

NATIONAL SLUDGE MANAGEMENT STRATEGY AND IMPLEMENTATION PLAN

1.6 Background Considerations to Wastewater Treatment

The future implementation of the NSMS in the Republic of Serbia will be based on the enforcement of Council Directive 91/271/EEC for Urban Waste Water Treatment (UWWTD) and sets out additional requirements for future WWTP design.

Future WWTP design and the upgrade of existing WWTP's shall include major requirements in order to reflect state of the art process technology, concerning:

- Reduced sludge production;
- Phosphorous recovery;
- Energy efficiency;
- Advanced sludge treatment.

It should be noted that the aforementioned requirements are closely related and may be realized step by step during the life-cycle of newly designed and completed WWTP's and shall be considered for upgrade and rehabilitation of existing WWTP's.

1.6.1 Reduce Sludge Production

Sludge production (primary sludge + waste activated sludge) is mainly dependant on the adopted wastewater and sludge treatment process technology.

- Primary sludge (PS) production depends on the required wastewater treatment efficiency, i.e. whether primary treatment is applied for secondary treatment or tertiary treatment at big WWP's;
- Secondary or WAS production depends on the biological treatment process, i.e. application of the attached growth or suspended growth process, or combinations thereof;
- Digested sludge production depends on the degradation efficiency of the sludge stabilization process and potential process optimisations.

For the purpose of *minimized primary sludge production* primary sedimentation (PS) shall be applied only in case anaerobic digestion is planned for sludge treatment. In such case it should be planned for maximized separation efficiency ($SRT \geq 2,5$ h) in case of secondary treatment and as coarse Sedimentation ($SRT \leq 0,5$ h) or COD-exfiltration⁵⁰ in case of tertiary wastewater treatment in order to maintain the readily, soluble COD fraction for biological treatment.

Reduction of *secondary & tertiary sludge production* (WAS) can be achieved by consideration of the attached growth process for secondary wastewater treatment (TF¹⁶, RBC) and by combinations of the suspended growth process (such as CAS) with the attached growth process in case of tertiary wastewater treatment. Such combinations include advanced wastewater treatment process variants of MBBR¹⁵, IFAS¹⁷ or Nereda¹⁸. In addition, it should be highlighted that multi-stage

⁵⁰ Exfiltration of the inert, non-dissolved COD-fraction by micro-sieves (<http://www.huber.de/huber-report/ablage-berichte/screens/huber-supplies-a-process-system-as-replacement-for-the-primary-settling-tank.html>)

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treatment processes, such as step-feed (cascade) or the modified multiple step Bardenpho process are more efficient at lower WAS production due to the cascade effect.

The review of different feasibility studies for ongoing WWTP projects, i.e. the cities of Cacac, Nis, Pomoravlje, Raska or Zrenjanin, concerning the proposed wastewater treatment process for BNR (biological nutrient removal, acc. Art. 4 of the UWWD) shows that in most cases the simple process of conventional, single stage activated sludge (CAS) for BNR, in acc. with the “plug flow” or A^2O process or SBR process, were recommended for biological wastewater treatment. WAS production acc. Abbildung 4-1.

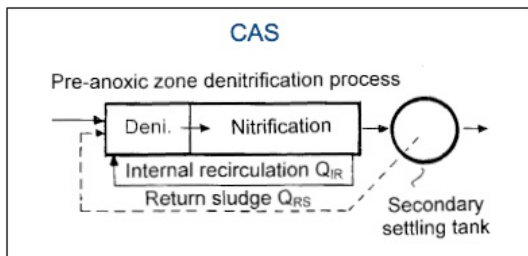


Abbildung 1-73 Flow chart for CAS for BNR in accordance DWA-A 131

More advanced wastewater-treatment options for reduced WAS-production are presented by the following flow-charts, based on the activated sludge process or combinations of the suspended growth and attached growth process applications.

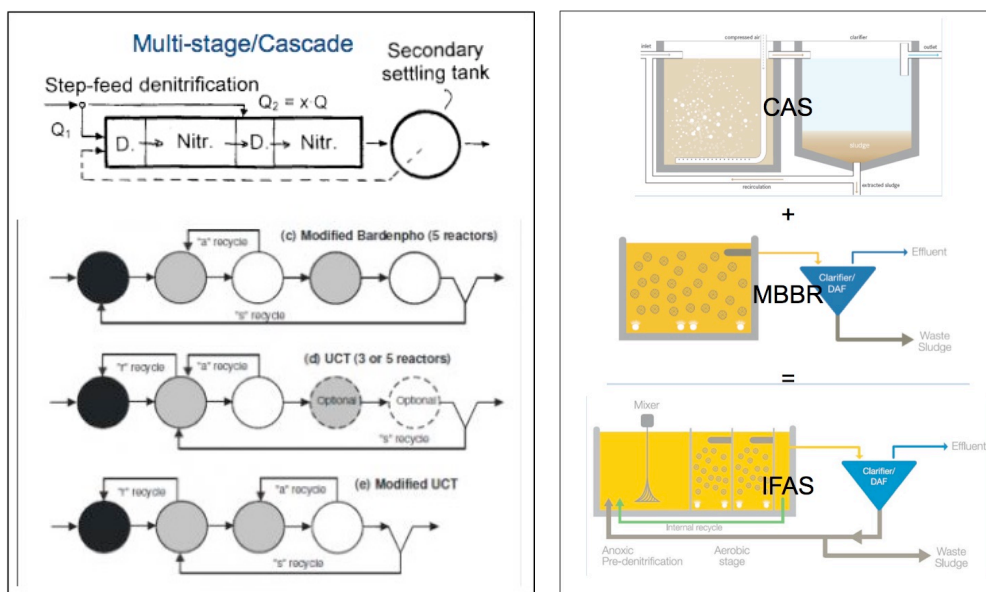


Abbildung 1-74 Flow chart for multi-stage process for BNR and IFAS process

The specific WAS production will be reduced due to the adapted biocenosis of multi-stage treatment processes or due to attached growth at MBBR and IFAS. Compared with single-stage CAS an overall reduction of the WAS production in a range of 5-20 % can be assumed⁵¹, depending on the adopted process variant.

