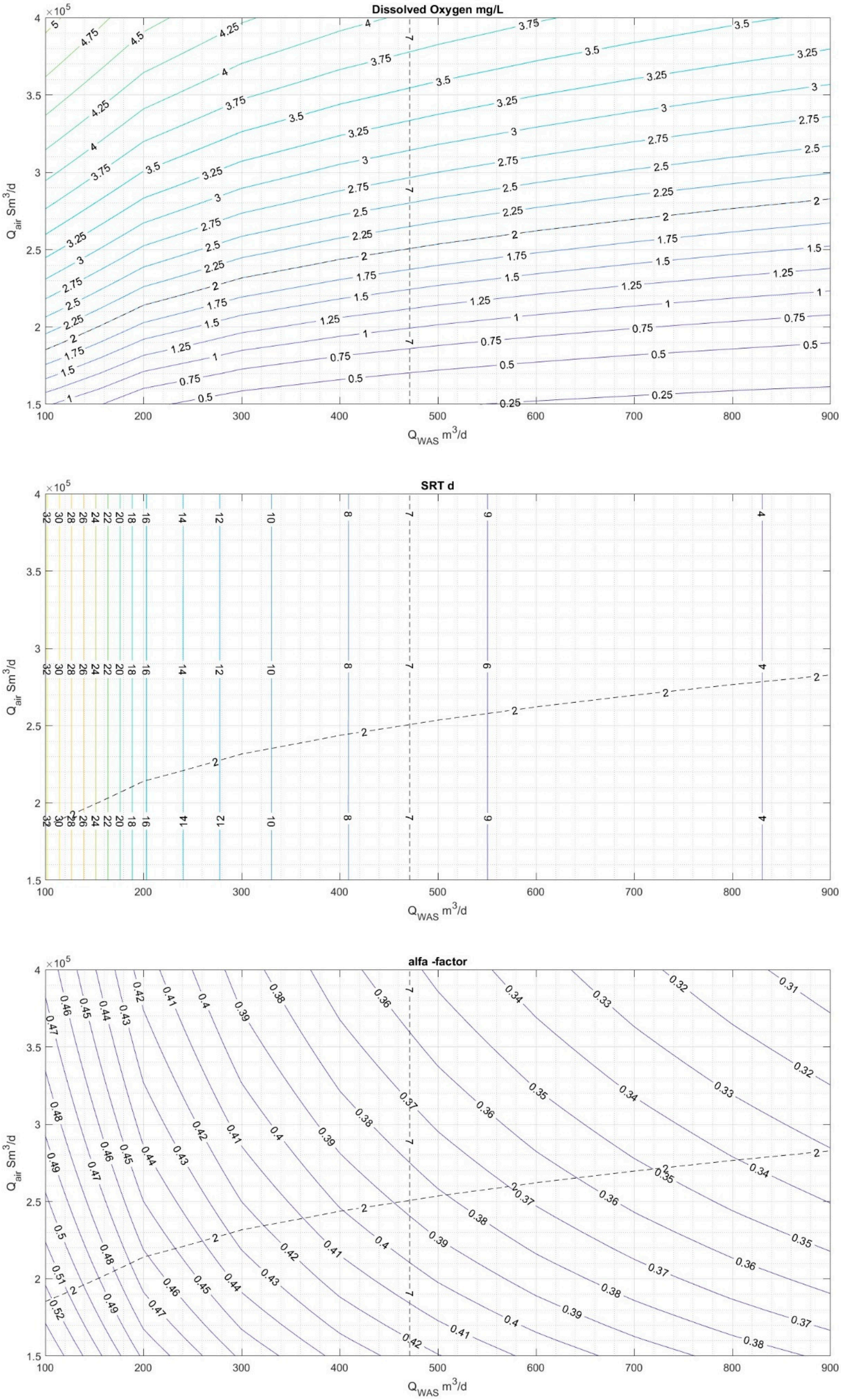
SM Figure S2b. Scenario 1 Process parameters, a function of Qwas (WAS flow rate) and Qair (air flow rate)



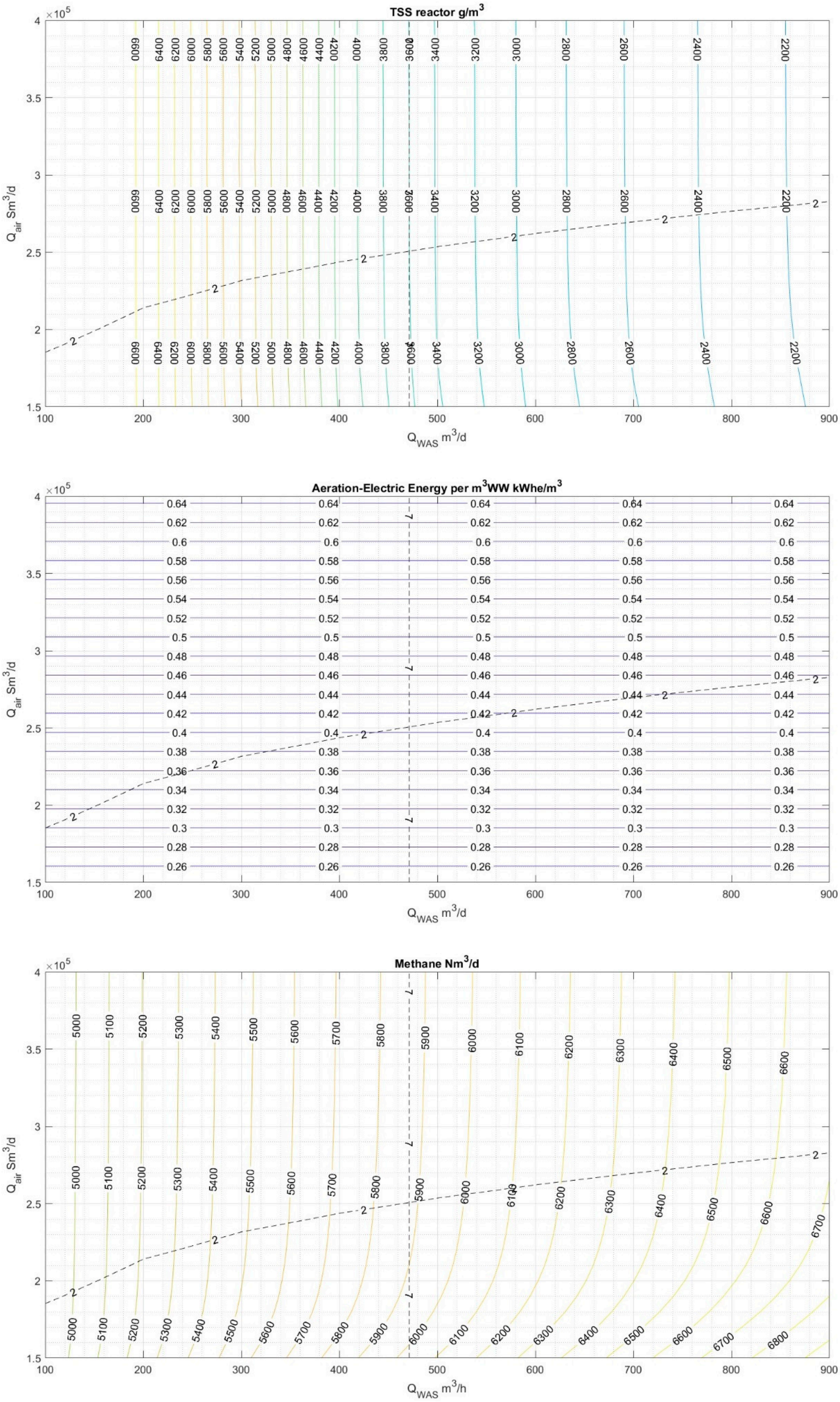
