ETV4WATER

**Project Partners:** IETU aquateam COWI Gdańska Fundacja Wody

# „ Improving energy efficiency of a wastewater treatment plant thanks to innovations”

## Oslo, 23.10.2017

Workshop: Environmental technology verification (ETV) as a tool facilitating implementation of innovative technologies for energy efficiency improvement at wastewater treatment plants


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Norway grants

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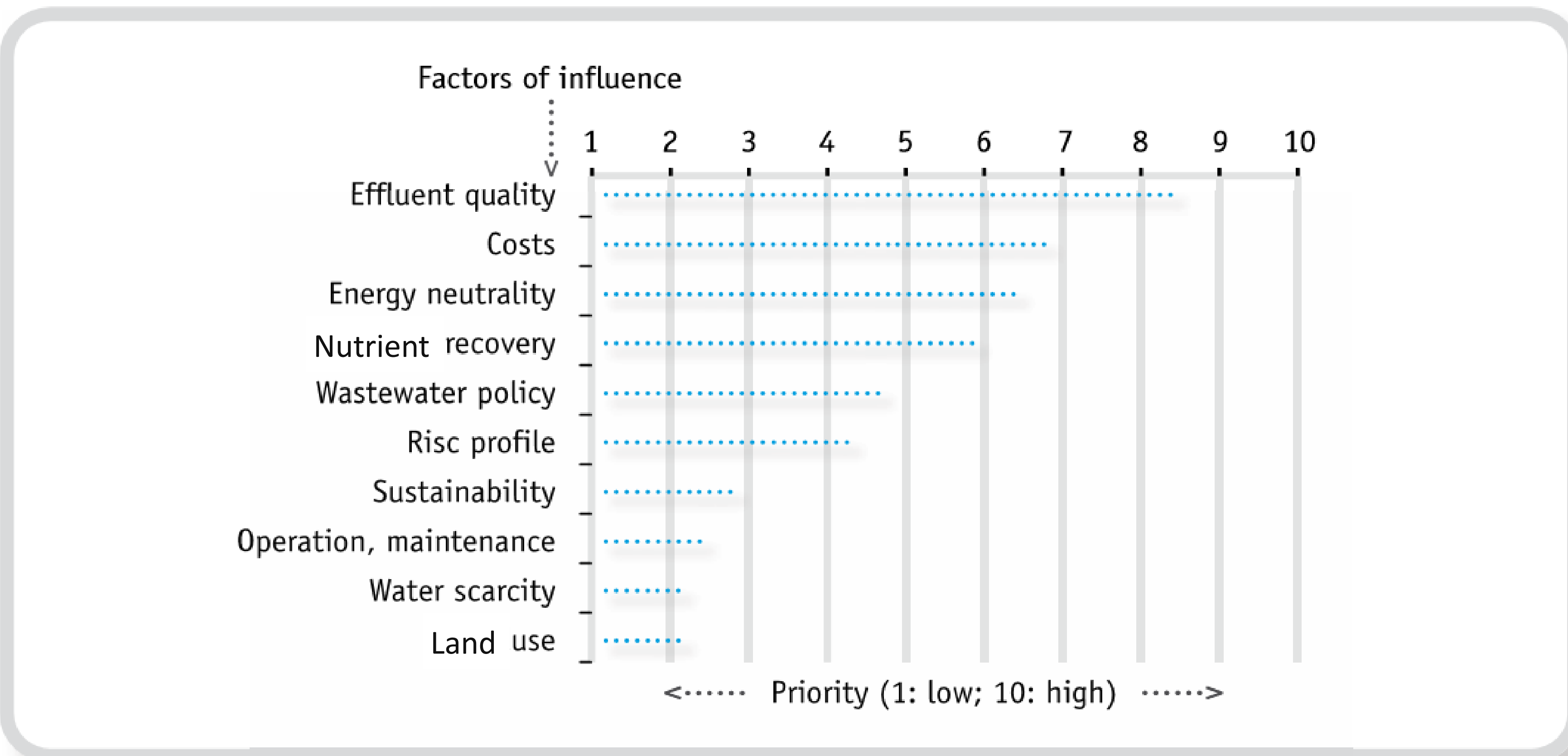
# Wastewater Technology Development