The principles for *digested sludge reduction* are mainly targeting on *disintegration* of WAS and/or DS in order to enhance hydrolysis of nutrients and organic carbon (COD) which are enclosed in the cell membranes of the organic matter (VDS). Thus, increasing the efficiency of VDS-decomposition by some 10-30 % which results in reduced SRT (HRT, digestion time) and increased digester gas production. The additional positive effects of sludge disintegration on the entire WWTP process

⁵¹ <https://www.iwapublishing.com/news/reduction-sludge-production-wastewater-treatment-plants>

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are detailed in chapter **xxxx**. However, sludge disintegration may increase the power demand of the activated sludge system due to increased back-charge from sludge water and supernatant which is balanced by the increased digester gas production.

More advanced processes options may consider hydrothermal oxidation (**HTC**) or combinations of mesophil anaerobic digestion with thermophilic aerobic digestion as well as 2-phase (high-rate) anaerobic digestion.

In addition, the final sludge quantity could be reduced by post-degradation of residual organic matter by sludge humification and composting. Sludge humification in reed beds shall be considered as additional process stage for small WWTP's because long-term storage will furthermore reduce the organic matter of digested sludge and significantly reduce the sludge volume.

The reduction potential of the overall specific digested sludge production by application of modern, commonly approved process technology can be achieved by combinations of the attached & suspended growth process variants for biological wastewater treatment as well as far reaching application of anaerobic sludge digestion combined with sludge disintegration.

The following graph illustrates the recommended range of application of different sludge treatment technologies:

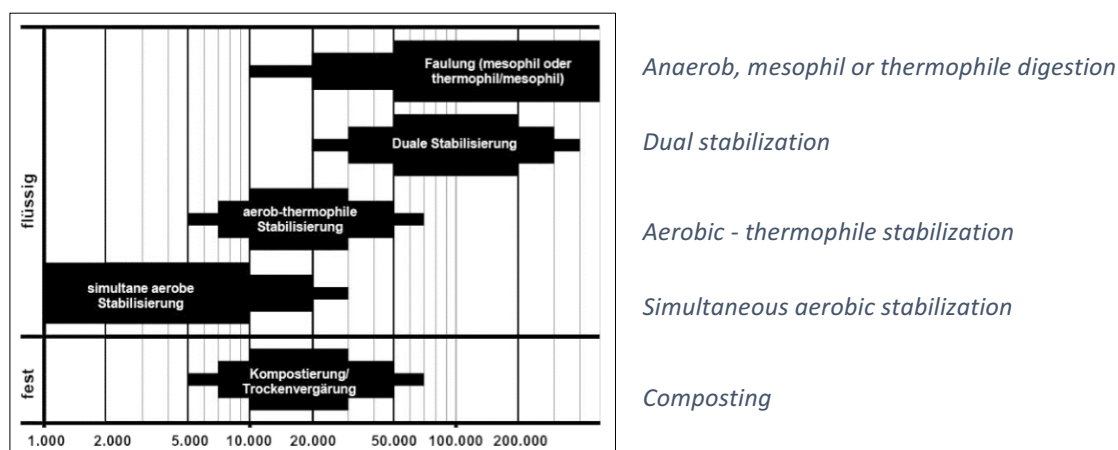


Abbildung 1-75 Recommended applications for sewage sludge stabilization (y – solid/liquid; x – P.E.) acc. DWA-M368

The review of the available feasibility studies for ongoing WWTP projects in the Republic of Serbia shows that mainly conventional sludge treatment process options for simultaneous aerobic sludge stabilization by extended aeration and single-stage anaerobic sludge digestion (with biogas utilization by CHP) are considered.

The Consultants shall be encouraged to consider modern, state of the art process technologies for both, wastewater and sludge treatment process technology in order to reduce the specific sludge production as far as possible.

1.6.1.1 Phosphorous Recovery

The main potential sources for P-reclamation from sewerage sludge are raw secondary & tertiary sludge (WAS), digested liquid sludge, dewatered sludge and its supernatant as well as dry sludge and sludge-ash (in case of mono-incineration).

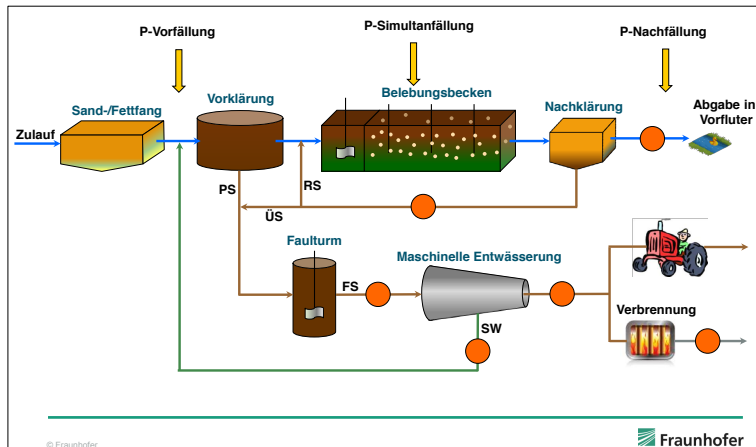


Figure: Potential reclamation sources

Various process technologies have been evolved in recent years which are in the commercial phase, now. Two main technologies are available:

- P-extraction from the liquid phase, and
- P-recycling from sludge ash.

