STEP- presentation 04.03.2021:

Effects on WWTP efficiency of reducing excess water from sewers.
Modelling Rønne WWTP on energy consumption, nutrient outflow, and sludge

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BORNHOLMS ENERGI & FORSYNING

STEP :

Sludge **T**echnological **E**cological **P**rogress - increasing the quality and reuse of sewage sludge

Project-partners

- Electrical Engineering Faculty, West Pomeranian University of Technology, Szczecin (lead);
- Goleniow Water and Sewage Compagny;
- Mittskåne Vatten, Höörs Kommun;
- Klaipeda University;
- Bornholms Energi og Forsyning (BEOF)

STEP

Interreg South Baltic

EUROPEAN UNION

BEOF = Bornholms Energy & Supply - Holding company for six utility companies

100 % owned by the municipality of Bornholm

- Bornholms Water
- **Bornholms Wastewater**
- Bornholms Heat
- Bornholms Power Production
- Bornholms Energy (Power retail)
- Bornholms Power grid

Rønne city, harbor, and Power Plant

SLUDGE TECHNOLOGICAL ECOLOGICAL PROGRESS
increasing the quality and reuse of sewage sludge

Bornholms Wastewater A/S

- Runs the public sewers and WWTPs on Bornholm
- Svaneke and Boderne WWTP: each 4.500 PE
- Nexø and Tejn WWTP: each 10.000 PE
- **Rønne WWTP: 60.000 PE –** build in 1995

Factsheet Bornholm

Population app. 40.000
Area: 589 km2
Coastline: 158 km
North to South: 40 km
East to West: 30 km
Swedish coast: 37 km
Poland: 90 km
Denmark: 135 km

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Excess water issues

Excess water is:

- Rainwater mixed with wastewater – mostly from city centers with no separation
- Groundwater that enters old sewers through cracks, and joints
- Water from drains, ditches, or small streams, that is connected by mistake, or connected before the WWTPs was build in the early 1990' (in Denmark)

Excess water issues:

- Reduces the efficiency of WWTPs - every m3 in outlet has a small concentration of nutrients, organic matter and micropollutants
- Overflow from sewer systems directly to recipient during and after heavy rain

Expected effects of reducing excess water

Before modelling we expected these effects of reducing excess water:

- Reduced total amount of N, P and BOD in outlet, proportional to reduction of excess water
- A small increase in sludge production, with increased amounts of N and P
- Reduced energy consumption, mostly for pumping and generating compressed air for aeration of the wastewater

- Effects on the amount af nitrous oxide (N_2O – ”laughing gas”) released ?

  larger Danish WWTPs must reduce the amount of N_2O release in 2025, because N_2O is app. 300 times more powerfull than CO_2 as greenhouse gas

Modelling Rønne WWTP

Objective: evaluate performance of Rønne WWTP in different scenarios, regarding:

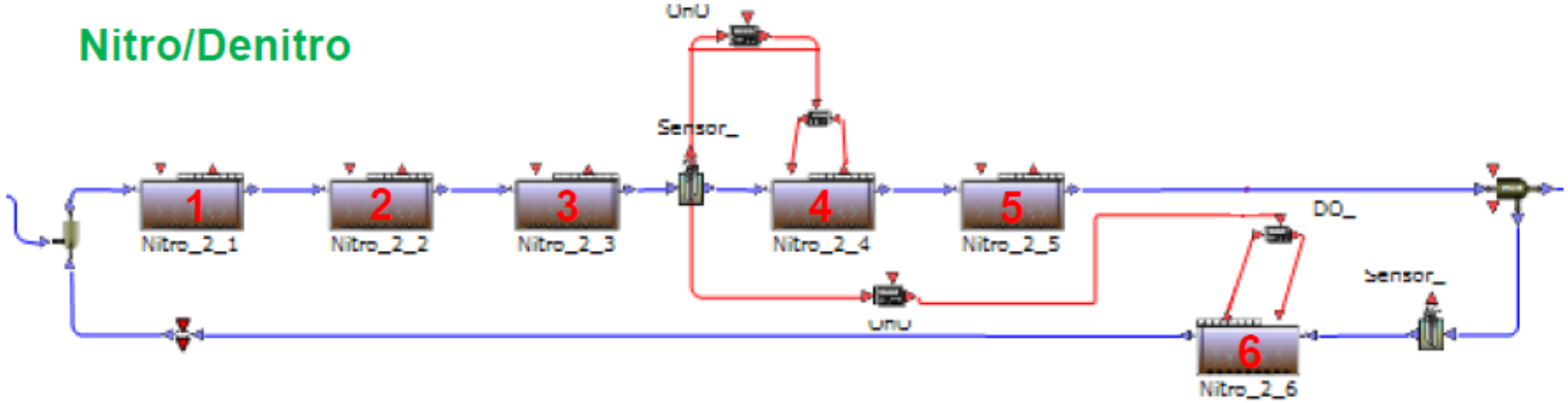
- Effluent quality (COD, N, P)
- Sludge production and composition (N, P)
- Energy use for pumping and aeration

