Ministry of Foreign Affairs of Denmark
The Trade Council

Wastewater innovation in Denmark

Water technology alliance

Jacob Vind
Head of the WTA

Ministry of Foreign Affairs of Denmark
jacvin@um.dk
+1 650-720-2642

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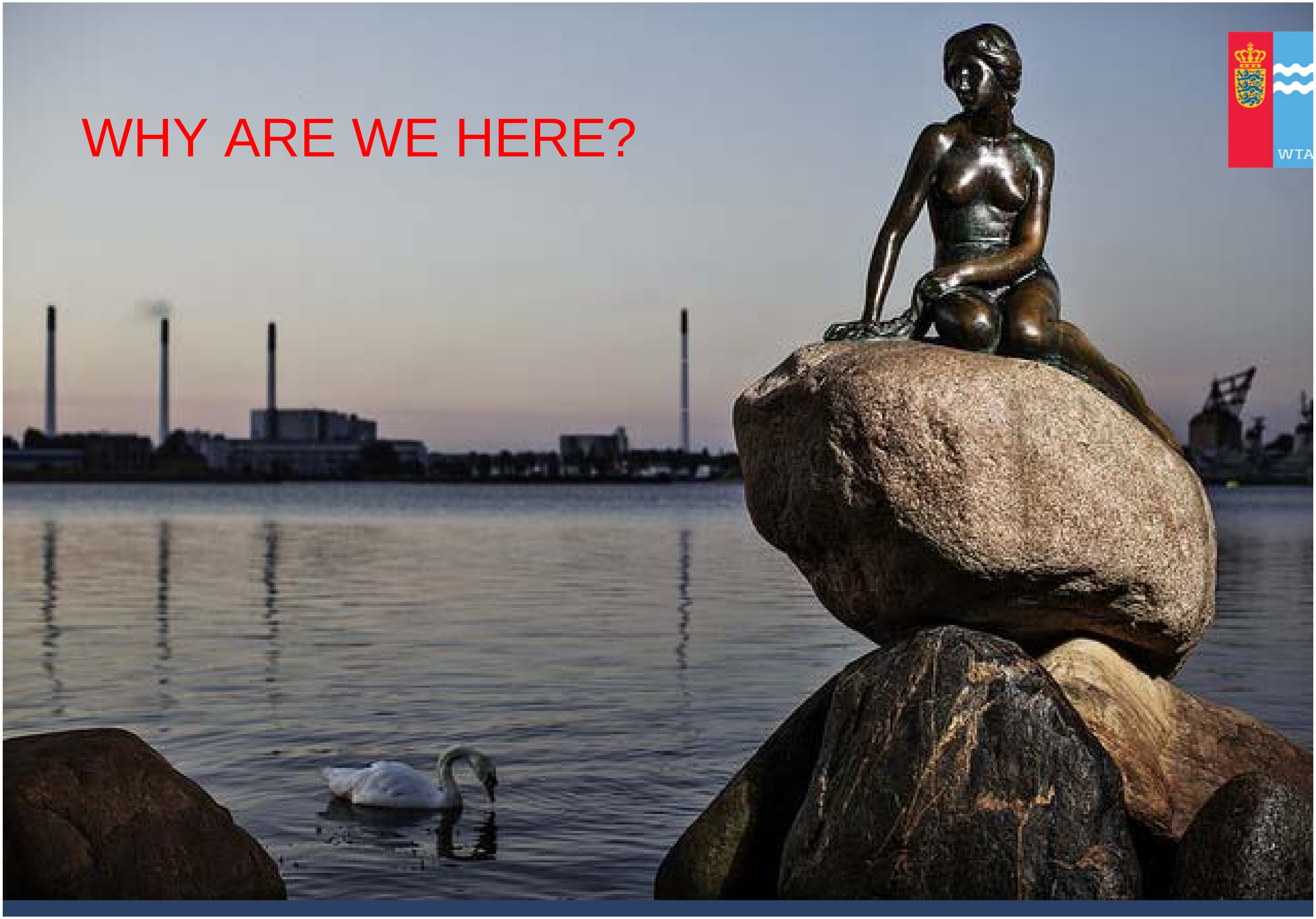
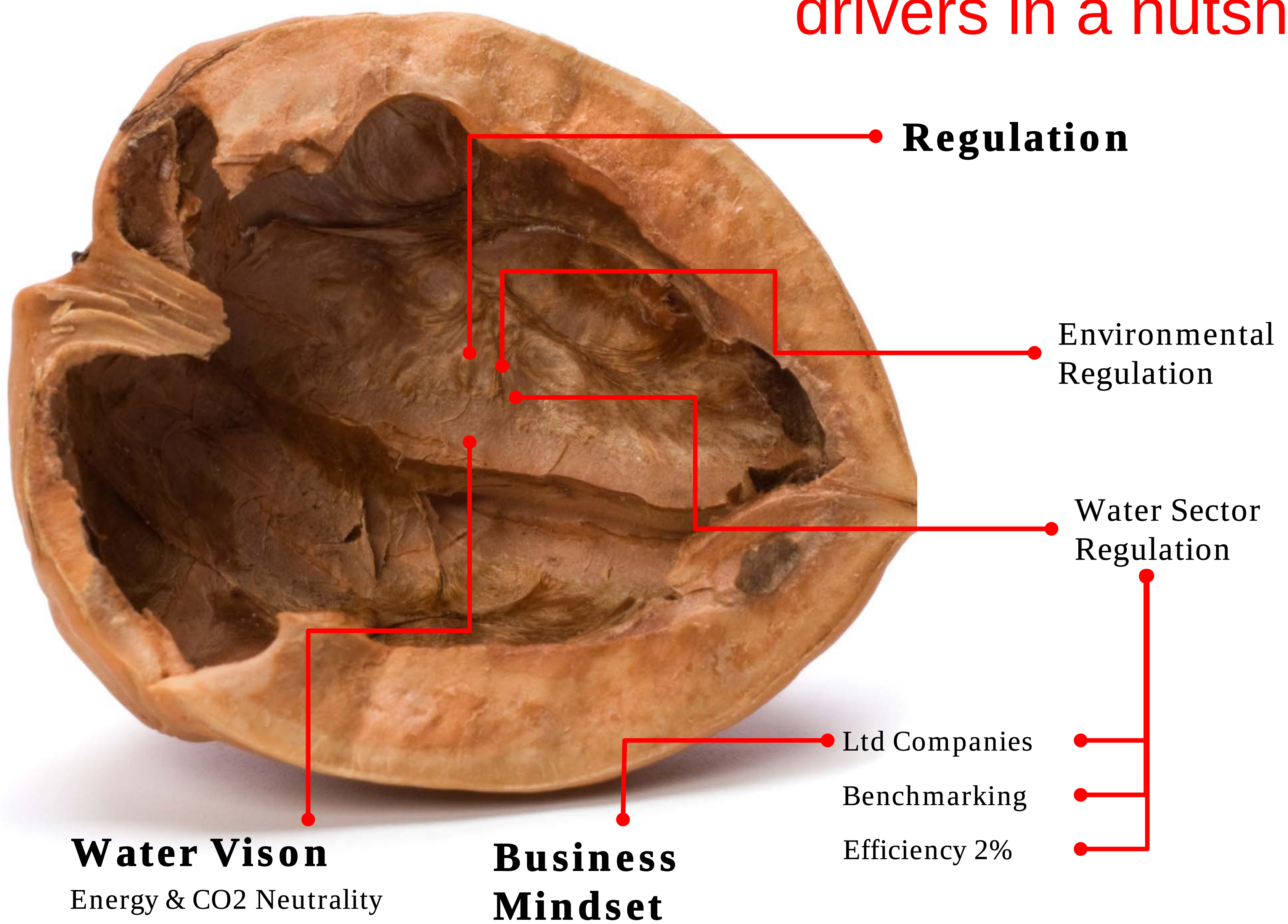
WHY ARE WE HERE?