The NSMS requires ultimate consideration of Phosphorus recovery options for WWTP design due to the fact that the access to this resource, which is most essential for future agricultural production, must be assured for the next generation!

- The wastewater treatment process options shall consider P-removal (EBPR + CPR);
- Sludge treatment shall consider future process options for P-reclamation from liquid sludge (i.e. space reservations and possibility to be included into the process);
- Sludge management and disposal shall avoid the loss of Phosphorous requiring mono-land-fill of dried sludge or sludge ash;
- Inter-regional (inter-communal) sludge incineration facilities with P-recovery from ash shall be considered on the long term.

Phosphorous recovery at the WWTP will reduce the final sludge quantities accordingly (by some 5 %) and is ultimately required for the next generation in order to make sure today's crop rates!

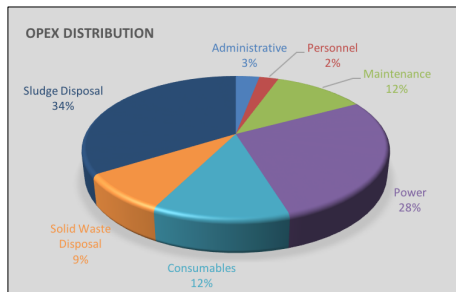
Future provisions for P-recovery shall be discussed by the new feasibility studies in order to consider future applications for the adopted process variants (consider space reservations) and in order to raise public awareness.

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1.6.1.2 Energy Efficiency and OPEX

Power consumption for wastewater and sludge treatment as well as sludge disposal costs are usually the major cost factors of OPEX for an individual WWTP and therefore the main cost factors for determination of the water tariff.

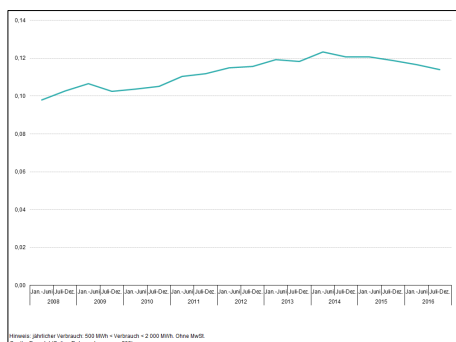


In the project area, the annual costs for sludge disposal are almost equal to annual power costs and may reach 50-60 % of the total WWTP-OPEX.

(Example 235.000 P.E.: CAS with anaerobic digestion and CCHP; dewatered sludge to mono-incineration at WWTP with ash-disposal to landfill).

Abbildung 1-76 OPEX Distribution

Power costs are depending on the specific power consumption of the wastewater treatment process whereas sludge treatment and disposal costs are depending on the specific sludge production of the individual WWTP.



In Serbia, the power market has been fully liberalized but future privatization should be taken into consideration with regard on the enormous investments necessary for network modernization and replacement of outdated power plants.

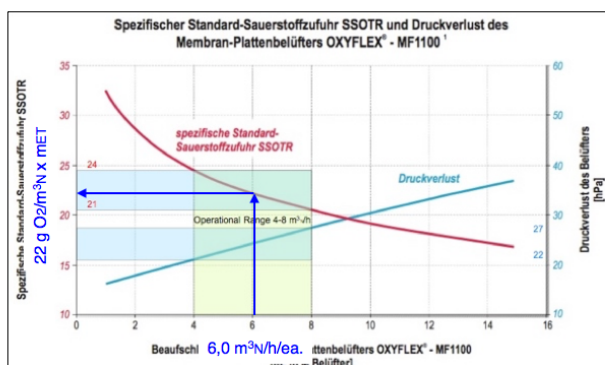
During an 8-year horizon the average industrial power costs increased by approx. 20 % on EU average.

Abbildung 1-77 Average cost for industrial power in EU (Source: Eurostat

It can be assumed that current power tariffs for both private households and industrial consumers will increase during the project horizon in a similar manner, which justifies consideration of energy efficiency measures for WWTP design.

Improvement of energy efficiency targets on the efficiency of the aeration system as well as on the benefit of self-generated (electrical) power after anaerobic, mesophilic sludge digestion.

At a conventional WWTP (CAS/SBR) the aeration system of the activated sludge system (blowers with membrane aerators or surface aerators) is the biggest consumer which causes approx. 60-70 % of the total power consumption.



Optimization shall consider multiple stage process variants and application of high efficient aeration systems ($OTE \geq 3,5 \text{ kg O}_2/\text{kWh}$).

Plate-type aerators with a specific oxygen intake capacity of $SSOTR \geq 22-25 \text{ g O}_2/\text{m}^3 \text{ N} \times \text{mET}$ [at $4-8 \text{ m}^3/\text{h/ea.}$] shall be applied in order to increase the efficiency of the aeration system.

Abbildung 1-78 SSOTR of the aeration system (Supratec)

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Optimised specific digester gas production (gas yield) is required for high efficient utilization of digester gas reuse for energy & heat recovery by CHP/CCHP⁵². The average specific power potential is approx. 15 kWh/P.E./yr. for conventional sludge digestion plants and up to 25 kWh/P.E./yr. for future conception of WWTP's.

As an example, it should be noted that during summer month excess heat, which is neither used for raw sludge heating or thermal sludge drying, and which is usually wasted by the emergency coolers of the CHP-engines, might be utilized for cold production by absorption chillers (CCHP, trigeneration) in order to provide cooling energy for the entire air-conditioning system of the WWTP (PLC/MCC'S and buildings).