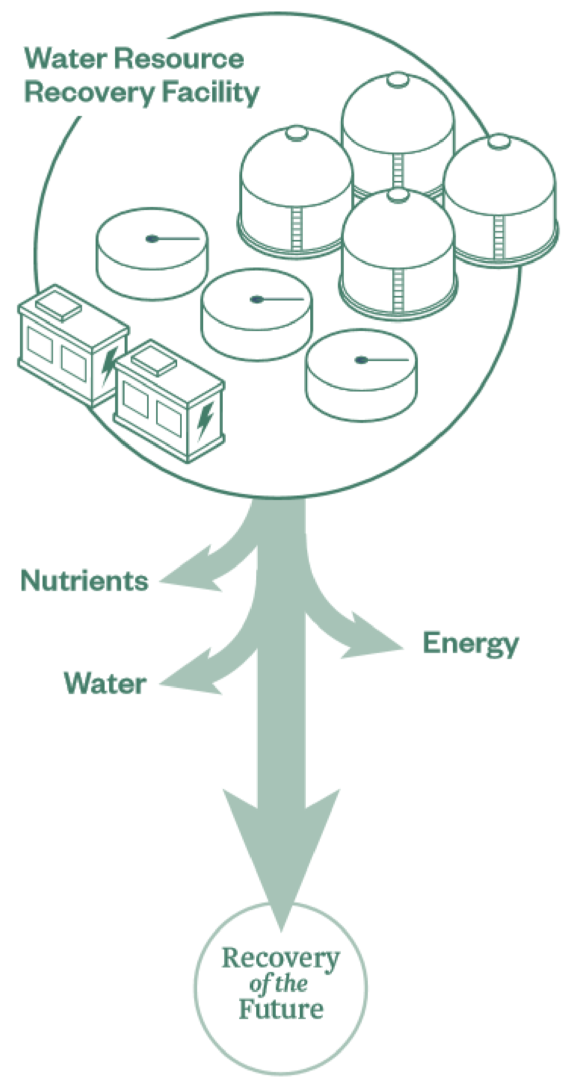

NEWS: THE DUTCH ROADMAP FOR THE WWTP OF 2030

Priority of expert group for factors of influence.

# Energy Efficiency

## Energy neutrality a new aspiration:

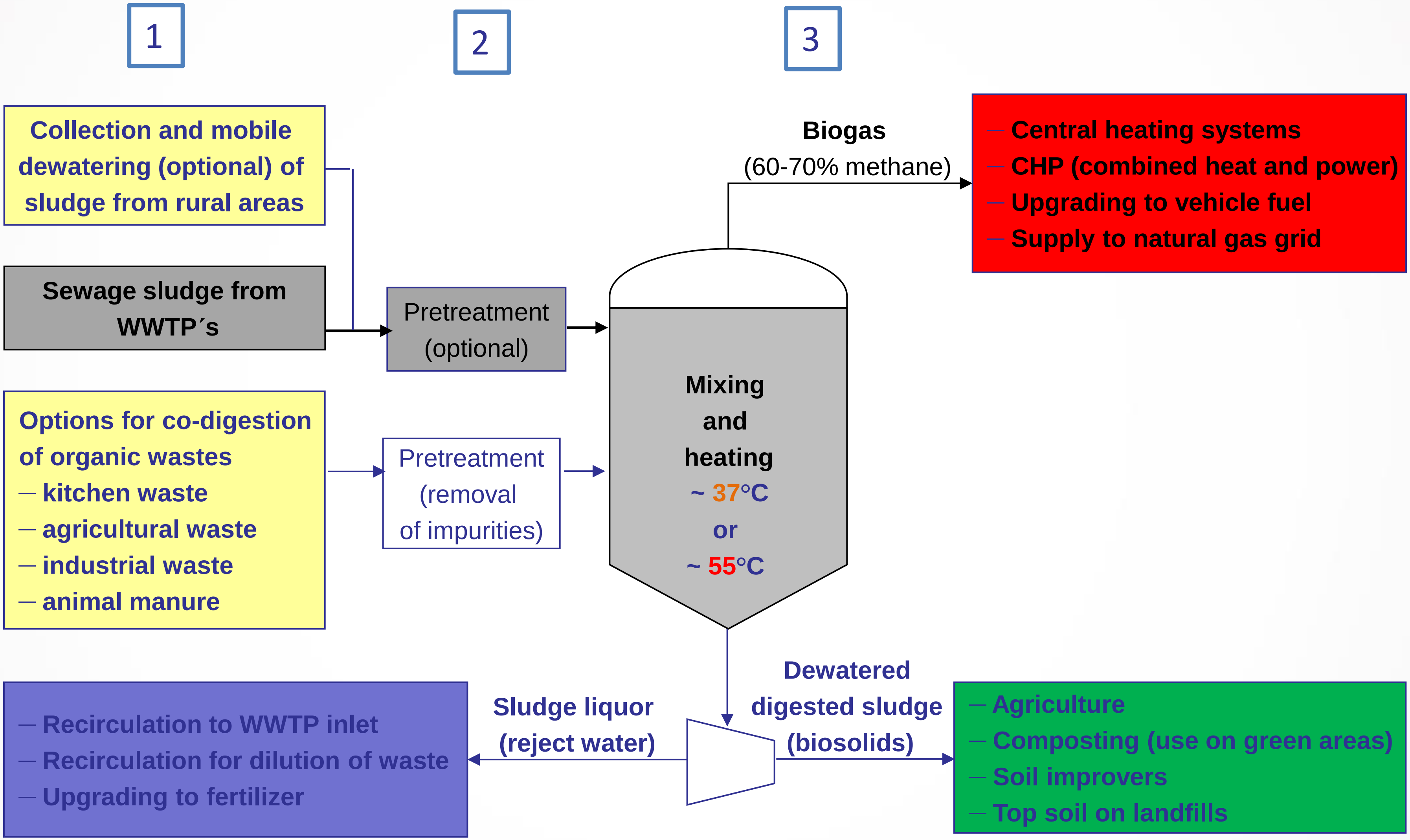
- increased energy production/recovery
- reduction in consumption