Knowledge sharing & collaboration

In California and in Denmark

drivers in a nutshell



Environment

Discharge Standards – Development

Parameter	Unit	1960	1970-80	1990	2016 (sensitive areas)	EC Standards (1)
BOD_5	mg/l	150	25	15	10	25
Total N	mg/l	-		8	8	15
Total P	mg/l	-		1.5	0.4	1
Treatment		M	MB	MBNP	MBNPS	

Legend:
M= Mechanical
MB= Mechanical-Biological
MBNP= Mechanical-Biological-Nitrogen-Phosphorus removal
MBNPS= Mechanical-Biological-Nitrogen-Phosphorus removal and sand filtration
(1) Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment

Tax Payment to Government on all three parameters

Regulation by ”pollution” tax

Tax Rates – Pollution Discharge	Units	2016
Total N	$/lb	2,25
Total P	$/lb	12,4
BOD_5	$/lb	1,25

1 USD = 6,63 DKK

CASE
Marselisborg WWTP Aarhus Water, Denmark

- 200.000 PE (1 PE = 0.060 kg BOD/day (= 0.13 lbs/day)
- Designed in the 80’s. Nutrient demands in the 90’s.

1990 Challenge: Optimization

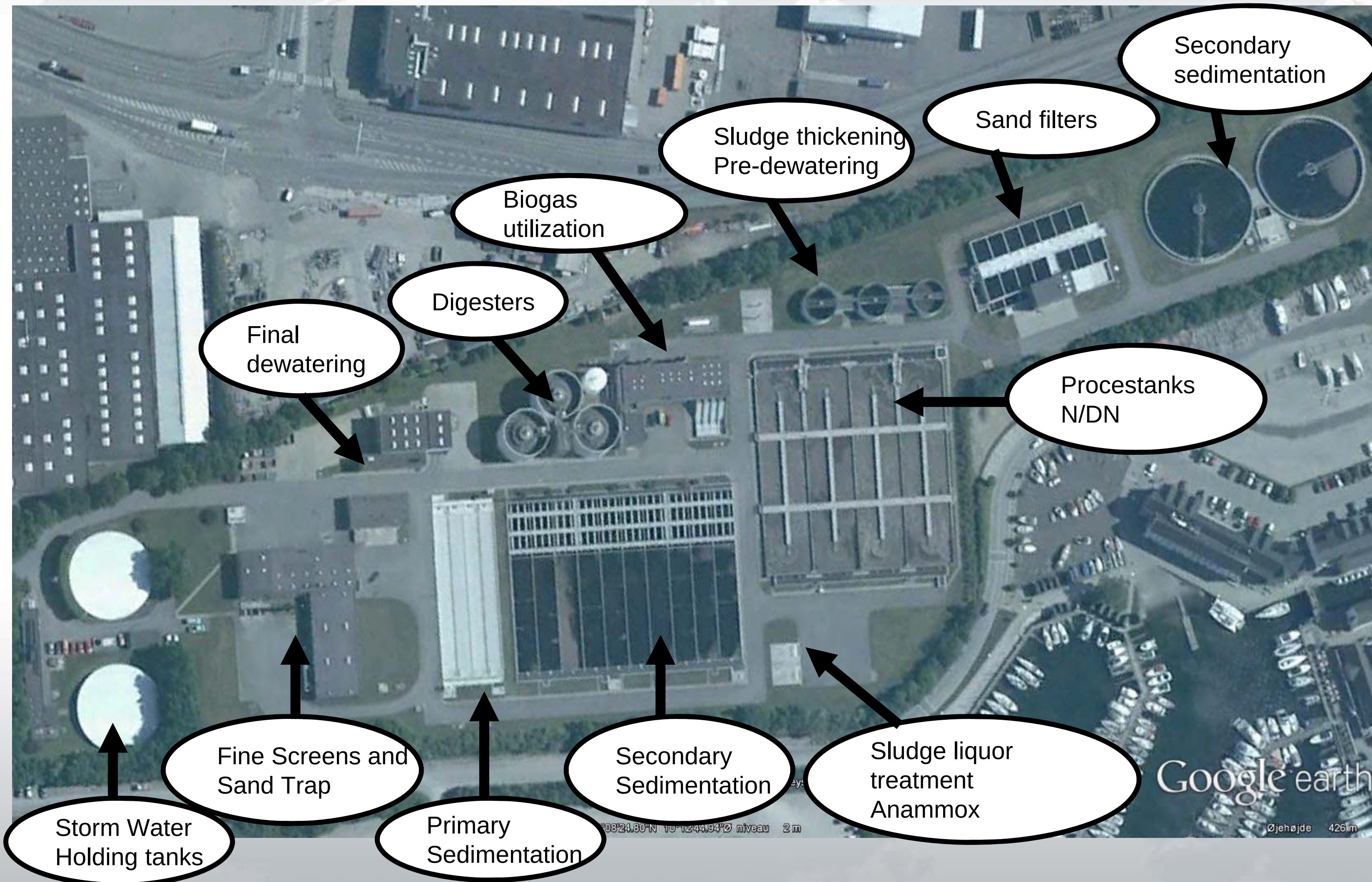
Increase the efficiency & capacity of the WWTP, oh and…