The following graph illustrates the average power demand for wastewater treatment and provides an overview about the specific power consumption based on DWA-benchmarking.

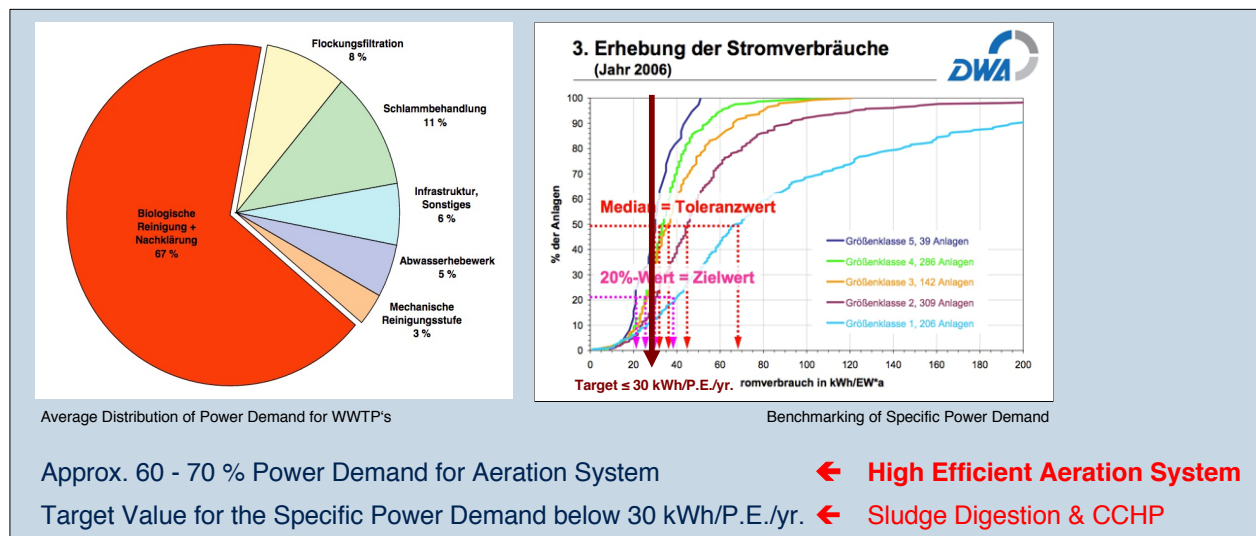


Abbildung 1-79 Average power demand for wastewater treatment and specific power consumption

The specific power demand for new WWTP's shall target on less than 25-30 kWh/P.E./yr. (Germany $\leq 23,5$ kWh/P.E./yr.).

Current developments in the process engineering industry promote the application of separate anaerobic digestion more widely, also for small WWTP's (≥ 10.000 P.E.). The DWA themed edition T1/2015⁴⁷ provides in deep technological and economic assessment of the topic as well as case studies from recent years.

Besides increased treatment performance and optimized energy efficiency the OPEX are significantly reduced, furthermore the carbon footprint of wastewater treatment is minimized.

In comparison with the process of anaerobic digestion the process of aerobic sludge stabilization requires a higher sludge age⁵³ and additional aeration capacity⁵⁴ for separate or simultaneous aerobic sludge stabilization. By application of anaerobic digestion, the bioreactor volume and power consumption (for aeration) will be significantly reduced.

⁵² CCHP - Trigeneration | Combined Heat Power Cooling (<https://www.clarke-energy.com/gas-engines/trigeneration>)

⁵³ $SRT_{aerob} = 22-25$ days instead of $SRT_{anaerob} = 10-15$ days

⁵⁴ BOD_{Load} appr. 2,5 kg DO/kg BOD_5 instead of 1,2 kg DO/kg BOD_5

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Self-generated power from digester gas utilization (CHP/CCHP) might reduce the overall specific power demand from some 60 kWh/P.E./yr. to less than 30 kWh/P.E./yr.

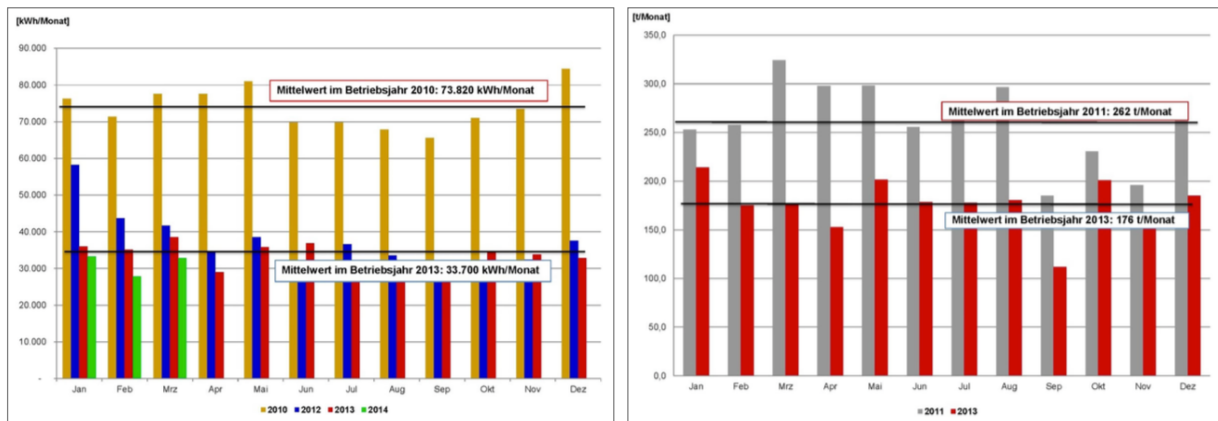


Abbildung 1-80 Drop of annual power consumption and sludge cake production after change from aerobic to anaerobic digestion for 28.800 P.E. design capacity, acc. DWA T1/2015, A.1.

