



Enabling  
& Transboundary Cooperation  
& Integrated Water Resources Management  
in the extended **DRIN RIVER BASIN**



GEF/UNDP/GWP-Med Project “Enabling Transboundary Cooperation and Integrated Water Resources Management in the Extended Drin River Basin

In the framework of the Memorandum of Understanding  
for the Management of the Extended Transboundary Drin Basin

*Pilot activity “Preparation of Wastewater Management Decision Support  
Tool”*

***Wastewater management solutions in the Shkodra city***

**Annex 1: SBR for Shkodra City**

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## 1 General

Wastewater treatment plant contains the following parts:

- Mechanical pretreatment
  - o rough rake,
  - o compact device with fine rake and grit and grease chamber (sand, fat and oil extraction,
  - o septage receiving station,
  - o primary settling tank
- Biological treatment
  - o Biological basins – SBR
  - o Pump units for cleaned water
  - o Pump units for recirculation
  - o Pump units for sludge
  - o Mixers for aeration stage
  - o Blowers for aeration
- Sludge treatment
  - o Pump units for primary sludge
  - o Sump unit for secondary sludge
  - o Digester

## 2 Inflow and mechanical pretreatment stage

Mechanical pretreatment (wastewater screening (rough and fine rake, sand and fat/oil extraction)) will be presented in the chapters below.

### 2.1 Mechanical Pre-Treatment

The raw wastewater contains coarse material and mineral substances. To minimize the abrasion of the plant systems and to support the biological treatment step, these biological not removable suspended substances have to be removed for trouble-free operation of the plant.

Furthermore, it is vital to remove biologically non-degradable components to get an excess sludge of good quality for further process.

#### 2.1.1 Aerated Grit and Grease Chamber

The wastewater contains mineral components that cannot be treated or decomposed in the biological treatment process. They also increase the inert matter in the activated sludge. Therefore mineral components are removed in the grit chamber. The aeration is used to enable the breakdown of grease and oil from sand and other sediments.

The sand sediments to the bottom and the floating substances are removed by automatic skimmers and sludge scrapers to the grit chamber's intake and the collecting shaft for the floating substances.

The wastewater contains mineral components which cannot be decomposed in the biological treatment process. They also increase the inert matter in the activated sludge. In order to remove the mineral components, they will precipitate in the grit chamber.

The sand is collected in an inflow cone and transported automatically into the sand classifier by mammoth pumps. The collected grease is removed by select suction vehicles. A large part of the water is separated along with the grease. This separated water will be returned to the beginning of the process.

The inflow and outflow of the grit chamber can be shut-off with slide gates.

The following shows the calculation of the classical aerated grit chamber divide into two separate lines.

#### 2.1.2 Pre-sedimentation (primary stage)

The purpose of preliminary sedimentation is the preliminary treatment of wastewater. From wastewater, we eliminate waste loads. In the primary settling tank there's a primary sludge zone and a partially cleaned water zone. Partially cleaned wastewater goes to biological treatment, primary sludge goes to the dehydrator, and further to the digester.

## 3 Biological treatment

### 3.1 SBR - Process

In the SBR process, the biological treatment and the separation of sludge and cleaned water occur in one chamber. In addition to that, the process steps have to work with temporary differences.

The first step is the inflow of the wastewater into the reactor and the aeration of the water. The chamber volume will be dammed with the increase of water inflow. After reaching the maximum high, the inflow will be stopped.

The aeration is shut off in the sedimentation phase, and the activated sludge will separate from the cleared water.

After the sedimentation of the sludge, the cleared water's remove phase will start, and the water will take off into the river. If the minimal filling level is reached, the pumps will be stopped, and the reactor is ready for the next treatment cycle.

### 3.2 Rotary (Piston) Blower

Rotary compressors supply the activated sludge with oxygen by blowing-in environmental air into the chamber. The blower units are covered to reduce noise.

Sufficient air exchange in the blower room is required due to the motors' production of waste heat. A fan for the used air and a fresh air grate are installed. The air inlets and outlets are sound insulated.