Modelling Principles:

- Implementation of layout of Rønne WWTP in WEST (done by engineers at DHI)
- Data collection, evaluation and selection
- Characterization of influent wastewater − f*rom COD, N, P to model variables*
- Calibration of the model against measured data
- Scenario analysis − c*hanges in effluent, sludge, energy*

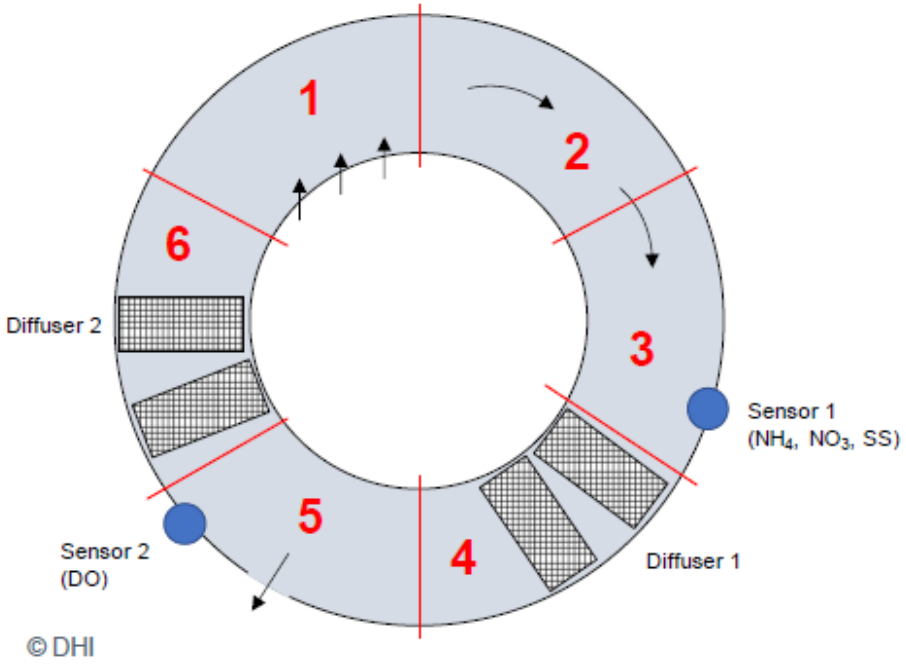
WEST layout of Rønne WWTP – Biological treatment