SM Figure S2c. Scenario 1. Process parameters, a function of Qwas (WAS flow rate) and Qair (air flow rate)



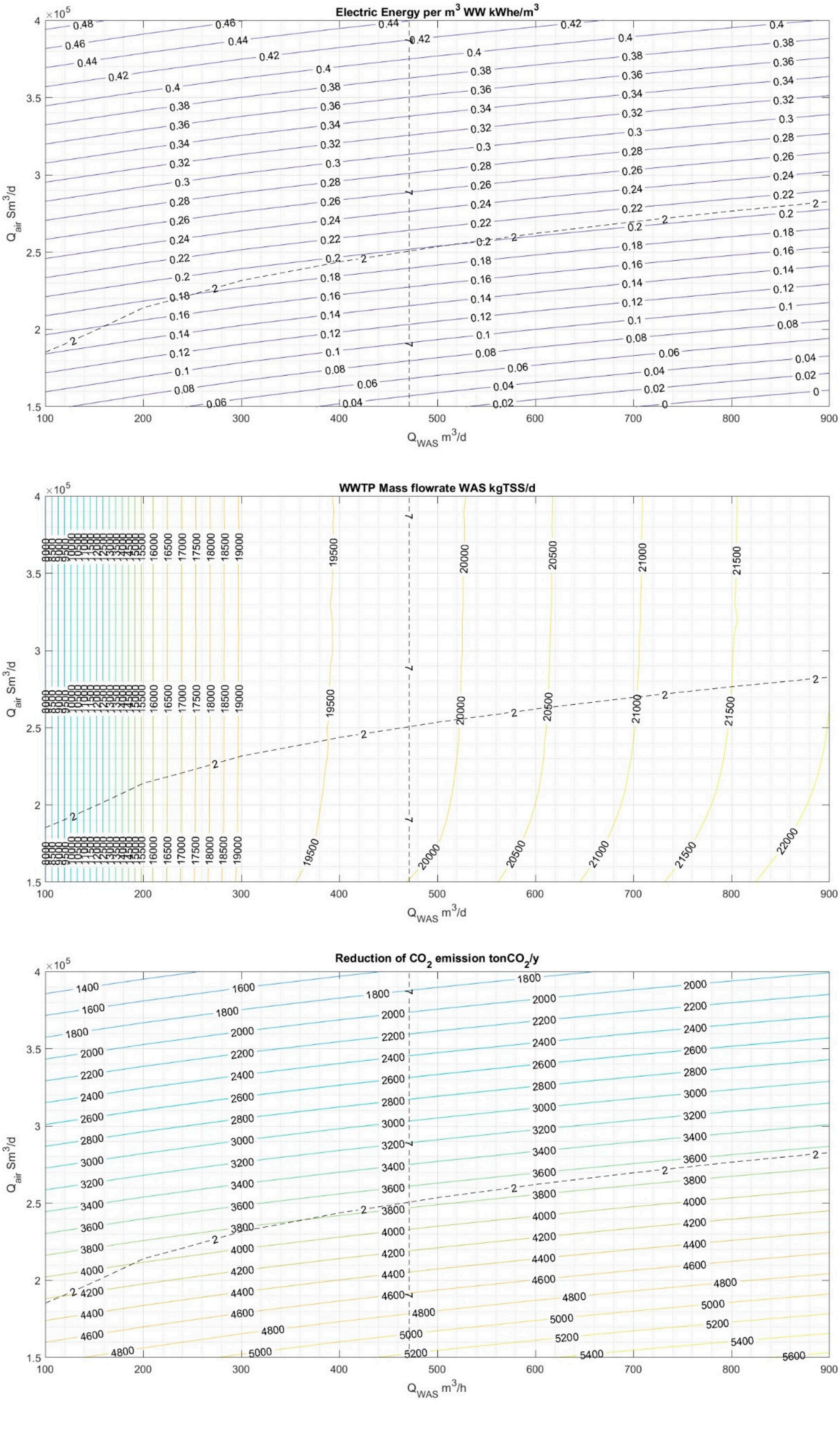
SM Figure S3a. Scenario 2. Process parameters, a function of Qwas (WAS flow rate) and Qair (air flow rate)