### 3.3 Aeration System

The compressed air is transported through collecting and distributing pipes to the aerators. Fine-bubble membrane aerators disperse the compressed air into the activated sludge chamber.

The aerators can be closed and lifted separately for maintenance works without interrupting the plant operation.

### 3.4 Fast-Revolution Mixer

Fast-revolving mixers are used for the recirculation in the denitrification zone.

### 3.5 Excess Sludge Pump Station

An excess sludge pump is placed in the return sludge pumping station and transports the excess sludge to the sludge treatment plant or the sludge silo. The pump can be operated manually or by an automatic time-controlled program. A centrifugal pump is used to transport the excess sludge.

### 3.6 Sludge Silo

The excess sludge is stored in a sludge silo. Drained water will be released by a manual operating device and transported to the screen inflow. A mixer homogenizes the thickened sludge for further treatment.



## 4 Anaerobic digestion of sludge

Dried primary and secondary sludge are collected from the sludge tank in anaerobic sludge digestion. For the mesophilic anaerobic stabilization of the sludge (33-37°C), four equal mounting digesters from stainless steel AISI 316L. The pipeline configuration and digester equipment allow the serial or parallel operation of the digesters.

Each digester is equipped with a mixer with a vertical axis, an outlet chamber, a biogas extraction system, a foam punching system, an inspection window, and a lateral revision for maintenance purposes, access paths, and a bridge for accessing the upper openings.

The biogas removal system includes on each digester a biogas evacuation cap, an anti-flame retarder, an overhead and ground-based safety valve, a biogas flow meter, a methane content meter, and a pressure gauge.

All sludge heating and manipulation equipment have been installed in the digester machine, located between the digester. Sufficient space is provided for the later addition of two identical digesters.

### **The digester machine**

In order to heat the inlet of condensed primary and secondary sludge and digester content, one tube coaxial heat exchanger (50 / 70°C ) is installed in the digester machine for each digester, which uses the heat generated on the CHP unit. For each digester, it contains two (one as a reserve) pumps for sludge recirculation.

Stabilized sludge is pumped from the digester into the digested sludge container to assist two pumps (one as a reserve).

### **Biogas tank**

To compensate and save biogas, it is installed in a spherical double-membrane biogas tank. Two blowers have been installed to inflate the outer membrane (one as a backup). A biogas meter is installed in the biogas tank, a biogas flow meter is installed in the main pipeline, and an automatic condensate extraction system is installed in the biogas container.

### **Purification of biogas**

Purification of biogas includes a sandy filter, a biological desulfurization device, and a carbon active filter. There is a system for automatic condensate extraction at the input to the desulfurization plant, biogas tank, and gas torch.

### **Gas torch**

For the incineration of biogas a gas torch is installed. The torch is equipped with an automatic high-voltage ignition system, a flame detector, and other legally required co-equipment.

### **Digested sludge tank**

The digested sludge tank is divided into two parts to allow for cleaning the tank and maintenance. Each tank is equipped with a submerged mixer with a horizontal shaft.

Perforated tubes are installed along the containers' peripheral walls for periodic rinsing of the tank walls with technological water. The washing system is switched on manually.

### **Sludge dehydration**

In dehydration object with a centrifugal decanter will be used to dehydrate the digested sludge. Dehydration sludge will be carried out using two centrifugal decanters (3 + 1). A worm conveyor will discharge the dehydrated sludge into the dehydrated sludge tank.

Characteristics of the dehydration object:

- Air purification from the dehydration facility should be ensured.
- The control cabinet will be separated.

Characteristics of equipment in the dehydration facility:

- Sludge dehydrating device:
  - o Maximum working time of dehydration = 8 hours / day, 5 days / week (including start, cleaning, and end of the operation).
  - o The number of centrifugal decanters is 4, and each is dimensioned to the total required capacity.
  - o The minimum dry matter content of the sludge after machine dehydration will be  $\geq 23\%$ .

### **Dehydrated sludge tank**

For this purpose will be installed a container with capacity for minimum three-day production of dehydrated sludge.