As energy demand continues to grow globally, technology will play an important role in creating a more sustainable energy environment.

Resource recovery will undoubtedly occur in the next few decades. Translating these concepts into practice will require concerted effort by all water industry stakeholders to understand how these emerging technologies, recovery products, and markets can be best leveraged to achieve multiple benefits at utilities.

# Energy Recovery – Anaerobic Digestion



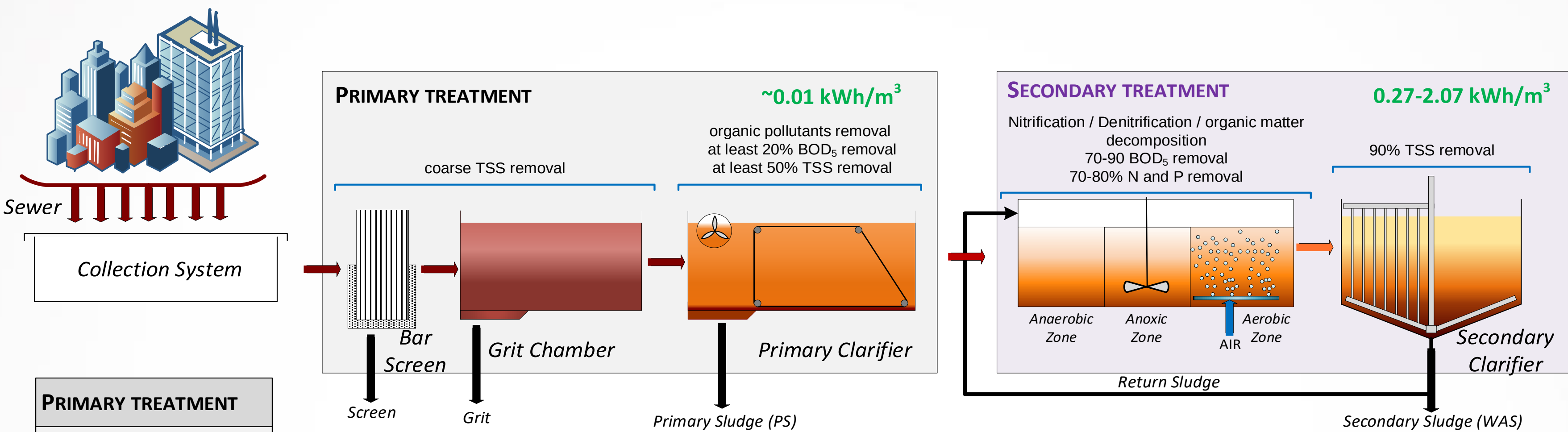
# Energy Recovery- Europe

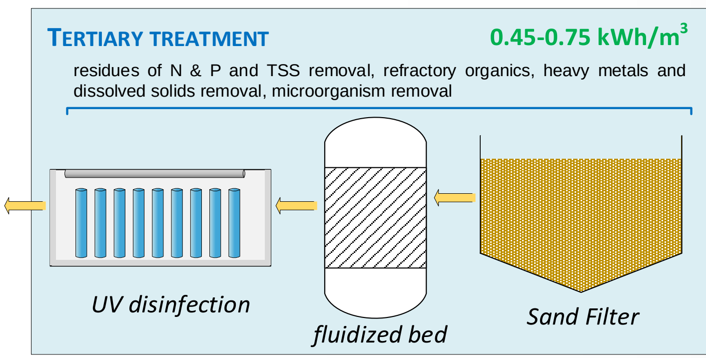
| WWTP (Country) | Capacity in PE | Load in kg COD/d | Production of Biogas in $Nm^3/y$ | Biogas to Cogen-eration in $Nm^3/y$ | Produced Electricity in kWh/y | Efficiency $kWh/Nm^3$ of Biogas | Electricity Self-sufficiency in % | Remark |
|---|---|---|---|---|---|---|---|---|
| Görlitz (D) | 140,000 | 8,923 | 949,858 | 940,086 | 1,536,586 | 1.63 | 72 | M, co-dig |
| Schönebeck (D) | 90,000 | 7,890 | 576,542 | 443,971 | 862,001 | 1.94 | 53 | M |
| Gera (D) | 200,000 | 15,099 | 1,099,716 | 903,761 | 1,705,205 | 1.89 | 68 | M, co-dig |
| Den Hague—Houtrust (NL) | 487,000 | 31,393 | 2,427,094 | 2,421,946 | 4,549,204 | 1.88 | 30 | M |
| Den Hague—Harnaschpolder (NL) | 1,473,000 | 95,096 | 4,976,878 | 4,967,487 | 12,612,500 | 2.54 | 43 | M |