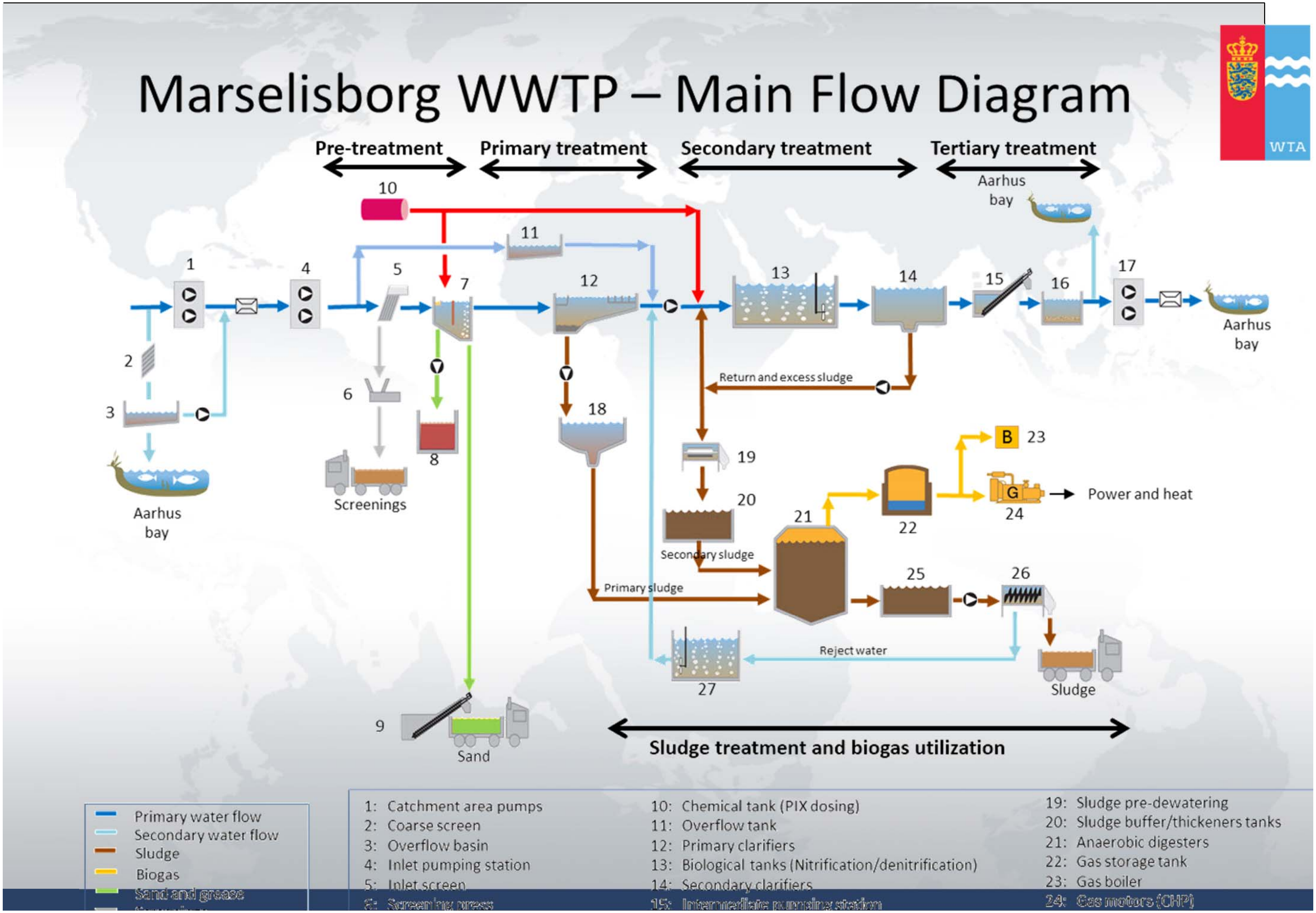
Reduce effluent values oh and…

without any major investments in the treatment plants themselves

- Open systems configurable by Aarhus Water's own staff

Plant Layout
Marselisborg WWTP - 220,000 PE




Marselisborg WWTP – Main Flow Diagram
Pre-treatment
Primary treatment
Secondary treatment
Tertiary treatment
WTA
Aarhus bay
Aarhus bay
Aarhus bay
Screenings
Sand
Sludge
Return and excess sludge
Secondary sludge
Primary sludge
Reject water
Power and heat
B
G
1
2
3
4
5
6
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8
9
10
11
12
13
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Sludge treatment and biogas utilization
Primary water flow
Secondary water flow
Sludge
Biogas
Sand and grease
1: Catchment area pumps
2: Coarse screen
3: Overflow basin
4: Inlet pumping station
5: Inlet screen
6: Screening press
10: Chemical tank (PIX dosing)
11: Overflow tank
12: Primary clarifiers
13: Biological tanks (Nitrification/denitrification)
14: Secondary clarifiers
15: Intermediate pumping station
19: Sludge pre-dewatering
20: Sludge buffer/thickeners tanks
21: Anaerobic digesters
22: Gas storage tank
23: Gas boiler
24: Gas motors (CHP)