Number of containers: 1

Retention time at maximum centrifugal operation: Min. 72 h

Number of screws for sludge extraction: 1

Type: worm conveyor

Screw material: steel

Carrier materials: Stainless steel AISI 316L or better

Engine protection and transmission: min. IP55, class F or H

Control: level measurement

### **Tank and pumping stations of purified technological water**

A submersible pump will be installed on the outgoing channel of the purified water, which will already purify the already purified water in two containers for the needs of technological water. The technological water tank is divided into two parts to allow the cleaning of the tank and maintenance. Each tank is equipped with measuring equipment. Tanks are tied to a pumping station for technological water.

The dimensioning of the purified wastewater and pumping stations will be so that the appropriate pressure and the required flow for each part of the equipment to be washed are ensured.

The supply system with technological water includes:

- Storage tank;
- Pumping Station;
- System of distribution of technological water and connection point.

Requirements will be met:

- Technological water is a purified effluent.
- The system of distribution of technological water and fire-fighting water will be separated.

Requirements for pumping and distribution of technological water will be fulfilled:

- Technological water is produced from a purified effluent.
- Define daily needs for technological water and maximal flow in normal working conditions.
- The volume of the technological water tank will be greater than or equal to daily consumption at the Plant's peak capacity. To ensure sufficient pressure, a hydrofor will be installed.
- The number of pumps required is one (1) work and one (1) backup, with alternate operation.
- The pumping station of technological water is physically connected with the independent pipeline system technological water with any equipment that requires rinsing.
- The pumping station will also contain all the equipment and instruments for monitoring purposes and pump management, and all protective equipment.
- The pump station is operated with automatic and local control and is connected to the NUS Facility.
- The technological water distribution system is derived from PEHD pipes, PE 100, SDR 17, PN 10 bar.
- All connection points for technological water will be appropriately labeled, text and graphic,
  - that this is non-drinking water.
- Technological and drinking water pipelines will be of different colors or marked in another suitable way.

## 5 Basic design (calculation)

### 5.1 Wastewater inflow

#### 5.1.1 Inlet parameters

Design Capacity: 115.000 PE  
 Internal Response: 7.782 PE

#### Municipal Wastewater

Spec. Wastewater Quantity:  $wS,d = 120,00 \text{ l}/(P*d)$   
 Wastewater flow, yearly average: 159,72 l/s  
 575,00 m<sup>3</sup>/h  
 Spec. Infiltration Coefficient:  $qf = 50,00 \%$   
 Hourly Average (infiltration): 24,00 h/d  
 Infiltration quantity:  $QF,aM = 79,86 \text{ l/s}$   
 = 287,50 m<sup>3</sup>/h  
 Dry weather flow, yearly average:  $QT,aM = 239,58 \text{ l/s}$   
 862,50 m<sup>3</sup>/h  
 20.700,00 m<sup>3</sup>/d  
 Divisor for the daily peak:  $xQmax = 16,00 \text{ h/d}$   
 Daily peak dry weather flow, yearly average:  $QT,h,max = 319,44 \text{ l/s}$   
 1.150,00 m<sup>3</sup>/h  
 Dewatering by Storm Water System  
 Factor of storm Water Inflow:  $fS,QM = 4,50$

$$QM = fS,QM * QS,aM + QF,aM \text{ l/s}$$

stormwater flow:  $QM = 798,61 \text{ l/s}$   
 2.875,00 m<sup>3</sup>/h

#### 5.1.2 Waste loads and concentrations

The hourly values are calculated with the hour index for domestic and infiltration

Table 1: Waste Loads and Concentrations

Waste Loads and Concentrations			
	g/(P*d)	kg/d	mg/l
COD-municipal	120,00	13.800,00	666,67
TSo-municipal	70,00	8.050,00	388,89
TKN-municipal	11,00	1.265,00	61,11
P-municipal	1,80	207,00	10,00