| Prague (CZ) | 1,641,600 | 210,800 | 17,878,058 | 13,868,369 | 27,863,300 | 2.01 | 75 | T, co-dig, MD |
| Pest-South (H) | 293,300 | 77,484 | 6,824,005 | 4,526,581 | 9,037,587 | 2 | 70 | T, co-dig |
| Pilsen (CZ) | 380,000 | 54,508 | 4,170,116 | 3,989,299 | 7,020,512 | 1.76 | 75 | T, co-dig |
| Braunschweig (D) | 275,000 | 54,400 | 3,708,000 | 3,590,200 | 8,537,000 | 2.38 | 66 | T, co-dig |
| Szeged (H) | 230,000 | 23,919 | 1,371,657 | 1,247,007 | 3,026,556 | 2.43 | 49 | M |
| Seafield (UK) | 800,000 | 75,000 | 10,380,600 | 5,784,309 | 12,725,479 | 2.2 | 53 | M |
| Olomouc (UK) | 259,500 | 15,183 | 1,695,252 | 802,381 | 1,794,500 | 2.24 | 32 | M, co-dig |
| Hrdec Kralove (CZ) | 141,000 | 9,622 | 1,149,020 | 940,073 | 1,248,000 | 1.33 | 32 | M, co-dig |
| Teplice (CZ) | 130,000 | 7,086 | 620,999 | 575,010 | 1,083,051 | 1.88 | 49 | M |
| Ústi (CZ) | 180,000 | 16,875 | 1,077,299 | 854,462 | 1,375,299 | 1.61 | 32 | M, co-dig |
| Liberec (CZ) | 190,000 | 12,122 | 1,266,245 | 1,205,941 | 1,927,317 | 1.6 | 46 | M |
| Berlin Wassmansdorf (D) | 1,767,000 | 176,672 | 14,302,069 | 14,093,068 | 28,261,147 | 2.01 | 64 | M, co-dig |
| Berlin Shonerlinde (D) | 675,000 | 83,795 | 6,228,528 | 1,721,5485 | 3,579,170 | 2.08 | 15 | M |
| Madrid Sur (Esp) | 3,007,950 | 169,242 | 12,171,800 | 10,170,321 | 18,555,443 | 1.82 | 59 | M |

M: mesophilic; T: thermophilic; Co-dig: codigestion; MD: mechanical disintegration.