Nitro/Denitro



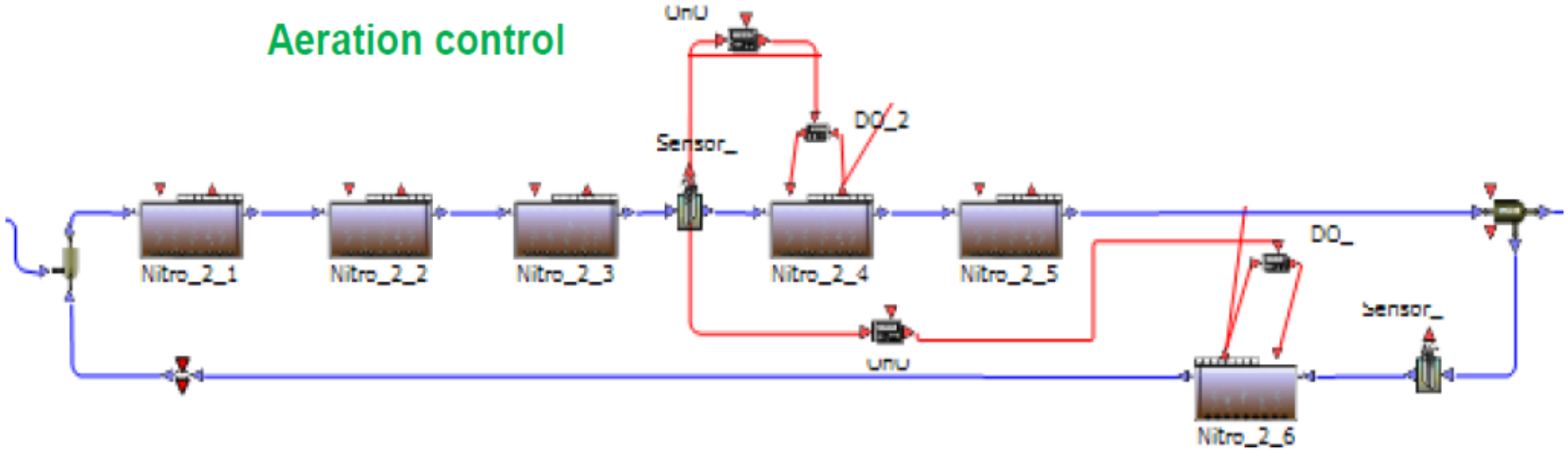
Reactor hydraulics

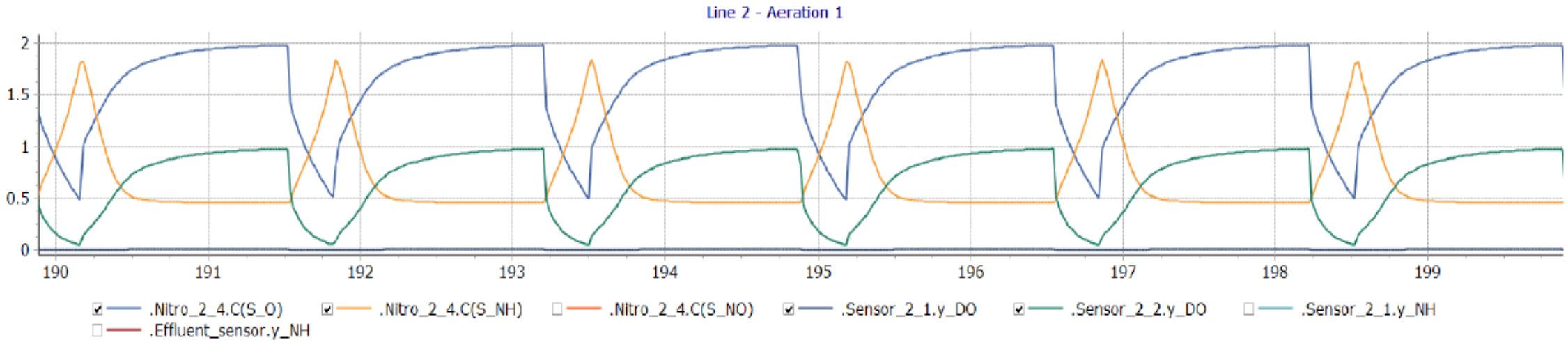
Aerated / non-aerated zones



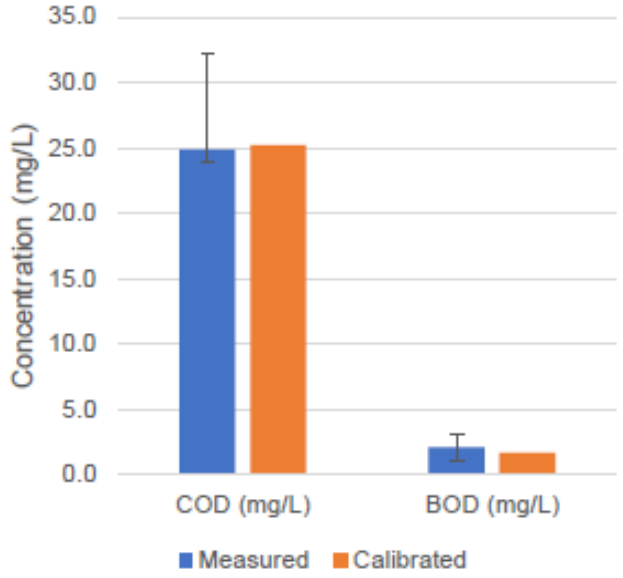
WEST layout of Rønne WWTP – Biological treatment