### 5.2 Pre-sedimentation (aerated grift chamber)

#### 5.2.1 Load

Dry Weather Flow:  $Qt = 1.150,00 \text{ m}^3/\text{h}$

Combined Inflow:	Qm	=	2.875,00 m <sup>3</sup> /h
Population Equivalent:			115.000,00 PE
Number of Lines:			2

### 5.2.2 Dimensioning

#### Grit Chamber

##### Minimum Values

Retention Time minimum (Qt):			10,0 min
Retention Time minimum (Qm):			5,0 min
Retention Time Dimensioning (Qt):			10,0 min
Retention Time Dimensioning (Qm):			10,0 min
Maximum Flow Velocity:			20 cm/s
Ratio Width/Depth (Dry Water System):		<	1,0
Ratio Width/Depth (Storm Water System):		>	0,8
Volume minimum (Qt):			95,83 m <sup>3</sup>
Volume minimum (Qm):			239,58 m <sup>3</sup>
Volume minimum (Dimensioning):	Vmin	=	239,58 m <sup>3</sup>
Width (Ratio Width/Depth = 0,8):			3,00 m

##### Real Values

Length chosen:	l	=	30,10 m
Width chosen:	b	=	3,00 m
Width (Grease Trap):			0,60 m
Height chosen:	h	=	3,70 m
Slope of Bottom:			45 °
Width of Groove:			0,50 m
Depth of Ditch:			0,30 m
Slope of the Ditch:			60 °
Flow cross Section:			7,98 m <sup>2</sup>
Surface:			90,30 m <sup>2</sup>
Volume:	V	=	240,05 m <sup>3</sup>
Ratio Width/Depth:			0,81
Surface Loading:			15,92 m/h
Velocity (Qt):			2,00 cm/s
Velocity (Qm):			5,01 cm/s
Retention Time (Qt):			25,0 min
Retention Time (Qm):			10,0 min

### 5.2.3 Dimensions (total)

Cross Section (total):	15,95 m <sup>2</sup>
Surface (total):	180,60 m <sup>2</sup>
Volume (total):	480,10 m <sup>3</sup>

### 5.2.4 Equipment

#### **Aeration**

Min. specific Air Input:		1,00 (m <sup>3</sup> /h)/m <sup>3</sup>
Volume:	V	= 240,05 m <sup>3</sup>
Required Air Volume:		480,10 m <sup>3</sup> /h
Chosen Air Volume:		480,10 m <sup>3</sup> /h
Aeration Depth:		3,40 m
Min. Pressure Height:		340 mbar

#### **Blower: Blower**

Number of Aggregates:	2
Capacity of each Machine:	244,20 m <sup>3</sup> /h
Motor Power:	5,5 kW
Power Consumption:	4,0 kW
Pressure Height:	400 mbar

#### **Grit Transportation**

Spec. Grit Yield:	12,00 l/E/a
Daily Grit Production:	3.780,82 l/d
Sand Concentration for Transport:	5,00 %
Daily Transport Volume:	75,62 m <sup>3</sup> /d

#### **Type of machine: Centrifugal Pump**

Number of Aggregates:	2
Capacity of each Machine:	1.900,00 m <sup>3</sup> /h
Transportation Height:	1,50 m
Motor Power:	22,50 kW
Power Consumption:	20,00 kW
Operation time based of calculated Transportation Volume:	0,04 h/d

#### **Sand Classifier**

Capacity:	30,00 m <sup>3</sup> /h
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#### **Scum Pump**

Spec. Grease Production:	6,00 l/E/a
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Daily Grease Production: 1.890,41 l/d  
 Grease Conc. for Transport: 10,00 %  
 Daily Transport Volume: 18,90 m<sup>3</sup>/d

**Type of machine: Centrifugal Pump**

Number of Aggregates: 2  
 Capacity of each Machine: 1.900,00 m<sup>3</sup>/h  
 Transportation Height: 1,50 m

Table 2: Specific Loads according to ATV-A131 (g/(P\*d))