For case study A.2 from DWA T1/2015 the total power demand could be reduced by more than 50 % after the process modifications in 2010.

The spec. sludge production decreased from 70 g DS/P.E./d to 45 g DS/P.E./d improving the de-waterability of the digested sludge at reduced flocculation aid consumption, reducing the transportation and disposal costs, accordingly.

The following pictures are showing compact solutions comprising ready-made digesters with integrated gas-storage:



Abbildung 1-81 Thickener & anaerobic digester with integrated gas holder (Source: www.lipp-system.de) and open digester with membrane covered gas-holder (Source: <http://www.mifratris.de>)

Based on the aforementioned developments WWTP design for new wastewater treatment plants shall consider anaerobic digestion with digester gas utilization for design capacities above 30.000 P.E. and below. Commonly approved technology is available at competitive market price.

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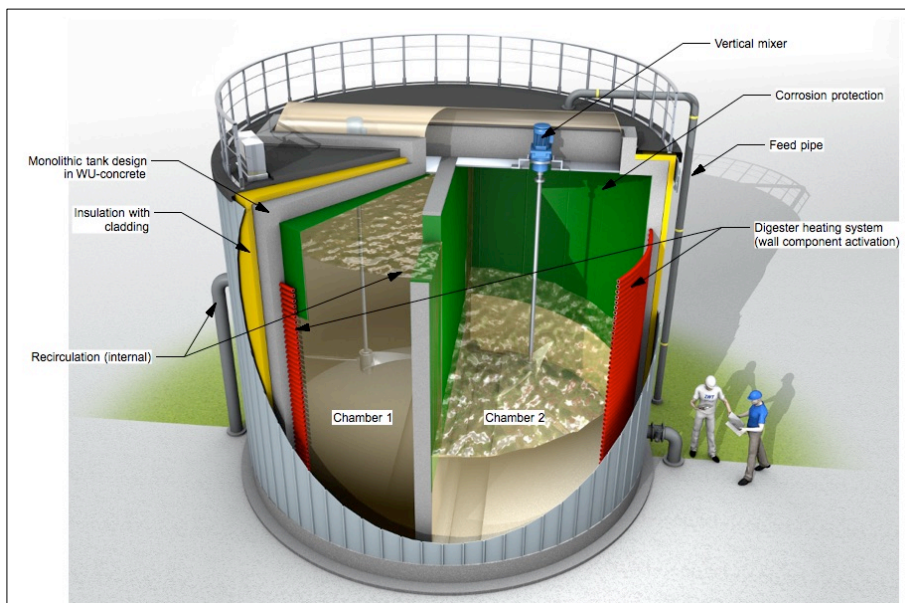
The following presents an example of a modern WWTP design (10.000 P.E.) designed for tertiary wastewater treatment, using the well-established Biocos® process⁵⁵ (modified SBR) for waste-water treatment and separate anaerobic sludge digestion with digester gas storage and power recovery by CHP.



Animation of a Biocos® WWTP design proposal.

*Abbildung 1-82 Layout
WWTP 10.000 E.W. with
separate anaerobic digestion*

The operation building, comprising administrative areas, mechanical treatment and sludge dewatering with lateral sludge storage area can be seen in the foreground. The blower house with generator room and the anaerobic sludge digester with gasholder are seen in the upper background, whereas the Biocos® bioreactors with sludge storage, intermediate pumping station and batch operated clarifiers are seen in the center background.



Anaerobic digester with twin-chamber, slow motion mixers and thermal wall component activation for digester heating.

Abbildung 1-83 Compact digester system design (Source: <http://www.zwt.de/leistungsbereiche/schlamm>)

The specific power consumption of the WWTP is calculated with less than 20 kWh/P.E./yr. and the specific digested sludge production is approx. 45 g DS/P.E./d.

⁵⁵ <http://www.zwt.de> and <http://www.hafi-group.com/en/technologies/overview.html>

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1.6.1.3 Wastewater Treatment Plant of the Future

The carbon footprint (GHG) of wastewater and sludge treatment can be minimized by reduction of the specific power consumption which requires far reaching self-supply of electricity and heat produced by CHP and/or CCHP from digester gas utilization.

Besides various options for wastewater treatment process optimization concerning raw *sludge production* and far reaching application of *anaerobic sludge treatment* processes an additional process for pre-treatment of feed sludge or recirculation sludge by *sludge disintegration* shall be applied for middle sized and bigger WWTP's. Such type of WWTP's will have a higher power demand due to future sludge drying requirements.

Current research for future and advanced WWTP conception⁵⁶ targets on digester gas yield optimization due to side stream reject water (supernatant) treatment by deammonification⁵⁷ with MAP⁵⁸ precipitation, or stripping of Ammonia (NH₃) which significantly reduces the power requirement of biological wastewater treatment. Ongoing research concerns substitution of Ammonia removal from the conventional process of Nitrification/Denitrification with the process of Deammonification in order to minimize the WWTP footprint, overall power consumption at reduced WAS production (IFAS, MBBR, Nereda) but increased digester gas production for high energy recovery. However, full-scale implementation of such advanced process variants in Serbia is not expected in the near future but should be taken into consideration for big WWTP's which might be subject to phased implementation.