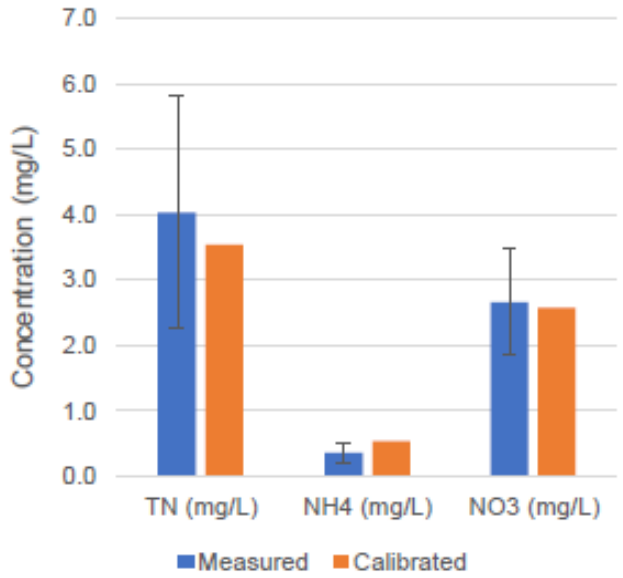
Aeration control

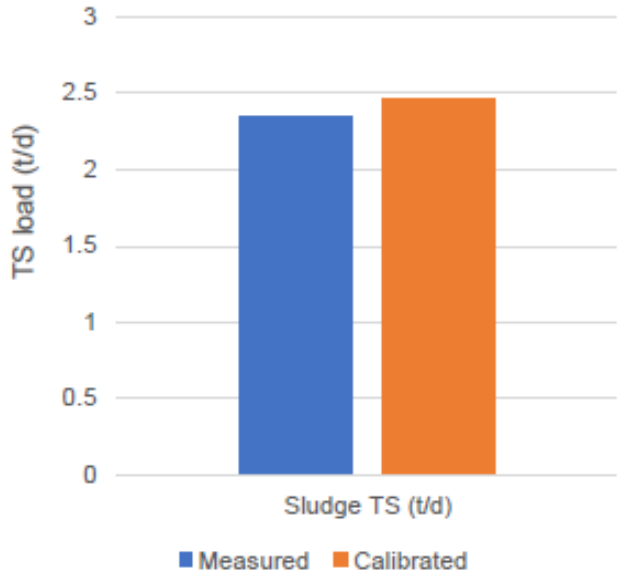


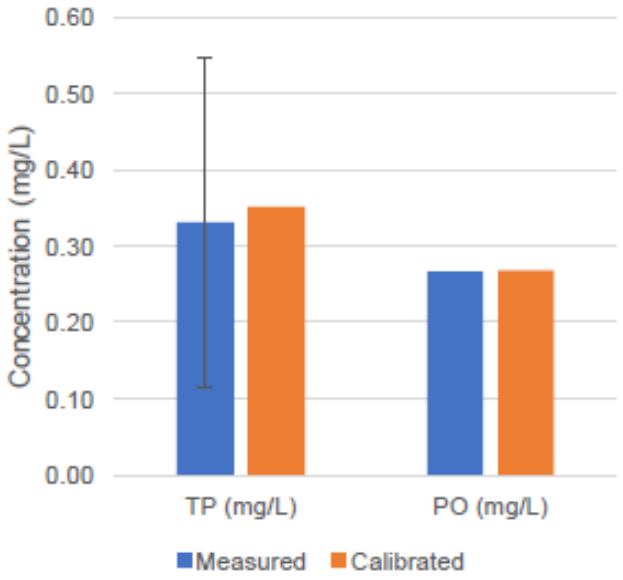


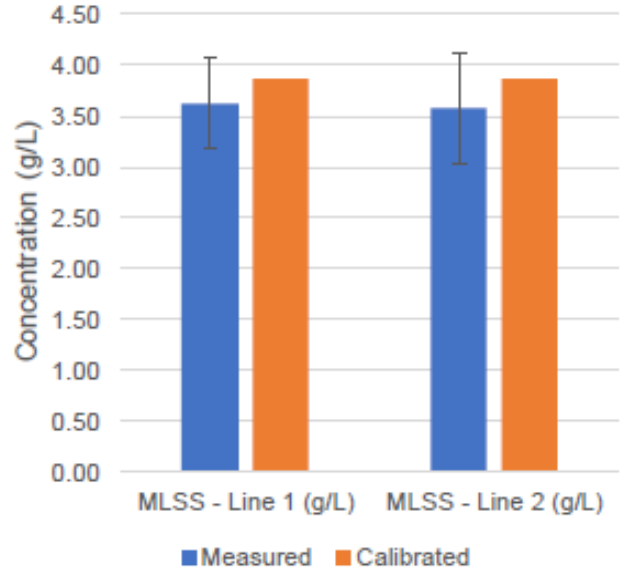
Comparison with 2018 average data