<b>Specific Loads according to table 1, ATV-A131 (g/(P*d)):</b>				
<b>Parameter</b>	<b>Raw Wastewater</b>		<b>Retention Time PS at Qt</b>	
		0,75 - 1,0 h	1,5 - 2,0 h	> 2,5 h
BOD5	60	42 (70%)	39 (65%)	36 (60%)
CCOD	120	42 (70%)	39 (65%)	36 (60%)
SS	70	35 (50%)	28 (40%)	25 (35%)
TKN	11	10 (90%)	10 (90%)	10 (90%)
P	1,8	1,6 (90%)	1,6 (90%)	1,6 (90%)

Retention Time: tD = 1,00 h

**5.3.4.1 Loads after Presedimentation**

BOD5 70 %  
 COD 70 %  
 SS 50 %  
 TKN 90 %  
 P 90 %

Table 3: Waste Loads and Concentrations (after Primary clarification)

<b>Waste Loads and Concentrations (after Primary clarification)</b>			
	<b>g/(P*d)</b>	<b>kg/d</b>	<b>mg/l</b>
COD-municipal	84,00	9.660,00	466,67
COD-Total		9.660,00	466,67
TSo-municipal	35,00	4.025,00	194,44
TSo-Total		4.025,00	190,16
TKN-municipal	9,90	1.138,50	55,00
TKN-Total		1.138,50	55,00
P-municipal	1,62	186,30	9,00
P-Total		186,30	9,00

**5.3.4.2 Primary Sludge Quantity**

SSo-Load (Primary Sludge): 4.025,00 kg/d

SS-Concentration in Primary Sludge: 25 kg/m<sup>3</sup>  
2,5 %

Primary Sludge Volume: 161,00 m<sup>3</sup>/d

#### 5.3.4.3 Chosen Dimensions Primary Settling Tank

Required Volume:

$$\text{Verf} = Q_{t,aM} * tD \text{ Error!} = 862,50 \text{ m}^3$$

Number of Tanks: 2 ea.

Required Volume (per Chamber): 431,25 m<sup>3</sup>

Diameter: 15,00 m

Water Depth: 3,00 m

Chosen Volume (per Chamber): 530,14 m<sup>3</sup>

Chosen Volume (total): 1.060,29 m<sup>3</sup>

Retention Time (real): 1,23 h

#### 5.3.4.4 Internal Response

Hourly Average for internal response: 8,0 h/d

#### Supernatant Water Quantity

COD Load: 9.660,00 kg/d

ES-Production (Estimation): 0,50 kgTS/kgCSB

Waste Sludge Volume (Estimation): 4.830,00 kgTS/d

Dry Solids Conc. in Excess Sludge: 10 kg/m<sup>3</sup>

Waste Sludge (Estimation): 483,00 m<sup>3</sup>/d

Primary Sludge Volume: 4.025,00 kg/d

SS-Concentration in Primary Sludge: 25 kg/m<sup>3</sup>

Primary Sludge: 161,00 m<sup>3</sup>/d

Dry Solids Conc. after Dewatering: 50 kg/m<sup>3</sup>

Volume flow of Supernatant: 466,90 m<sup>3</sup>/d



## 5.3 Biological treatment

### 5.3.1 Dimensioning of the SBR-Plant according to ATV-M 210

#### Basic data for Dimensioning (A 131), Summary

Dimensioning based on COD.

Sludge Age:	tTS,Bem =	11,98 d
Suspended Solids:	TSBB =	4,00 kg/m <sup>3</sup>
Spec. Surplus Sludge Production (12°C):	ues =	0,46 kgTS/kgCOD
Sludge Load:	BTS =	0,18 kgCOD/(kg*d)
Volume (A131) (per Chamber):	VBB =	3.635,30 m <sup>3</sup>
Volume (A131) (total):	VBBges =	14.541,19 m <sup>3</sup>