The following shall be considered for WWTP design:

- Anaerobic selector for WAS sludge feed (digester) plus separate WAS thickening;
- Intensified, anaerobic, mesophil sludge digestion for WWTP's ≥ 30.000 P.E. with digester gas utilization by CHP;
- Intensified, anaerobic, mesophil (or thermophile) sludge digestion for WWTP's ≥ 60.000 P.E. with digester gas utilization by CCHP;
- Sludge disintegration for WWTP's ≥ 100.000 P.E., thermal disintegration or thermal hydrolysis and in case sludge disinfection is required;
- Multi-stage, intensified, anaerobic, mesophil (or thermophile) sludge digestion for WWTP's ≥ 250.000 P.E. with sludge disintegration and separate supernatant treatment (Anammox⁵⁹) after COD-exfiltration, with digester gas utilization by CCHP;

The following graphs present the COD and mass balance of sludge treatment which illustrates the optimization potential for future WWTP design that shall be considered for the design of big WWTP's ≥ 250.000 P.E. in the Republic of Serbia:

⁵⁶ Final Report "Wastewater Treatment Plant of the Future", Chair of Urban Water Management TU München, 2009

⁵⁷ <https://www.essde.com/en/demon/demon-process>

⁵⁸ MAP = Magnesia-Ammonium-Phosphate (NH₄MgPO₄·6H₂O) = Struvite

⁵⁹ De-Ammonification: <https://www.sswm.info/water-nutrient-cycle/wastewater-treatment/hardwares/semi-centralised-wastewater-treatments/anammox>

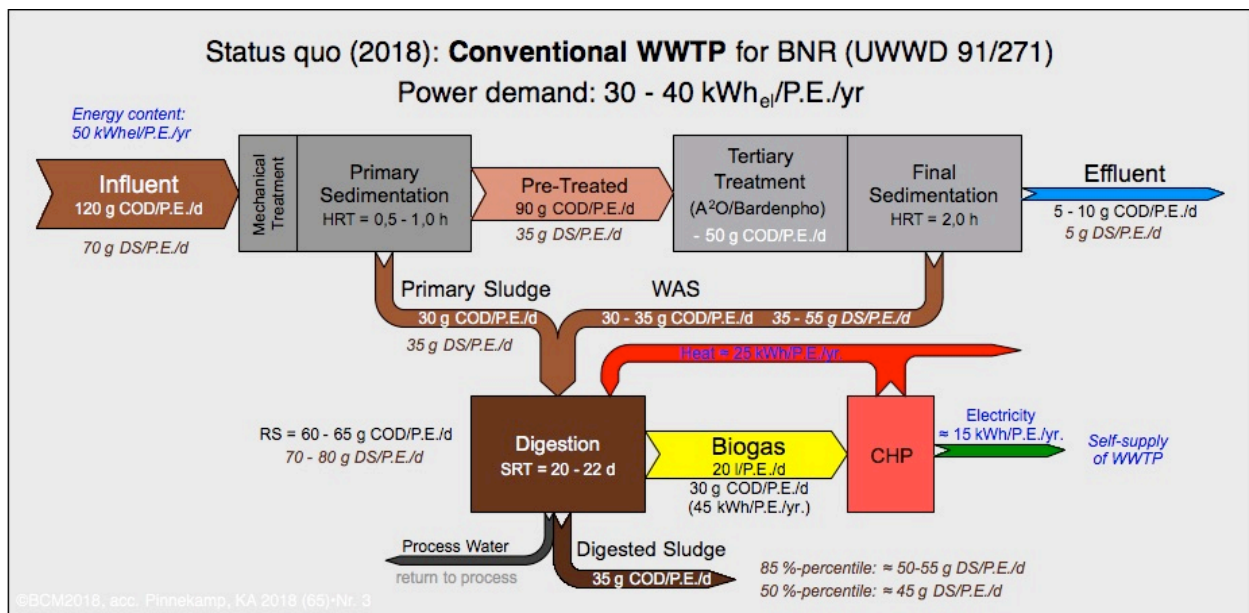


Abbildung 1-84 Mass balance for conventional sludge treatment (Source: Pinnekamp, KA 2018 (65), Nr. 3)