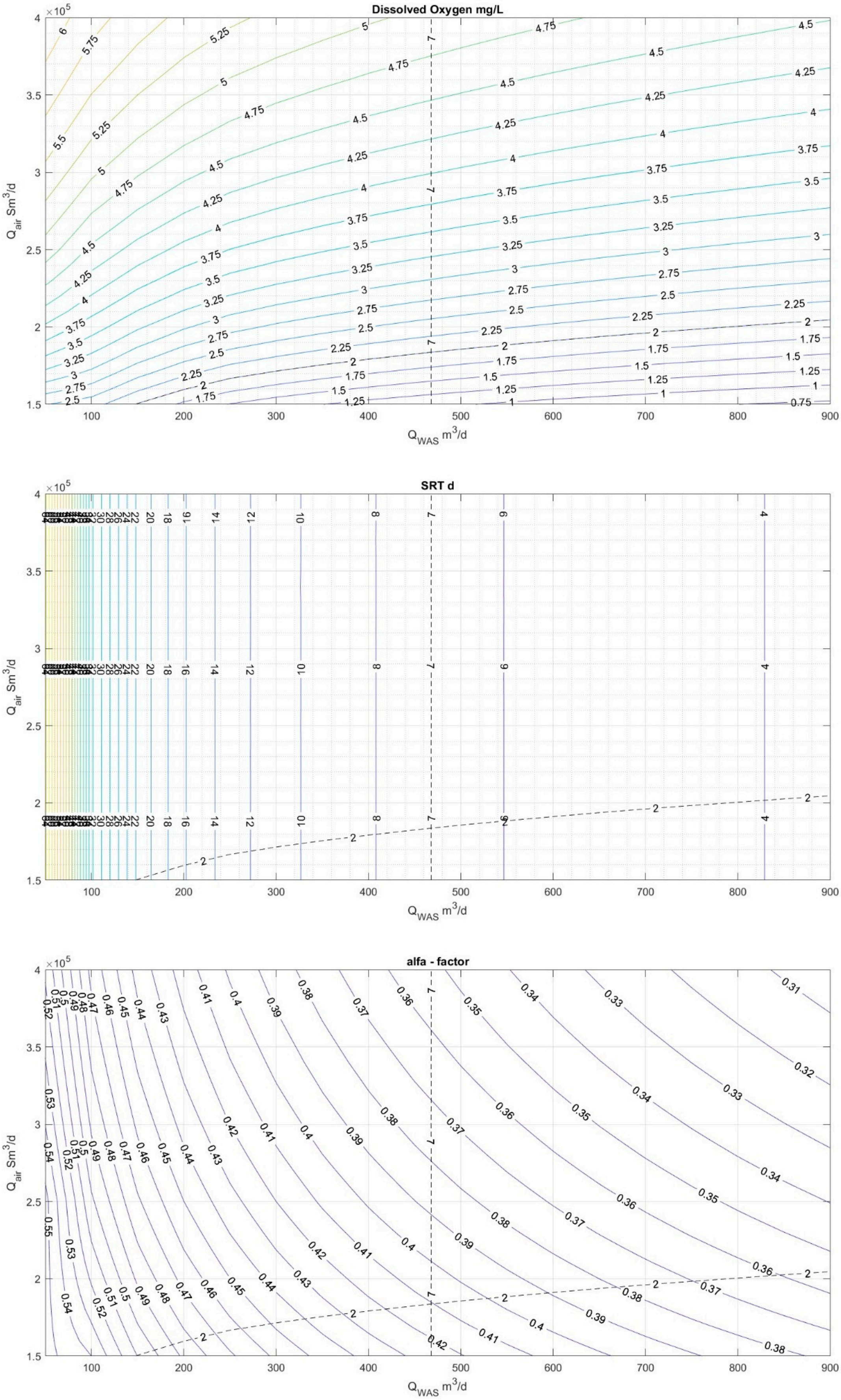
SM Figure S3b. Scenario 2. Process parameters, a function of Qwas (WAS flow rate) and Qair (air flow rate)



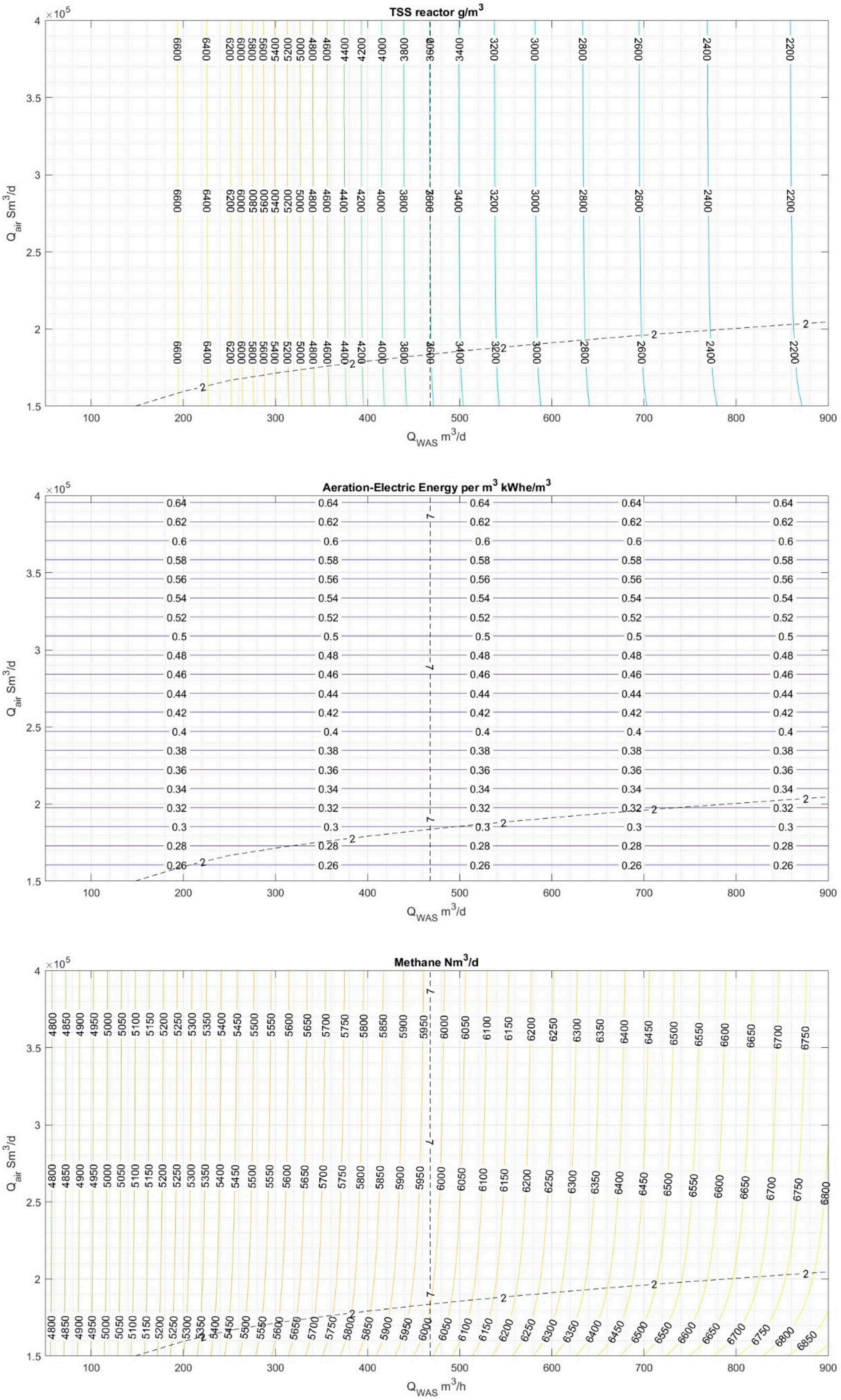
SM Figure S3c. Scenario 2. Process parameters, a function of Qwas (WAS flow rate) and Qair (air flow rate)



SM Figure S4a. Scenario 3. Process parameters, a function of Qwas (WAS flow rate) and Qair (air flow rate)



SM Figure S4b. Scenario 3. Process parameters, a function of Qwas (WAS flow rate) and Qair (air flow rate)



SM Figure S4c. Scenario 3. Process parameters, a function of Qwas (WAS flow rate) and Qair (air flow rate)