*Chudoba et al, 2011, Journal of Residuals Science & Technology,* Vol. 8, No. 2—April 2011

# Energy Efficiency of WWTPs with Activated Sludge




## PRIMARY TREATMENT

- solids removal: KWh/kg TSS removed

## SECONDARY TREATMENT

- BODred %; kg/pe/day
- CODred %; kg/pe/day
- TOCred %; kg/pe/day
- $Ntot_{red}$ %; kg/pe/day
- $Ptot_{red}$ %; kg/pe/day
- $NH_4/NH_3$-Nred %; kg/pe/day
- OCP (Oxygen Consumption Potential)$_{red}$ %; kg/pe/day
- Energy aeration kWh/pe/day, kWh/kg oxygen need; % of total energy need
- Energy mixing kWh/pe/day; % of total energy need energy/reduced parameter kWh/kg $_{\text{reduced parameter}}$:
  - kWh/kg COD $_{\text{removed}}$,
  - kWh/kg $NH_4$ $_{\text{removed}}$,
  - kWh/kg TN $_{\text{removed}}$,
  - kWh/kg P $_{\text{bio removed}}$

## TERTIARY TREATMENT

- solids removal: kWh/kg TSS removed
- ammonia removal: kWh/kg $NH_4$ removed
- TN removal: kWh/kg TN removed
- solids and P removal: kWh/kg TSS removed, kWh/kg P removed
- pathogens removal: kWh/log reduction
- hazardous pollutants (eg estradiol) removal: kWh/µg estradiol removed