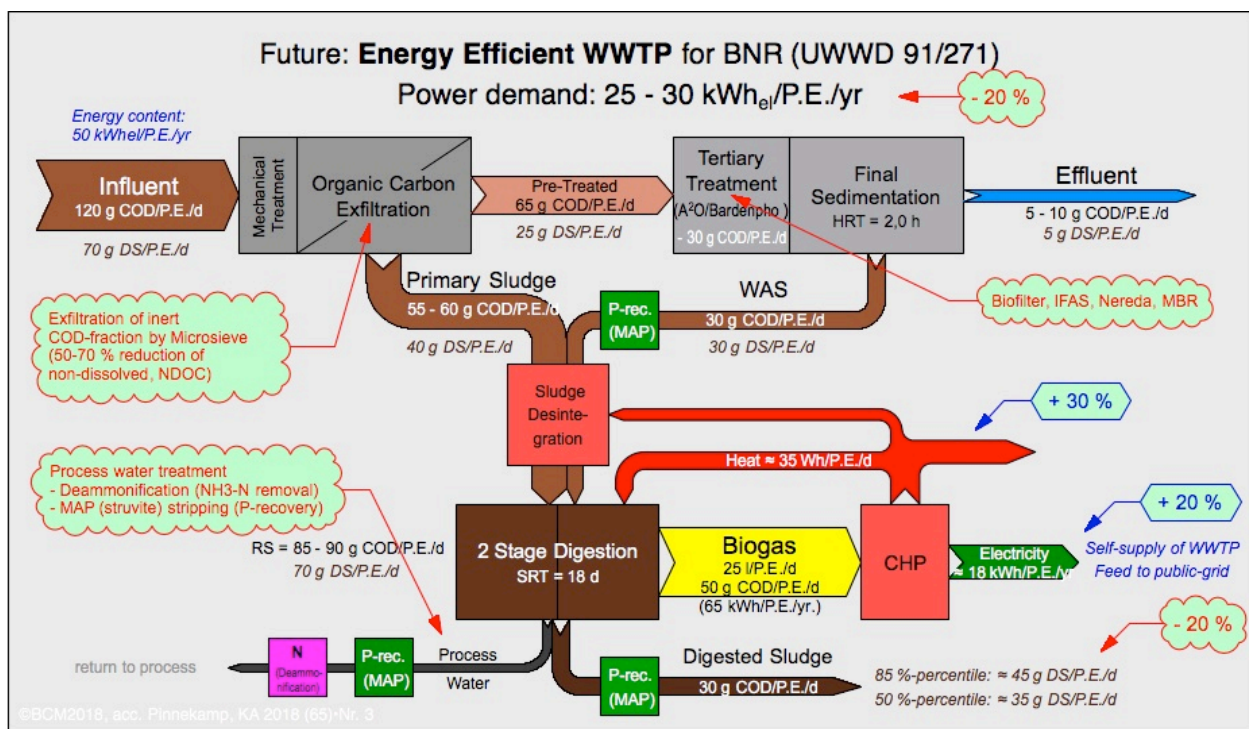


Abbildung 1-85 Mass balance for optimized sludge treatment (Source: Pinnekamp, KA 2018 (65), Nr. 3)

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1.6.1.4 Requirements for WWTP Design

In order to comply with the NSMS newly designed WWTP's shall consider state of the art process technology and latest developments and tendencies concerning sludge treatment and sludge management in market leading EU-Member States, which are summarized as follows:

Secondary wastewater treatment (≤ 10.000 P.E.):

- Conservative determination of design capacity;
- Primary sedimentation in case of attached growth with anaerobic digestion;
- Attached growth or MBBR for secondary wastewater treatment in multi-lane application;
- High efficient aeration systems (plate type diffusers, SOTE $> 3,5$ kg O₂/kWh) for the activated sludge process;
- IT based monitoring of power consumption of individual process steps (energy efficiency, set-point control);
- Disinfection of purified effluent (see multi-resistant-germs);
- Anaerobic, mesophilic sludge digestion with digester gas utilization by CHP (simple commercial system solutions) in case of attached growth (with pre-sedimentation);
- Extended aeration for simultaneous sludge stabilization (in case of activated sludge);
- Sludge thickening and post treatment in reed beds, if land is available;
- Liquid sludge transport to inter-communal STC⁶⁰ for sludge dewatering and advanced sludge treatment (≤ 5.000 P.E.);
- Sludge dewatering and transport to inter-communal STC for advanced sludge treatment (sludge drying, etc.).

Tertiary wastewater treatment (> 10.000 P.E.):

- Conservative determination of design capacity;
- Primary sedimentation or COD-exfiltration for tertiary treatment (BNR);
- Bio-P (EBPR), pre-applied (plus CPR);
- Anaerobic selector for return sludge (RAS) feed;
- Multi-lane and multi-stage (step-feed) process for biological wastewater treatment (BNR) by the activated sludge process;
- Optional upgrade for capacity extension by IFAS/MMBR (approx. + 30 % P.E.);
- High efficient aeration systems (plate type diffusers, SOTE $> 3,5$ kg O₂/kWh) with fuzzy logic process control;
- IT based monitoring of power consumption of individual process steps (energy efficiency, set-point control);
- Disinfection of purified effluent (see multi-resistant-germs);

⁶⁰ STC - Sludge Treatment Center providing sludge drying plus pyrolysis or mono-incineration.

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- Anaerobic selector for WAS sludge feed (digester) plus separate WAS thickening;
- Extended aeration for simultaneous sludge stabilization for design capacities ≤ 20.000 P.E. with sludge reed beds for long-term storage (and post-degradation), eventually sludge dewatering and transport to inter-communal STC for advanced sludge treatment;
- Intensified, anaerobic, mesophil sludge digestion for WWTP's ≥ 30.000 P.E. with digester gas utilization by CHP at gross-power demand of the WWTP ≤ 30 kWh/P.E./yr. and spec. sludge production ≤ 50 g/P.E./d;
- Intensified, anaerobic, mesophil (or thermophile) sludge digestion for WWTP's ≥ 60.000 P.E. with digester gas utilization by CCHP⁶¹;
- Sludge disintegration for WWTP's ≥ 100.000 P.E., thermal disintegration or thermal hydrolysis and in case sludge disinfection is required at gross-power demand of the WWTP ≤ 25 kWh/P.E./yr. and spec. sludge production ≤ 50 g/P.E./d (85 %-percentile);
- Solar or thermal sludge drying depending on WWTP design capacity and heat balance for WWTP's ≥ 30.000 P.E. (considered as STC);
- Multi-stage, intensified, anaerobic, mesophil (or thermophile) sludge digestion for WWTP's ≥ 250.000 P.E. with sludge disintegration and separate supernatant treatment (Anammox⁶²) after COD-exfiltration, with digester gas utilization by CCHP at gross-power demand of the WWTP ≤ 25 kWh/P.E./yr. and spec. sludge production ≤ 45 g/P.E./d (85 %-percentile);
- Advanced sludge treatment for dewatered sludge pyrolysis (or similar) for WWTP's ≥ 100.000 P.E. with waste gas and waste heat utilization for sludge drying (STC), granular disposal at mono-landfill (eventually direct side-stream fertilizer application);
- Advanced sludge treatment for dry sludge mono-incineration for WWTP's ≥ 250.000 P.E. with waste gas and waste heat utilization for sludge drying (STC), ash disposal at mono-landfill;
- Dry sludge or ash disposal only to mono-landfill for future P-reclamation.