Marselisborg WWTP
Compliance with effluent standards

Marselisborg WWTP		Limits	Discharge, 2015		
Parameter	Unit	Standard	Average	Control Value, C	Compliance
Total N	mg/l	8	5.59	4.86	Yes
Total P	mg/l	0.8	0.25	0.22	Yes
Total P	kg/d	20.8	7.21	6.46	Yes
$BI5_{mod}$	mg/l	15	2.14	2.47	Yes
COD	mg/l	75	24.19	21.75	Yes
SS	mg/l	20	3.01	3.35	Yes

Number of samples: 24

Marselisborg WWTP
Capacity and loadings 2015

Parameter		Capacity Average	Loading 2015 Average	Loading Rate [%]
Flow	MGD	6,8	8,7	127
BOD5	[lb/d]	26,675	23,737	89
Total N	[lb/d]	3,417	4,045	118
Total P	[lb/d]	943	595	63
PE_{BOD}	á 60 g BOD/pxd	200,000	179,450	90

Additional loading to the WWTP:

(1) Septic sludge to inlet = 20-30,000 PE

(2) Reject water from sludge treatment = 15-17,000 PE_N

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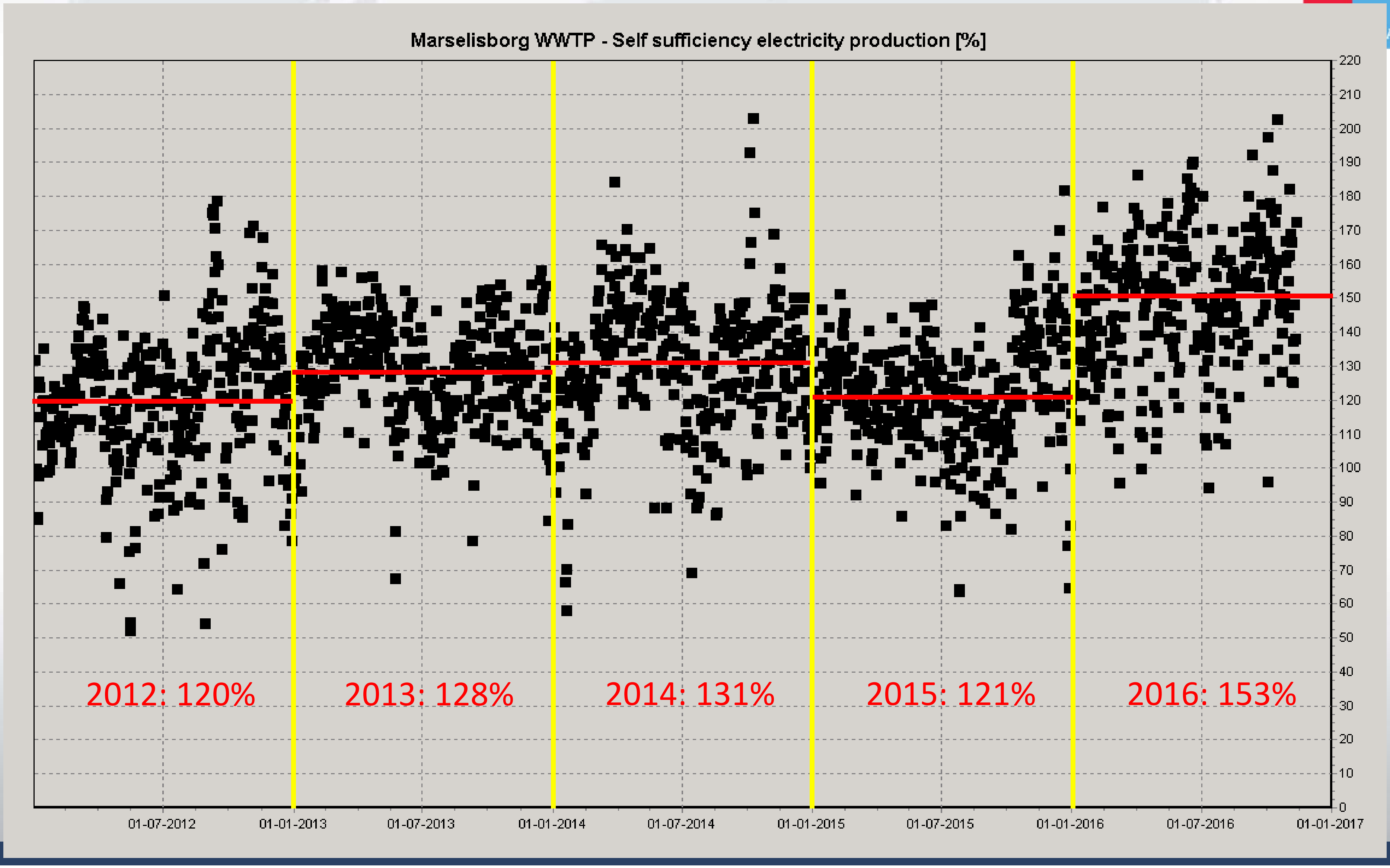
Energy self sufficiency - electricity