**Important process performance indicators influencing energy efficiency**

**Project funding:** Norway grants

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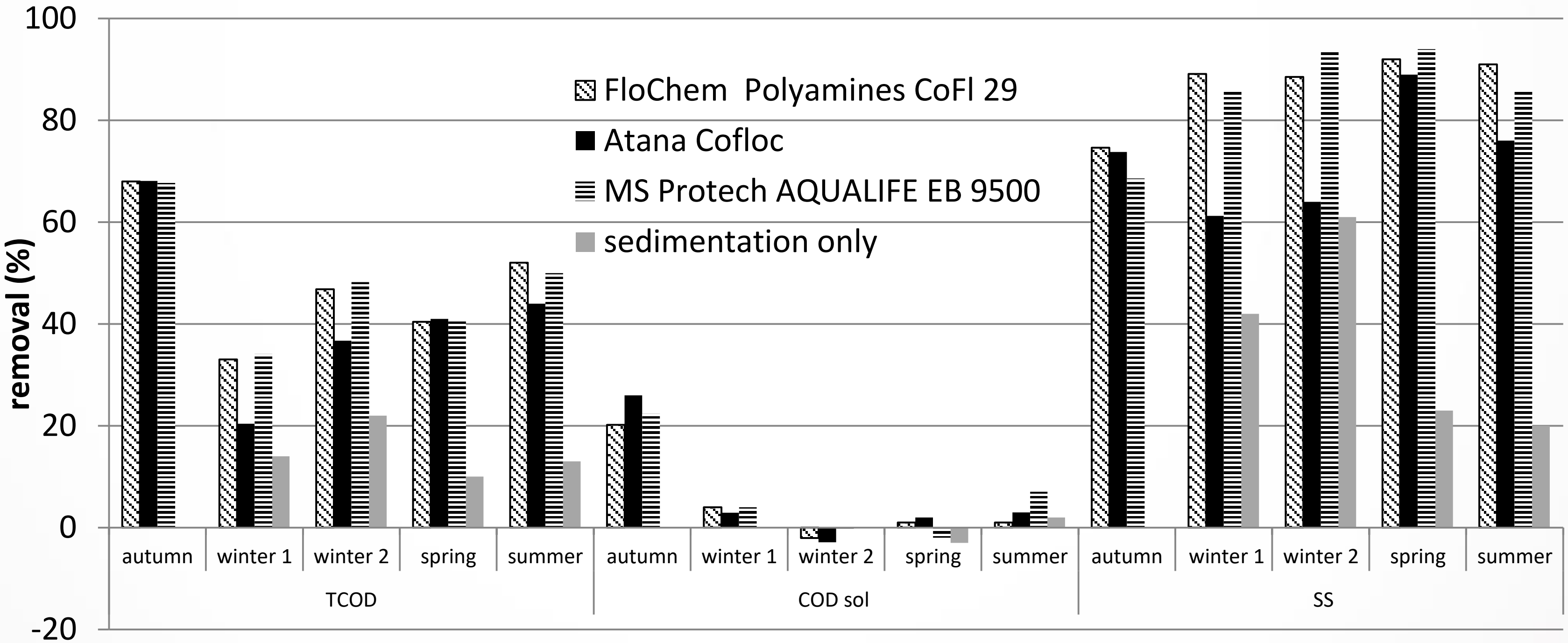
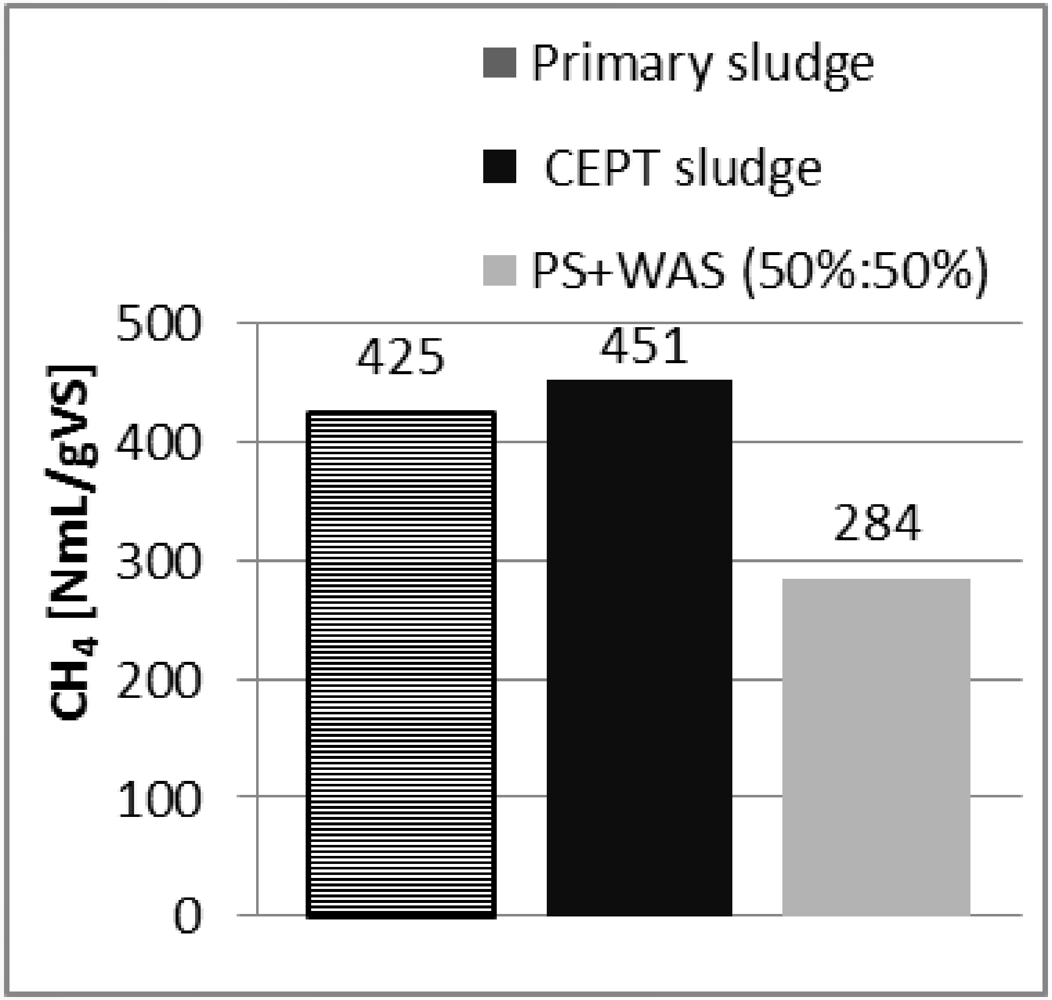
# Advanced Primary Treatment