#### 5.2.3 Design of Cycle

Duration of a Cycle (Dry Weather):	tZ(TW) =	8,00 h
Duration of a Cycle (Storm Weather):	tZ(RW) =	8,00 h
Duration of Anaerobic Phase:	tBioP =	0,50 h
Duration of Reaction Phase (Dry Weather):	tR(TW) =	5,50 h
Duration of Reaction Phase (Storm Weather):	tR(RW) =	5,50 h
Duration of Flocculation Phase:	tFlock =	0,17 h
Duration of Sedimentation Phase (Dry Weather):	tSed =	1,00 h
Duration of Decantation (Dry Weather):	tAB =	1,00 h
Duration of Pause (Dry Weather):	tStill =	0,00 h
Duration of Sedimentation Phase (Storm Weather):	tSed =	1,00 h
Duration of Decantation (Storm Weather):	tAB =	1,00 h
Duration of Pause (Storm Weather):	tStill =	0,00 h

#### Chosen Dimensions of the Reactor

Width:	b =	30,00 m
Length:	l =	70,00 m
Maximum Water Level:	hW =	4,81 m

Volume (per Chamber):	VR =	10.096,89 m <sup>3</sup>
Volume (total):	VRges =	40.387,56 m <sup>3</sup>

#### Oxygen Demand

the calculation for the oxygen demand is based on the models of the DWA M-229-1.

Capacity of the selected blowers :

QL,N (per Chamber):	5.988,00 m <sup>3</sup> /h
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QL,N (Total: 4 Chamber):	23.952,00 m <sup>3</sup> /h
Q1 (per Chamber):	7.482,82 m <sup>3</sup> /h
Q1 (Total: 4 Chamber):	29.931,28 m <sup>3</sup> /h

Pressure Height for Dimensioning of Blowers Blowers 1: 700,00 mbar

### Technical Equipment

#### Aeration

#### Blower: Roots Blower

#### Machine data

#### Machine data

Number of Aggregates (per Chamber): 2,0 ea.

Number of Aggregates (4 Chamber): 8 ea.

Capacity of each Machine per Chamber: 2.994,00 m<sup>3</sup>/h

Capacity Total per Chamber: 5.988,00 m<sup>3</sup>/h

Capacity Total (4 Chamber): 23.952,00 m<sup>3</sup>/h

Motor Power: 90,00 kW

Power Consumption: 73,20 kW

Pressure Height: 700,0 mbar

### Waste Sludge Production

Removed excess Sludge per Cycle:

$$V\ddot{U}S * TS\ddot{U}S = \text{Error!} = 404,60 \text{ kgTS/Zyklus}$$

Daily Quantity of Excess Sludge:  $\ddot{U}Sd = 4.855,19 \text{ kg/d}$

Control Calculation:  $\ddot{U}Sd = Bd,CSB * \ddot{U}SC,CSB = 4.855,19 \text{ kg/d}$

MLSS at the end of the Decantation Phase:  $TS\ddot{U}S > 1000/ISV = 10,00 \text{ kg/m}^3$

Removed Sludge Volume per Cycle: 40,46m<sup>3</sup>/Zyklus

## 5.4 Sludge handling – anaerobic digestion

### 5.4.1 Sludge Volume

#### Primary Sludge

SSo-Load (Inflow):	8.050,00 kg/d
Reduction in the Primary Settling:	50 %
SSo-Load (after Primary clarification):	4.025,00 kg/d
SSo-Load (Primary Sludge):	4.025,00 kg/d
SS-Concentration in Primary Sludge:	25,00 kg/m <sup>3</sup>
Primary Sludge Volume:	161,00 m <sup>3</sup> /d

#### Waste Sludge

Real total Surplus Sludge Production:	0,458 kgTS/kgCSB
COD Load after Primary clarification:	10.593,80 kg/d
Waste Sludge:	4.855,19 kg/d
SS-Concentration in Waste Sludge:	10,00 kg/m <sup>3</sup>
Waste Sludge Volume:	485,52 m <sup>3</sup> /d

#### Mixed Sludge

SSo-Load:	8.880,19 kg/d
Sludge Volume:	646,52 m <sup>3</sup> /d
MLSS Concentration:	13,735 kg/m <sup>3</sup>

Table 4: Calculation for the anaerobic sludge digestion

Overview	kg/d	kg/m <sup>3</sup>	m <sup>3</sup> /d
Primary Sludge	4.025,00	25,00	161,00
Waste Sludge	4.855,19	10,00	485,52
Mixed Sludge	8.880,19	13,735	646,52