The aforementioned requirements are targeting on reduced sludge, and are summarized in the following table considering the different categories and WWTP design capacities:

Cat.	Design Capacity [P.E.]	Wastewater Treatment	Sludge Treatment	Power Consumption	Sludge Disposal
a	≤ 2.000	<u>Secondary Treatment</u> Primary sedimentation (Imhoff tank); Attached growth (TF/RBC); Constructed wetland/reed.	Psychrophilic digestion (Imhoff tank)	$\leq 15-20$ kWh/P.E./yr.	Liquid sludge transport to STC; Sludge reed bed.
b	≤ 10.000	<u>Secondary Treatment</u>			

⁶¹ CCHP - Trigeneration | Combined Heat Power Cooling (<https://www.clarke-energy.com/gas-engines/trigeneration>)

⁶² De-Ammonification: <https://www.sswm.info/water-nutrient-cycle/wastewater-treatment/hardwares/semi-centralised-wastewater-treatments/anammox>

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Cat.	Design Capacity [P.E.]	Wastewater Treatment	Sludge Treatment	Power Consumption	Sludge Disposal
		Primary sedimentation in case of attached growth; Attached growth (TF/RBC); CAS or MBBR with extended aeration/without pre-sedimentation.	Mesophilic anaerobic digestion (attached growth) with CHP; Simultaneous aerobic stabilization.	≤ 35-60 kWh/P.E./yr.	Liquid sludge transport to STC; Sludge reed bed for post-stabilization.
c	≤ 50.000	<u>Secondary Treatment</u> Primary sedimentation; Attached growth (TF); CAS or MBBR. <u>Tertiary Treatment</u> Coarse Sedimentation; Bio-P (EBPR) with anaerobic selector (plus CPR); Anaerobic selector RAS CAS in multi-lane and single-stage process; Consider IFAS/MMBR.	Mesophilic anaerobic digestion with CHP; Mechanical sludge dewatering. Anaerobic selector WAS + mechanical WAS thickening; Intensified, anaerobic, mesophilic sludge digestion for WWTP's ≥ 30.000 P.E. with digester gas utilization by CHP; Mechanical sludge dewatering.	≤ 35-40 kWh/P.E./yr. ≤ 30 kWh/P.E./yr.	Dewatered sludge transport to STC; Sludge reed bed for post-stabilization. Dewatered sludge transport to STC;
d e	≤ 100.000 ≤ 150.000	Coarse Sedimentation or COD-exfiltration; Bio-P (EBPR) with anaerobic selector (plus CPR); Anaerobic selector RAS CAS in multi-lane and multi-stage process; Consider IFAS/MMBR; Consider MBR; Effluent disinfection.	Anaerobic selector WAS + mechanical WAS thickening; Intensified, anaerobic, mesophilic sludge digestion with digester gas utilization by CCHP; Sludge disintegration (≥ 100.000 P.E.); Mechanical sludge dewatering; Solar or thermal sludge drying; Sludge pyrolysis (or similar).	≤ 25 kWh/P.E./yr.	STC Dry sludge disposal to mono-landfill; Granular utilization as fertilizer.
f	≤ 250.000	Coarse Sedimentation or COD-exfiltration; Bio-P (EBPR) with anaerobic selector (plus CPR); Anaerobic selector RAS CAS in multi-lane and multi-stage process; Consider IFAS/MMBR; Consider MBR; Effluent disinfection; MAP precipitation; Separate supernatant treatment by Annamox.	Anaerobic selector WAS + mechanical WAS thickening; Intensified, anaerobic, mesophilic sludge digestion with digester gas utilization by CCHP; Thermal sludge disintegration or thermal hydrolysis; Mechanical sludge dewatering; Solar or thermal sludge drying.	≤ 25 kWh/P.E./yr.	STC/SMC Dry sludge disposal to mono-landfill; Dry sludge to mono-incineration; Granular utilization as fertilizer.

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Cat.	Design Capacity [P.E.]	Wastewater Treatment	Sludge Treatment	Power Consumption	Sludge Disposal
g	≥ 250.000	Coarse Sedimentation or COD-exfiltration Bio-P (EBPR) with anaerobic selector (plus CPR); Anaerobic selector RAS CAS in multi-lane and multi-stage process; Consider IFAS/MMBR; Consider MBR; Effluent disinfection; MAP precipitation; Separate supernatant treatment by Annamox.	Anaerobic selector WAS + mechanical WAS thickening; Sludge disintegration for WWTP's ≥ 100.000 P.E. Multi-stage, intensified, anaerobic, mesophil sludge digestion with digester gas utilization by CCHP; Mechanical sludge dewatering; Thermal sludge drying; Dry sludge mono-incineration.	≤ 25 kWh/P.E./yr.	STC/SMC Ash disposal to mono-landfill.

Abbildung 1-86 Overview WWTP design requirements, acc. NSMS

The Consultants and Contractors working on WWTP design proposals for new projects shall be encouraged to consider modern, state of the art process technologies for both, wastewater and sludge treatment in order to reduce the specific sludge production and energy consumption of the WWTP under consideration of provisions for future Phosphorous reclamation.