## Chemically Enhanced Primary Treatment (CEPT)

Use of organic coagulants to increase primary sludge production and reduce the load on downstream biological nutrient removal (BNR) processes



# Specific Biomethane Potential (SBP) test




CEPT sludge: 6 % increase of SBP compared to PS

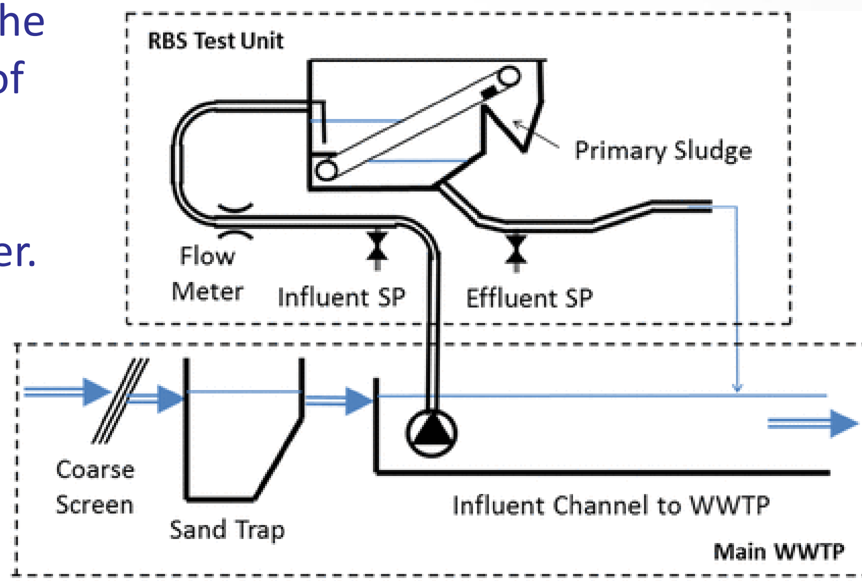
CEPT sludge: 59% increase of SBP compared to PS+WAS

# Advanced Primary Treatment

Application of **fine sieves/filters** instead of primary clarification → more BOD can be removed from the wastewater and converted into biogas through digestion.

Primary treatment using a 350 microns belt showed 40 -50 % removal of total suspended solids (TSS) and 30% removal of chemical oxygen demand (COD) at sieve rates as high as 160 $m^3/m^2$-h.

CEPT is a simple and effective way of increasing the removal efficiency of RBS. Adding about 1 mg/L of cationic polymer and about 2 min of flocculation time, the removal of TSS typically increased from 40–50% without polymer to 60–70% with polymer.




**Note**: 1. sufficient BOD has to be available in the wastewater to comply with the requirements for nitrogen removal. 2. By improving the digestion process an increase in the nitrogen load in the reject water can be encountered; in this case advanced side stream reject water treatment can be applied.

Rusten et al, 2017 (Water Sci and Techol, 75 (11) 2598-2606).

# Side Stream Treatment

**Deammonification** – biological autotrophic process applied for treatment of ammonium-rich side-streams (ongoing research towards implementation in the main technological stream).

Increases the efficiency of main technological line and allows to save energy for aeration in the main stream.

Includes two stages: oxidation of half of ammonium to nitrite (partial nitritation), and next conversion of remaining ammonium with nitrite into nitrogen gas under anaerobic conditions (Anammox).

Requirements: a low C/N and high temperature

Full-scale data from Strass WWTP in Austria indicates that the electricity consumption for nitrogen removal in side stream sludge dewatering reject water was **1.16 kWh/kgN**, what is significantly lower than the 6.5 kWh/kgN in main stream conventional nitrification/denitrification treatment (Wett, 2007).

After application of Anammox in side stream, oxygen consumption for ammonia removal was reduced by 50%, corresponding to approximately **12%** savings of the total electricity consumption of the whole plant.

# Anaerobic Wastewater Treatment

Most of the energy efficiency proposals involve implementation of better control of existing processes. They would be feasible on relatively short time and at comparatively low cost. The more radical proposal with greater potential benefits is to replace current aerobic systems treatment with low temperature **anaerobic processes**

There will be a **change in paradigm** in the main unit operation used at WWTP. A major development will be the **application of anaerobic processes to mainstream** flows (Stephenson and Aunger et al, 2009).

