

3) Optimize the thickener - digestion system

MEt2 =	686	kg TSS/d	MEv2 =	480	kg VSS/d	Cp =	4,2	kJ/(kg.degC)	Cth =	876	876	eur/m3
MET_eff =	80	kg TSS/d	MEv_eff =	56	kg VSS/d	dH Nat. Gas =	35,0	MJ/m3 nat.gas	Cdi =	824	824	eur/m3
MEt_q2 =	606	kg TSS/d	MEv_q2 =	424	kg VSS/d	dH CH4 =	810	kJ/mol CH4	Cng =	0,35	0,35	eur/Nm3 n.g.
MEt1 =	0	kg TSS/d	MEva_q2 =	163	kg VSS/d	dH CH4 =	50,6	MJ/kg CH4	Ann. Factor=	11,3	11,3	(avg of C/M/l)
MEt (q1+q2)=	606	kg TSS/d	fav2 =	38%	(-)	CH4 content =	65%	in biogas	Tdes,di =	30		degrees C
Xt1 =	0	kg TSS/m3	MEv1 =	0	kg VSS/d	Combust. Eff. =	80%	as heat	Tavg,amb =	12		degrees C
Xt2 =	4	kg TSS/m3	MEva1 =	0	kg VSS/d	MWCH4	16	kg/kmol	Tavg,r =	17		degrees C
q1 =	0	m3/d	MEvna1 =	0	kg VSS/d				Tmin,r =	12		degrees C
q2 =	152	m3/d										
					MCH4 =	50	kg CH4/d					
Rdp =	56%	(-)	Rdi =	12,7	days	Avail. Energy =	2012	MJ/d				
Rdn =	16%	(-)	MEvae =	31	kg VSS/d	Qbg =	107	Nm3/d				
MEd2 =	132	kg VSS/d	MEve =	292	kg VSS/d	Pgen (bg) =	23	kW				
MEd1 =	0	kg VSS/d	MEte =	474	kg TSS/d	k =	0,445640024	l/g TSS	Hdi	6		m
MEd =	132	kg VSS/d	MSd =	199	kg COD/d	v0 =	155,4879808	m/d	Hdi (b.gl.)	2		m
MNdi =	13	kg N/d	fav (qdi) =	0,10	(-)	Hth =	3	m	Hdi (a.gl.)	4		m
Ndi =	3,3	mg N/l	fat (qdi) =	0,06	(-)	Sfth =	1,5	(-)	Hcone	3		m

Selection of optimal thickener/digester combination according to minimum total volume; minimum total construction cost or minimum annualized total costs												
Xth,r	Xth,l	Fl	Vth	qth	Vdi	Total Volume	Total Constr	Annualized	Energy req.	Energy req.	Energy Cost	Annualized
kg/m3	kg/m3	kg/(m2*d)	m3	m3/d	m3	m3	Cost	Total Costs	kW (avg)	kW (max)	(opportunity)	Constr. Cost
12	9,0	101,4	27	51	642	669	€ 553.000	€ 57.000	25	49	€ 7.900	€ 49.000
13	10,1	78,1	35	47	593	628	€ 519.000	€ 53.000	22	44	€ 6.800	€ 46.000
14	11,2	59,2	46	43	550	597	€ 494.000	€ 50.000	19	39	€ 5.800	€ 44.000
15	12,3	44,2	62	40	514	575	€ 477.000	€ 47.000	16	35	€ 5.000	€ 42.000
16	13,3	32,7	83	38	482	565	€ 470.000	€ 45.000	14	32	€ 4.300	€ 41.000
17	14,3	23,9	114	36	453	567	€ 473.000	€ 46.000	11	29	€ 3.600	€ 42.000
18	15,4	17,3	157	34	428	586	€ 491.000	€ 46.000	10	26	€ 3.000	€ 43.000
19	16,4	12,5	219	32	406	624	€ 526.000	€ 49.000	8	23	€ 2.500	€ 46.000
20	17,4	8,9	306	30	385	691	€ 585.000	€ 54.000	7	21	€ 2.100	€ 52.000
21	18,4	6,3	430	29	367	797	€ 679.000	€ 62.000	5	19	€ 1.600	€ 60.000
22	19,5	4,5	608	28	350	958	€ 821.000	€ 73.000	4	17	€ 1.300	€ 72.000
23	20,5	3,2	863	26	335	1198	€ 1.032.000	€ 92.000	3	16	€ 900	€ 91.000
24	21,5	2,2	1232	25	321	1553	€ 1.343.000	€ 120.000	2	14	€ 600	€ 119.000
25	22,5	1,5	1765	24	308	2073	€ 1.799.000	€ 159.000	1	13	€ 300	€ 159.000
26	23,5	1,1	2537	23	296	2833	€ 2.465.000	€ 218.000	0	12	€ -	€ 218.000
27	24,5	0,7	3659	22	285	3944	€ 3.439.000	€ 303.000	-1	10	€ 200-	€ 303.000
28	25,5	0,5	5294	22	275	5569	€ 4.861.000	€ 429.000	-2	9	€ 500-	€ 429.000
29	26,5	0,4	7680	21	266	7946	€ 6.943.000	€ 612.000	-2	8	€ 700-	€ 613.000
30	27,6	0,2	11172	20	257	11429	€ 9.993.000	€ 881.000	-3	7	€ 900-	€ 882.000