#### Gravity thickening

SS-Concentration after Thickening:	TSRohschlamm =	50,00 kg/m <sup>3</sup>
Sludge Volume after Thickening:		177,60 m <sup>3</sup> /d
Supernatant out of Thickening:		468,91 m <sup>3</sup> /d

### 5.4.2 Anaerobic Digestion

#### Basic Data

Sludge Volume:	QRohschlamm =	177,60 m <sup>3</sup> /d
Dry Solids:	Q	= 8.880,19 kg/d
Retention Time:	tRF	= 20,00 d
Volume:	VRF = tRF * QRohschlamm	= 3.552,07 m <sup>3</sup>

Organic Volume Loading:

$$\text{BRF} = \text{Error!} = 1,63 \text{ kgorgTS}/(\text{m}^3 \cdot \text{d})$$

Spec. Digester Volume:	30,89 l/E
Reduction of Dry Solids in the Anaerobic Digestion:	30 %
Dry Solids after Anaerobic Digestion:	6.216,13 kg/d
MLSS after Digestion:	35,00 kg/m <sup>3</sup>

### Gas Yield

Organic Part of Dry Solids in the Inflow:	GV	=	65 %
Spec. Gas Yield:	GE	=	450 l/kgorgTS
Gas Yield:	$GE * Q * GV / 1000 = 2.597,45 \text{ m}^3/\text{d}$		

### Energy Yield

Energy Content of Gas:	6,40 kWh/m <sup>3</sup>
Electric Efficiency:	33 %
Heat Efficiency:	50 %
Production of Energy:	5.485,82 kWh/d
Heat Production:	8.311,85 kWh/d
Internal Use of Heat:	30 %
	2.493,56 kWh/d
Heat Overplus:	5.818,30 kWh/d
Downtime of the Power Station:	5 %
Yearly Electricity Production:	1.902.209,00 kWh/a
Yearly Heat Production:	2.882.135,00 kWh/a
Yearly Internal Use of Heat:	864.641,00 kWh/a
Yearly Heat Excess:	2.017.495,00 kWh/a

### 5.4.3 Dewatering

Sludge Volume after Digestion:	177,60 m <sup>3</sup> /d
Dry Solids after Anaerobic Digestion:	6.216,13 kg/d
MLSS after Dewatering:	320,00 kg/m <sup>3</sup>
Sludge Volume after Dewatering:	19,43 m <sup>3</sup> /d
Supernatant out of Dewatering:	158,18 m <sup>3</sup> /d

## 6 Operation costs estimation

### 6.1 Energy Costs

#### Pumping Stations

Energy Consumption for Wastewater Transportation:

$$E = Q * H * e_{SPEZ} \quad \text{kWh/a}$$

Q      Average Volume      m<sup>3</sup>/h

H Transportation Height incl. all Losses m  
 eSPEZ Specific Energy Consumption Wh/(m<sup>3</sup>\*m)  
 Assumed Rain Frequency for Storm Water System: 0,20

	eSPEZ	Transportation Height	Average Capacity
	Energy Consumption		
<b>Primary Sludge</b>			
Centrifugal Pump	5	Wh/(m <sup>3</sup> *m)	5,00 m6,71 m <sup>3</sup> /h 1469 kWh/a
<b>Waste Sludge</b>			
Centrifugal Pump	5,5	Wh/(m <sup>3</sup> *m)	5,00 m20,23 m <sup>3</sup> /h 4873 kWh/a