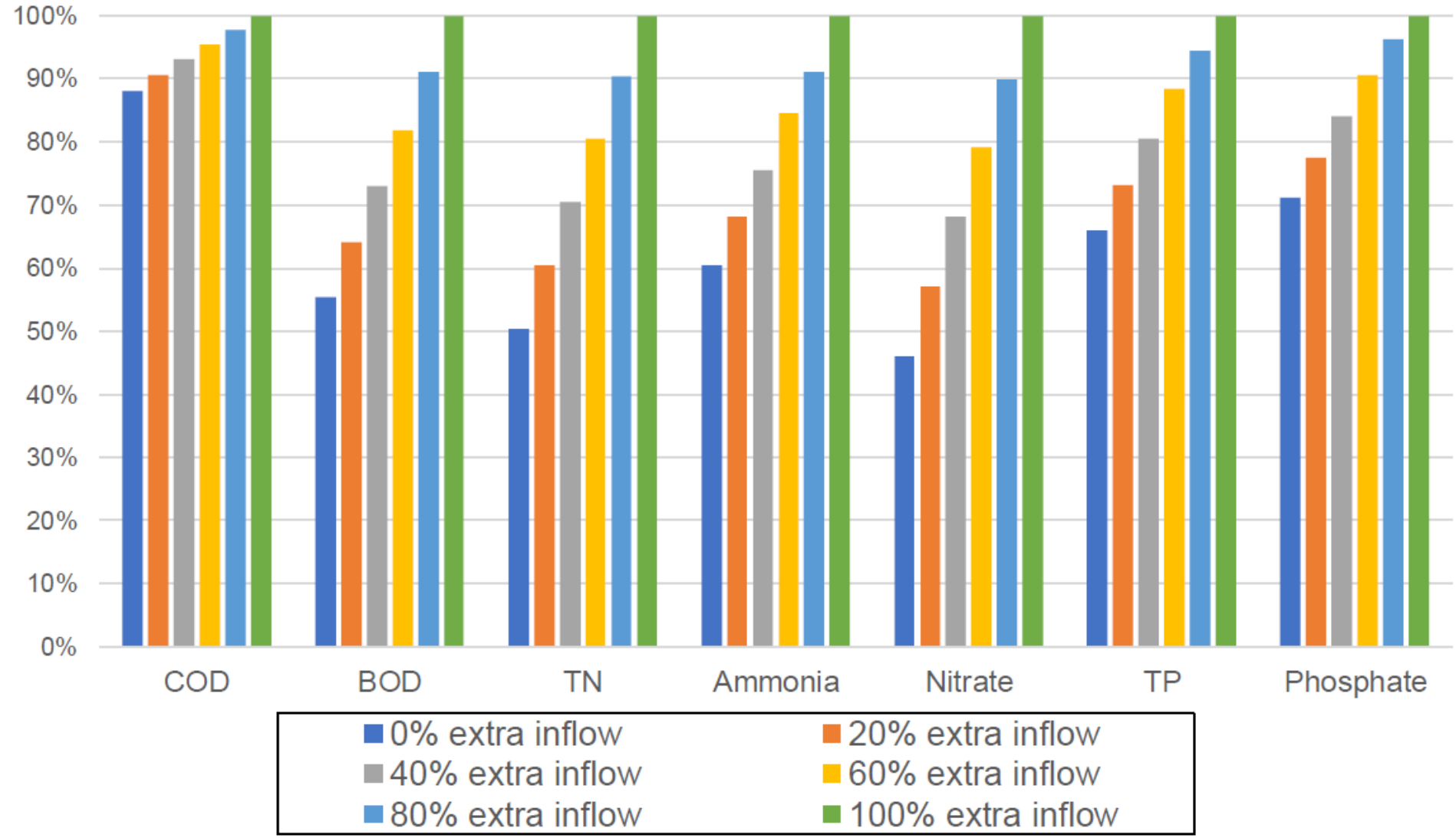








Effluent COD, N and P loads

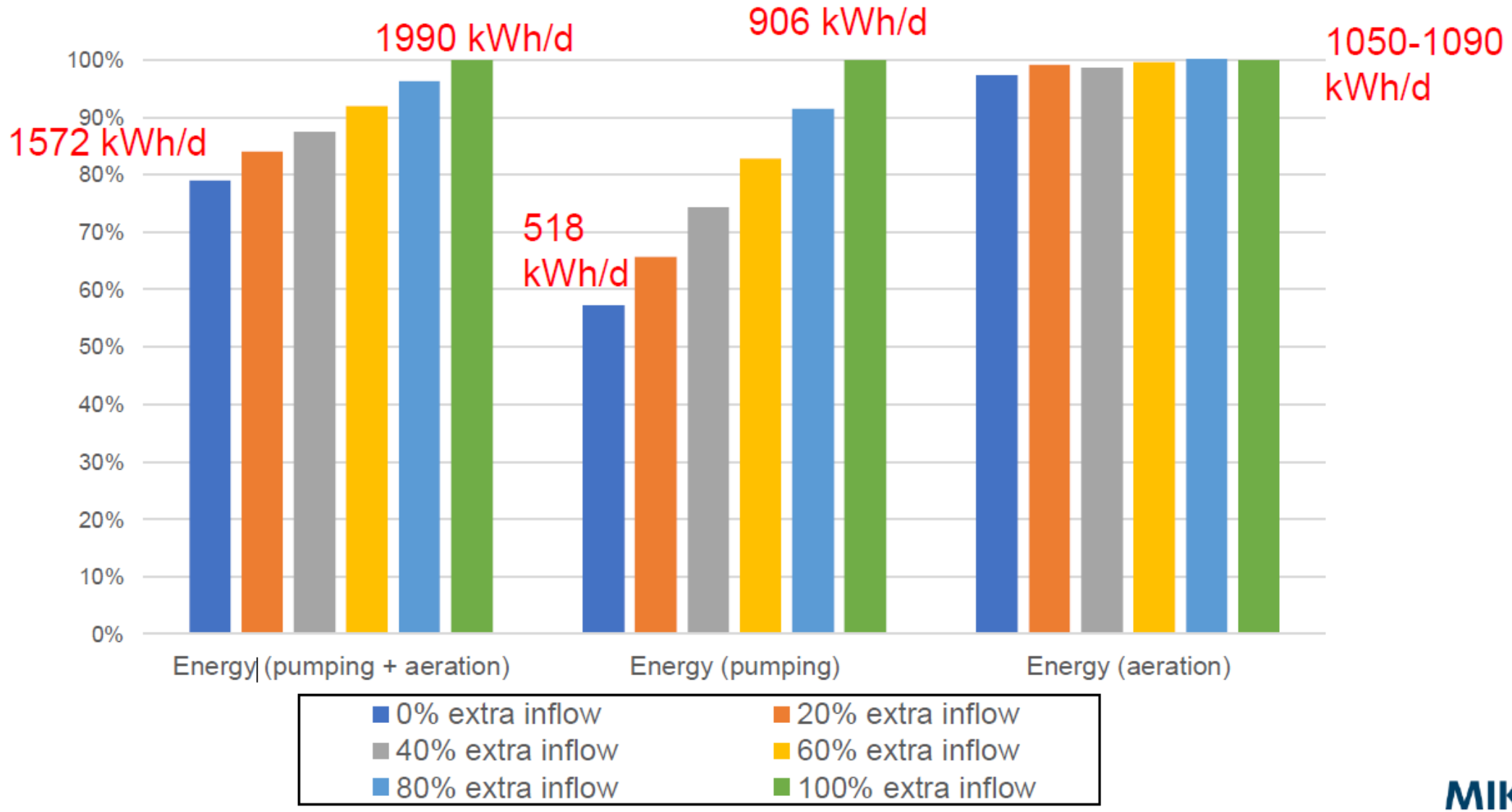


Sludge production and composition

	% extra inflow					
	0%	20%	40%	60%	80%	100%
MLSS (g/L)	4.10	4.08	4.07	4.05	4.04	4.03
Sludge production (t TS / d)	2.59	2.59	2.59	2.58	2.58	2.58
N content (% TS)	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%
P content (% TS)	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%