Steps:

- Select the target thickened sludge concentration for minimum total volume, minimum construction costs or minimum annualized construction costs including heating
- Compare the average available energy with the average energy requirements for heating the digester. Adapt the operational digester temperature if needed.
- Check the hydraulic residence time in the thickener: adapt settling chars, H, Sf, Xth if required

Minimum total constr. cost solution =	€ 470.000	for Xth,r =	16	kg TSS/m3	Rhth =	13	hr	
Minimum annualized total cost solution =	€ 45.000	for Xth,r =	16	kg TSS/m3	Rhth =	13	hr	
Minimum total volume solution =	565	m3	for Xth,r =	16	kg TSS/m3	Rhth =	13	hr

Selected	Minimum total annualized costs	▼						
Xth,r =	16	kg TSS/m3	Vdi =	482	m3	Nett. En. Req.=	14	kW (avg)
qth =	38	m3/d	qdi =	38	m3/d		32	kW (max)
Vth =	83	m3	Xte =	12,5	kg TSS/d	Nat. Gas req. =	33	m3/d (avg)
Rhth =	13	hr	Xtdw =	300	kg TSS/m3		78	m3/d (max)
Hth =	3	m	qdw =	1,6	m3/d	Pgen (tot) =	46	kW (avg)
Ath =	28	m2					69	kW (max)
Dth =	6,0	m						

Material and insulation:

Fixed steel covers; 6 mm thick; not insulated	▼
Plain concrete wall (below ground); surrounded by moist earth	▼
Plain concrete walls (above ground); 300 mm; insulation	▼
Plain concrete floors; 300 mm; in contact with dry earth	▼

	Tavg	Tmin	Tdi - Tavg	Tdi - Tmin	U
Cover	12	0	18	30	4,7
Walls (b.gl.)	12	0	18	30	1,25
Walls (a.gl.)	12	0	18	30	0,7
Floor	10	-5	20	35	1,7

Calculation of heating requirements digester													
Digester size		Surface area				Heat loss				Influent Heating			
H	D	Wall (a.gl)	Wall (b.gl)	Floor	Roof	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
m	m	m2	m2	m2	m2	kW	MJ/d	kW	MJ/d	kW	MJ/d	kW	MJ/d
6	11,7	147	73	120	107	16,6	1438	28,1	2426	31,8	2746	44,0	3801
6	11,2	141	70	112	99	15,5	1342	26,2	2264	29,3	2534	40,6	3509
6	10,8	136	68	105	92	14,6	1259	24,6	2124	27,2	2353	37,7	3258
6	10,4	131	66	99	86	13,7	1186	23,2	2001	25,4	2196	35,2	3041
6	10,1	127	64	93	80	13,0	1123	21,9	1894	23,8	2059	33,0	2851
6	9,8	123	62	89	76	12,3	1066	20,8	1799	22,4	1938	31,1	2683
6	9,5	120	60	84	71	11,8	1016	19,8	1714	21,2	1830	29,3	2534
6	9,3	117	58	81	68	11,2	971	19,0	1638	20,1	1734	27,8	2401
6	9,0	114	57	77	64	10,8	930	18,2	1569	19,1	1647	26,4	2281
6	8,8	111	55	74	61	10,3	893	17,4	1506	18,2	1569	25,1	2172
6	8,6	108	54	71	58	9,9	859	16,8	1449	17,3	1498	24,0	2074
6	8,4	106	53	69	56	9,6	828	16,2	1397	16,6	1432	23,0	1983
6	8,3	104	52	66	54	9,3	799	15,6	1348	15,9	1373	22,0	1901
6	8,1	102	51	64	51	8,9	773	15,1	1304	15,3	1318	21,1	1825
6	7,9	100	50	62	49	8,7	748	14,6	1263	14,7	1267	20,3	1755
6	7,8	98	49	60	48	8,4	726	14,2	1224	14,1	1220	19,6	1690
6	7,6	96	48	58	46	8,2	705	13,8	1188	13,6	1177	18,9	1629
6	7,5	94	47	57	44	7,9	685	13,4	1155	13,1	1136	18,2	1573
6	7,4	93	46	55	43	7,7	666	13,0	1124	12,7	1098	17,6	1521