**Other Aggregates**

	Number	Power	Daily Oper. Time	Energy
<b>Mechanical Treatment</b>				
Piston Compressor	2	2,00 kW	24,00 h/d	35.040 kWh/a
Centrifugal Pump	2	2,00 kW	0,04 h/d	58 kWh/a
Sand Classifier	2	2,00 kW	0,04 h/d	58 kWh/a
Centrifugal Pump	2	2,00 kW	0,01 h/d	15 kWh/a
Remover Motor	2	2,00 kW	24,00 h/d	35.040 kWh/a
<b>Pre Sedimentation</b>				
Sludge Removal Device	2	2,00 kW	24,00 h/d	35.040 kWh/a
<b>Biological Stage</b>				
Blower 1	8	90,00 kW	10,84 h/d	2.848.752kWh/a
Mixers	4	22,00 kW	18,00 h/d	578.160 kWh/a
Dewatering		0,00 Wh/kgTS		0 kWh/a

Yearly total Power Consumption: 3.538.505,00 kWh/a

Spec. Costs: 0,100 EURO/kWh

**Yearly Costs: 353.850,50 EURO/a**

6.2 Sludge Removal

**Grit Volume**

Spec. Grit Yield: 12,00 l/(P\*a)  
 Yearly Grit Yield: 1.380,00 m<sup>3</sup>/a  
 Spec. Removal Costs: 100,00 EURO/m<sup>3</sup>  
 Yearly Removal Costs: 138.000,00 EURO/a

**Grease Volume**

Spec. Grease Yield: 6,00 l/(P\*a)  
 Yearly Grease Yield: 690,00 m<sup>3</sup>/a  
 Spec. Removal Costs: 100,00 EURO/m<sup>3</sup>  
 Yearly Removal Costs: 69.000,00 EURO/a

**Total yearly Grit and Grease Removal Costs: 207.000,00 EURO/a**

### **Sludge Removal**

Concentration of Dry Solids thickened: 320,00 kg/m<sup>3</sup>  
Yearly Quantity of Primary Sludge: 1.469.125,00 kg/a  
Yearly Excess Sludge Quantity: 1.772.144,00 kg/a  
  
Yearly Sludge Yield (total): 3.241.269,00 kg DS/a  
10.128.97 m<sup>3</sup>/a  
11.648,31 t/y of sludge (22 % DS)  
  
Spec. Removal Costs: 60,00 EURO/m<sup>3</sup>  
Yearly Removal Costs: 698.898,93 EURO/a

**Total yearly Sludge Removal Costs: 698.898,93 EURO/a**

### 6.3 Sludge digestion

Yearly total Power Consumption: 542.244,00kWh/a  
  
Spec. Costs: 0,100 EURO/kWh  
  
**Yearly Costs: 54.224,40 EURO/a**

### 6.4 Phosphorus Removal

Yearly Precipitant Consumption: 802,44 m<sup>3</sup>/a  
Spec. Precipitant Costs (40% FeCl<sub>3</sub>): 100,00 EURO/m<sup>3</sup>  
  
**Yearly Precipitant Costs: 80.244,00 EURO/a**

### 6.5 Staff Costs

Yearly Costs for one Person: 16.570,00 EURO/Person  
Number of Persons: 11,0 Persons  
Daily Working Time of one Person: 8,00 h/d  
  
**Yearly Staff Costs: 182.270,00 EURO/a**

### 6.6 Summary of O&M costs for WWTP and mechanical dewatering

Energy Costs: 353.850,50 EURO/a  
Grit and grease Removal: 207.000,00 EURO/a  
Sludge Removal: 698.898,93 EURO/a  
Sludge digestion 54.224,40 EURO/a  
Phosphorus Removal: 80.244,00 EURO/a  
Staff Costs: 182.270,00 EURO/a

<b>Total Costs of all Positions:</b>	<b>1.576.487,83 EURO/a</b>
<b>6.7 Energy Production (optional)</b>	
Payment for Power Input:	0,060 EURO/kWh
Enhanced Payment for Power Production:	0,015 EURO/kWh
Payment for Heat:	0,030 EURO/kWh
Yearly Electricity Production:	1.902.209,00 kWh/a
Yearly Heat Production:	2.882.135,00 kWh/a
Yearly Reception out of current Production:	142.665,70 EURO/a
Yearly Reception out of Heat Production:	86.464,05 EURO/a
<b>Total Reception:</b>	<b>229.129,70 EURO/a</b>
Spec. Reception:	1,99 EURO/E/a