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Marselisborg WWTP

Energy Self sufficiency – Status 1.1.2016 – 6.9.2016

Energy Self sufficiency	Net energy production %	Energy self sufficiency %
Electricity, year to day	147 %	147 %
Heat, year to day	193 %	
Energy in total, year to day	169 %	233 %

Net energy production = Production / Consumption
Energy self sufficiency = Sold / Bought

Solutions

1. Process Optimization

- Biological Nitrogen and Phosphorus removal
- Clarifier control (increased hydraulic capacity during rain)
- Sensors and VFDs (integrated real time process control)

2. Component Optimization

- Turboblowers
- Gasengines (CHPs)
- Fine bubble diffusers / mixers

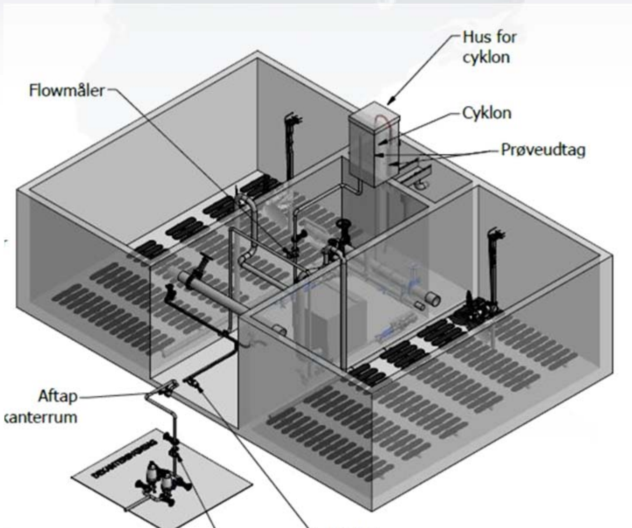
3. New Processes

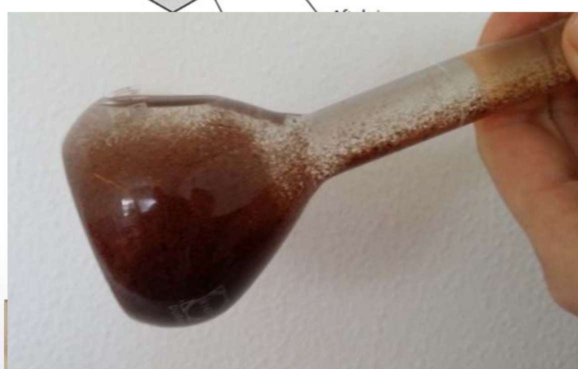
- Simultaneous Nitrification/Denitrification
- Sidestream Hydrolysis/Bio-P
- Sidestream De-Ammonification
- Mainstream Nitrite-shunt
- Mainstream De-Ammonification

Results from 1st round Process Optimization

Economic results: Process Optimization - Municipality of Aarhus	Unit	Wastewater Treatment Plant				Total
		Marselis	Egaa	Viby	Aaby	
WWTP size	PE	200,000	120,000	83,000	84,000	487,000
Reduction of use of resources - energy and chemicals	EUR/year	73,000	31,000	40,000	132,000	276,000
Reduced effluent values - lower effluent tax	EUR/year	114,000	19,000	27,000	2,000	162,000
Increased capacity - depreciation time 25 years	EUR/year	54,000	50,000	132,000	27,000	263,000
Total	EUR/year	241,000	100,000	199,000	161,000	701,000
Return of investment	Years	1.0	1.5	1.6	0.9	1.2

