

Die Ökoeffizienz von Systemalternativen im Wasser-Energie-Abfall Nexus

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In the following four tables are presented, which gives additional information regarding the life cycle inventory (LCI) (Tables A1 and A2) and the costs (Tables A3 and A4), differing between system operation (Table A1 and A3) and system construction (Table A2 and A4).

Table A1: System operation

Process	Unit	SQ	SYAL1	SYAL2	SYAL3
<i>Drinking water</i>					
Drinking water consumption	m ³	195,768	142,523	106,378	106,378
Energy requirement	MWh	78	57	43	43
<i>Wastewater and greywater</i>					
Run-off (collected rainwater)	m ³	282,647	183,721	84,794	0
Treated wastewater or greywater	m ³	¹ 481,215	² 318,603	³ 137,683	³ 137,683
Energy requirement	MWh	⁴ 0	368	193	193
Diesel for road-transport of sewage sludge	Mg	0.5	--	--	--
Recovered heat	MWh	--	1,601	2,065	2,065
<i>Organic MSW and blackwater</i>					
Organic MSW generation	Mg	249.0	249.0	249.0	249.0
Energy requirement organic MSW	kWh	14,938	647	7,622	7,622
Diesel for road-transport of organic MSW	Mg	0.6	0.2	--	--
Blackwater generation	m ³	--	7,641	7,641	7,641
Energy requirement vacuum systems	MWh	--	76	76	76
Biogas provision	MWh	--	45,565	45,565	45,565
Recovered phosphorus	Mg	0.4	3.2	3.2	3.2
Recovered nitrogen	Mg	1.7	23.0	23.0	23.0
Recovered potassium	Mg	1.1	7.0	7.0	7.0
<i>Energy requirement of households</i>					
Space and water heating	MWh	36,359	⁵ 0	⁵ 0	⁵ 0

Notes: -- = not applicable

¹ Wastewater consisting of rainwater, greywater, urine and feces

² Greywater plus rainwater

³ Greywater

4 Is set to zero as the energy expenditure is fully covered by sewage gas and co-incineration

5 Is set to zero as the energy expenditure is fully covered by the biogas production.

Source: Friedrich et al. 2020.

Table A2: System construction

Material	Unit	SQ	SYAL1	SYAL2	SYAL3
Concrete	Mg	885.0	517.7	517.6	231.3
Steel	Mg	56.5	12.6	11.3	7.2
Gravel	Mg	21.5	98.5	98.5	98.5
Chemicals	Mg	14.3	10.1	0.0	0.0
Cement	Mg	10.6	4.0	4.0	0.0
Iron	Mg	0.1	9.4	9.4	9.4
Ethylene	Mg	0.0	0.0	11.9	11.9
Polyethylene	Mg	0.5	2.2	6.2	6.2
Misc.	Mg	7.4	11.1	10.7	9.2
Sum	Mg	995.9	665.6	669.6	373.7

Source: Friedrich et al. 2020.

Table A3: Operating costs

Process	Unit	SQ	SYAL1	SYAL2	SYAL3
<i>Drinking water</i>					
Drinking water supply	kEUR	244.8	178.2	128.2	128.2
<i>Wastewater and greywater</i>					
Wastewater treatment	kEUR	680.9	340.4	177.8	--
Greywater treatment	kEUR	--	--	85.4	85.4
Biogas plant	kEUR	--	508.1	508.1	508.1
Wastewater separation	kEUR	--	33.1	33.1	33.1
Shredder	kEUR	--	0.5	2.0	2.0
Heat exchanger	kEUR	--	9.9	--	--
Sludge transport vehicle (maintenance)	kEUR	0.4	--	--	--
Coal power plant	kEUR	0.3	--	--	--
<i>Organic MSW and blackwater</i>					
Compost plant	kEUR	0.2	--	--	--
Garbage truck (maintenance)	kEUR	2.3	2.3	--	--
Fuel costs	kEUR	0.9	0.3	--	--
Annual operating costs	kEUR	929.8	1.072.9	934.4	756.6
NPV of operating costs over 80 yrs.	kEUR	28,081.1	32,402.5	28,221.3	22,850.5

Note: -- = not applicable

Table A4: NPV of investment costs incl. reinvestments

Component	Life span	SQ	SYAL1	SYAL2	SYAL3
	Years	kEUR	kEUR	kEUR	kEUR
Digging	0	2,260	847	847	445
Sewage treatment plant	30	1,422	1,422	--	--
Sewer system	80	2,543	954	954	--
Vehicle sludge transport	15	9	--	--	--
Coal power plant	30	141	--	--	--
Garbage truck	15	55	55	--	--
Toilette system	30	1,894	7,425	7,425	7,425
Composting plant	25	2	--	--	--
Pressure pipe	60	--	109	109	109
Vacuum station	20	--	557	557	557
Liner and resin	50	--	559	559	559
Biogas plant	20	--	10,314	10,314	10,314
Heat pump	20	--	108	--	--
Heat exchanger	50	--	84	--	--
Shredder	20/15*	--	37	2,892	2,892
Greywater treatment plant and 2 nd grid	20	--	--	7,323	7,323
Investment costs (components)	--	8,326	22,471	30,980	29,624
Planning costs (10% of investment costs)	--	833	2,247	3,098	2,962
Investment costs (w/o financing)	--	9,159	24,718	34,078	32,586
Financing costs	--	4,983	8,254	10,256	9,228
Investment costs (total)	--	14,142	32,971	44,334	41,814

Notes: -- = not applicable

* = 20 years in case of a centralized shredder; 15 years in case of a de-centralized shredder