It has been estimated that by 2030 aerobic treatment consuming 0.15-0.7 kWh/m$^3$ could be replaced by **anaerobic treatment producing 1.7 kWh/m$^3$** (WssTP, 2011; GWRC, 2010).

# New models of WWTPs

Wett et al., (2007) proposes the following solution:

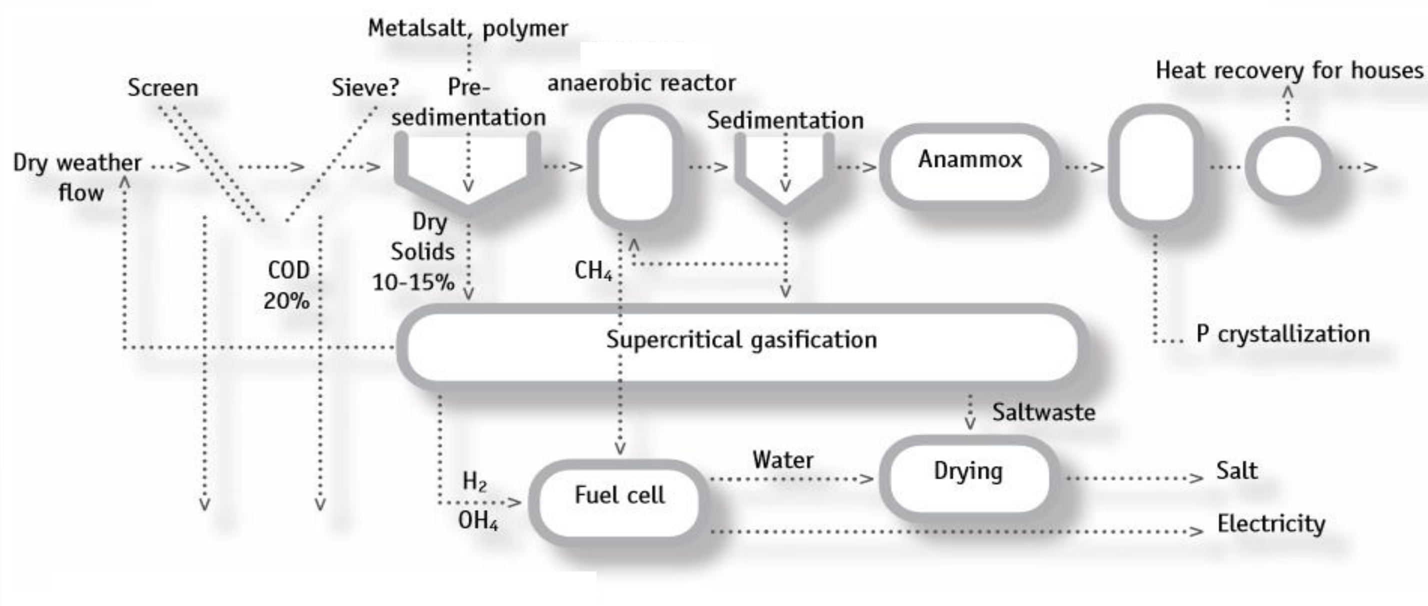
- enhanced primary treatment with organic polymer addition for increasing biogas production in AD,
- activated sludge process with short SRT and HRT to adsorb colloidal and soluble COD for more biogas production,
- dynamic control of aeration and pH,
- thermal pre-treatment of sludge,
- high efficiency generators or fuel-cell for electricity generation,
- and application of Anammox in the side-stream.

# Future Systems – Energy Factory 2030

Net production of energy requires minimization of energy consumption and maximization of energy recovery.

The proposed system includes:

- Separation of COD instead of aerobic degradation (optimisation of biogas production and energy consumption at aeration)
- In terms of energy consumption, economic removal of N and P and residual COD (deammonification as an important tool)
- Maximal recovery of sludge calorific content



# THANK YOU FOR YOUR ATTENTION

Project **ETV4WATER** ***Facilitating the use of ETV to improve energy efficiency of the water and wastewater sector*** has received funding from the **Norwegian Financial Mechanism 2009-2014** under the Bilateral Cooperation Fund, Operational Program PL04.