Side-stream treatment of centrate





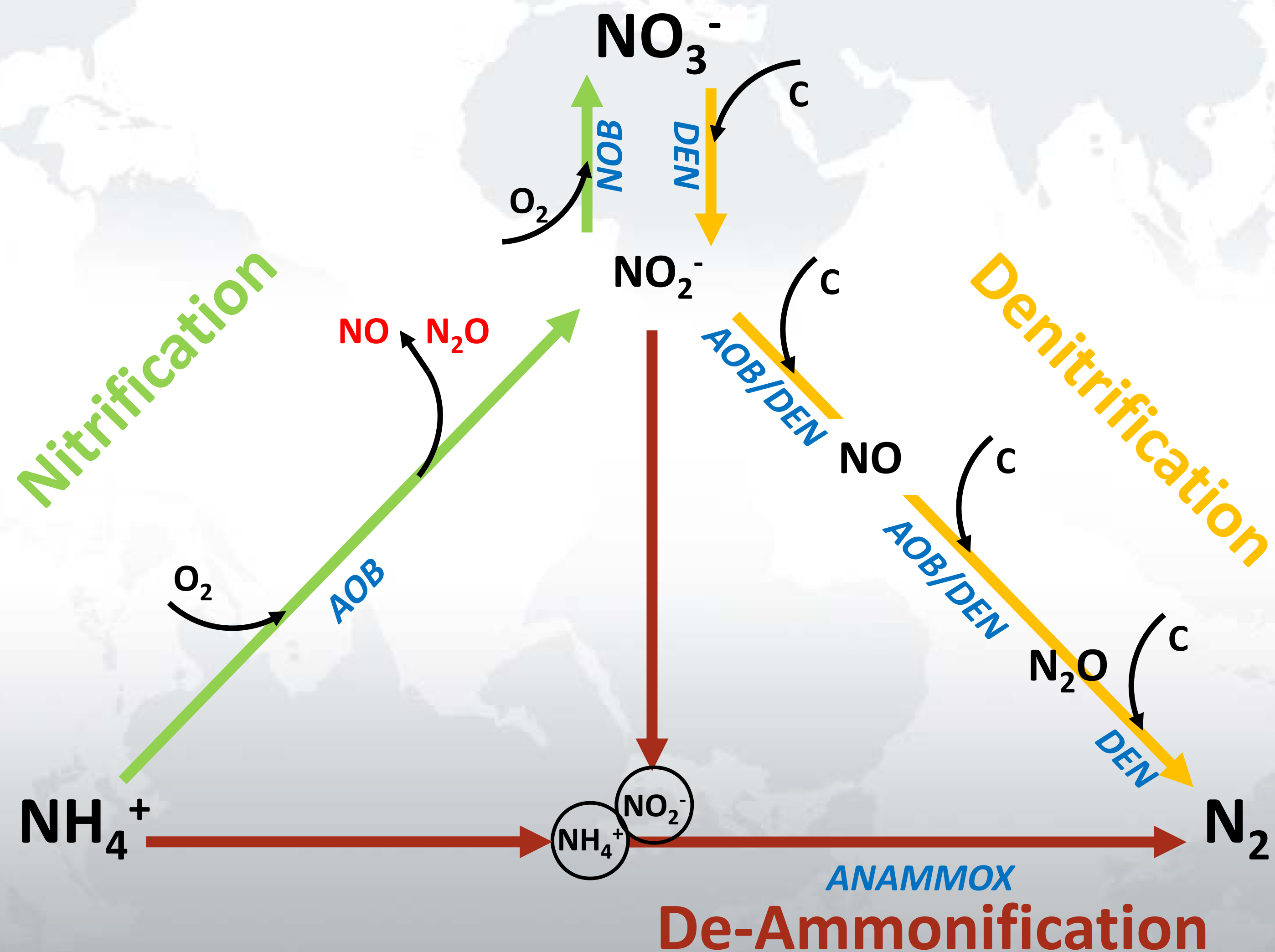
- Installed and running: 2015
- Flow, max. 15 m3/h
- Average daily flow 280 m³/d
- Ammonium load, average 250 kg/d

- DEMON **Plant design data (existing tanks):**
- Equalizing tank 100 m^3
- Process volume (Process tank 1+2) 280 m^3
- Sedimentation tank 5.2 m^2