*Mixed liquor suspended solids (**MLSS**) is the concentration of suspended solids, in an aeration tank during the activated sludge process*

Energy consumption



Excess water reduction = cost reduction

% Excess water	0%	20%	40%	60%	80%	100%
Pumping energy	132,356 kr.	152,206 kr.	172,055 kr.	191,905 kr.	211,755 kr.	231,604 kr.
Aeration energy	269,310 kr.	274,663 kr.	272,874 kr.	275,940 kr.	277,473 kr.	276,962 kr.
Energy costs / year	**401,666 kr.**	**426,869 kr.**	**444,929 kr.**	**467,845 kr.**	**489,228 kr.**	**508,566 kr.**
Effluent tax BOD	48,542 kr.	56,184 kr.	63,894 kr.	71,604 kr.	79,786 kr.	87,541 kr.
Effluent tax N	176,270 kr.	211,603 kr.	246,863 kr.	282,075 kr.	316,739 kr.	350,353 kr.
Effluent tax P	92,332 kr.	102,335 kr.	112,575 kr.	123,602 kr.	132,189 kr.	139,859 kr.
Effluent tax costs / year	**317,144 kr.**	**370,122 kr.**	**423,332 kr.**	**477,281 kr.**	**528,714 kr.**	**577,753 kr.**
Total yearly costs	**718,810 kr.**	**796,991 kr.**	**868,261 kr.**	**945,126 kr.**	**1,017,942 kr.**	**1,086,319 kr.**
Total yearly cost reduction 100% -> 0% excess water: 34%						
Note : The effluent tax has increased by 5,5% in 2020 = 17,41 kr./kg BOD_5, 31,65 kr./kg N, 174,07 kr./kg P						

Modelling Rønne WWTP- conclusions

Eliminating all excess water (accounting for 40% of average flow today) **results in:**

- 50% reduction of **N**, and 25% reduction of **P** in effluent
- No major changes in sludge production and N, P content in sludge
- 20% reduction in energy consumption, mostly related to pumping energy
- 34% reduction in costs - energy and effluent taxes

it is estimated that every 20% step in reduction of excess water will correspond to app.:

- 9%, 10% and 7% reduction in effluent BOD, N and P, respectively
- 4% reduction in energy consumption (pumping)
- 7% reduction in costs – energy and effluent taxes

See also https://www.dhigroup.com/global/references/emea/overview/reducing-hydraulic-loading-to-maximise-efficiency

Rønne WWTP- key figures

Key figures				Rønne	WWTP	
Belastning		**2018**	**2017**	**2016**	**2015**	**2014**
Vand						
Flow	m^3	2,860,675	3,190,701	2,653,190	2,953,885	2,739,798
Excess water - estimated	m^3	1,800,000				
Rain	mm	487	806	531	741	702
Belastning						
PE (COD-based)	PE	51,902	60,445	48,210	44,989	66,856
PE (BOD-based)	PE	38,173	46,360	48,191	43,925	64,227
Influent		**2018**	**2017**	**2016**	**2015**	**2014**
Stoffer						
COD	kg	3,089,529	2,983,305	3,065,455	2,649,408	4,212,439
BOD	kg	1,051,298	1,091,752	1,375,577	1,167,921	1,849,364
Total N	kg	159,721	141,454	164,090	155,420	273,751
Total P	kg	24,101	23,000	28,491	25,290	36,805
Efluent		**2018**	**2017**	**2016**	**2015**	**2014**
Flow	m^3	2,860,675	3,190,701	2,653,190	2,953,885	2,739,798
COD	kg	71,159	65,077	52,389	60,496	69,408
BOD	kg	5,984	5,380	3,929	5,265	5,875
Total N	kg	9,655	11,141	6,876	6,558	8,334
Total P	kg	898	641	490	549	583
Purification		**2018**	**2017**	**2016**	**2015**	**2014**
COD	%	97.7	97.8	98.3	97.7	98.4
BOD	%	99.4	99.5	99.7	99.5	99.7
Total N	%	94.0	92.1	95.8	95.8	97.0
Total P	%	96.3	97.2	98.3	97.8	98.4