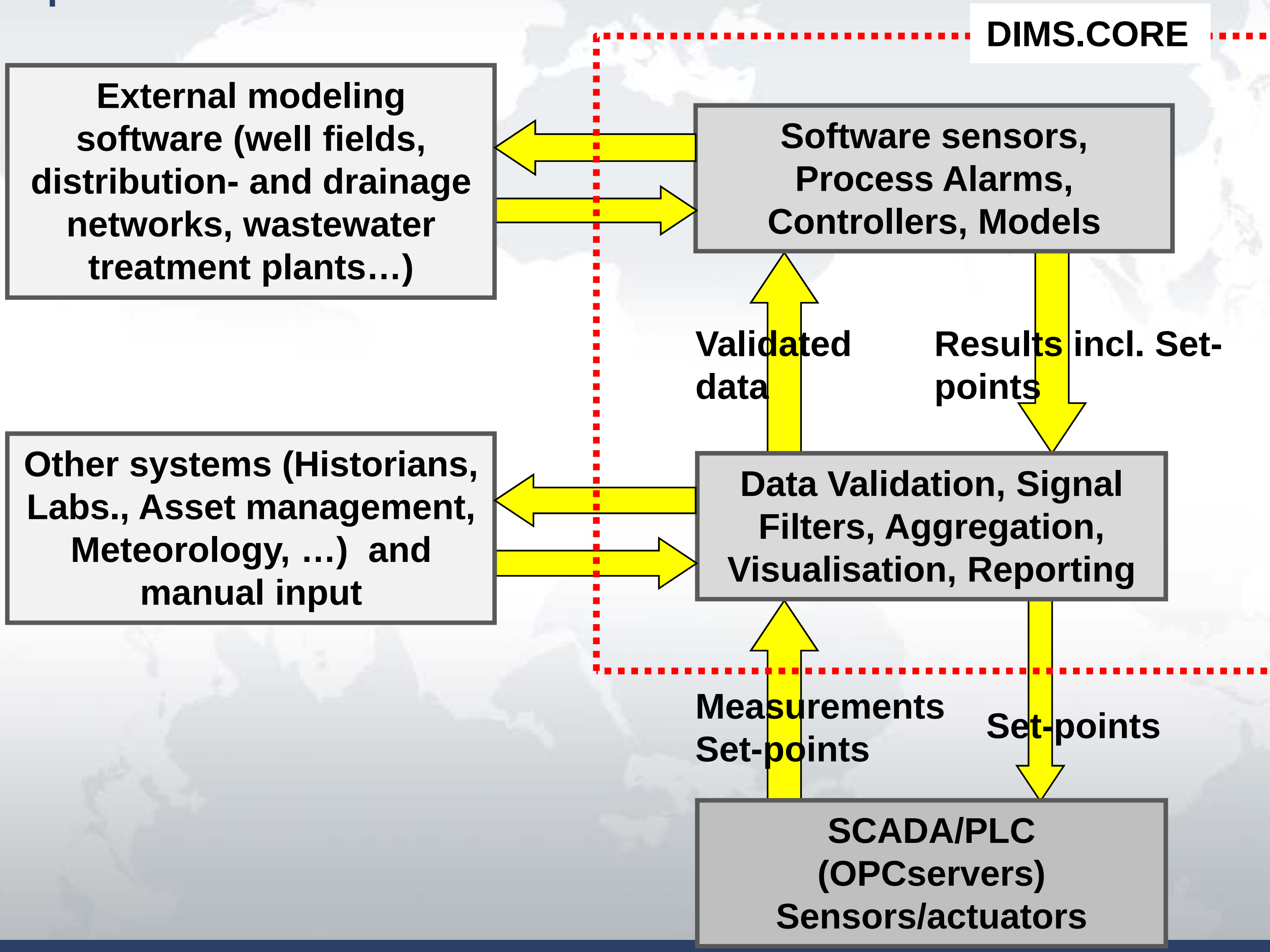
Results:

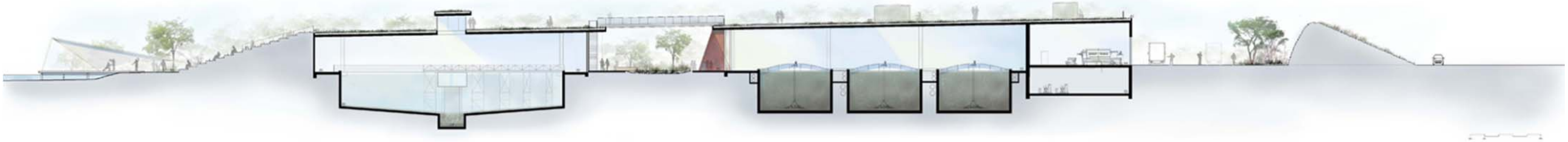
- Removal efficiency (NH4-N) > 85%
- Energy consumption ~1,3 kWh/kg NH4-N removed
- Total N in effluent reduced with aprox. 2 mg/l
- Reduced wastewater tax 600,000 DKK/year

Processes for Nitrogen Removal



Standard platform for process control and daily operation





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MARSELISBORG REWATER
- An Open Invitation

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October 9th to 15th