Making wastewater treatment energy efficient – good practices and new ideas

IWAMA Webinar I

Anna Mikola

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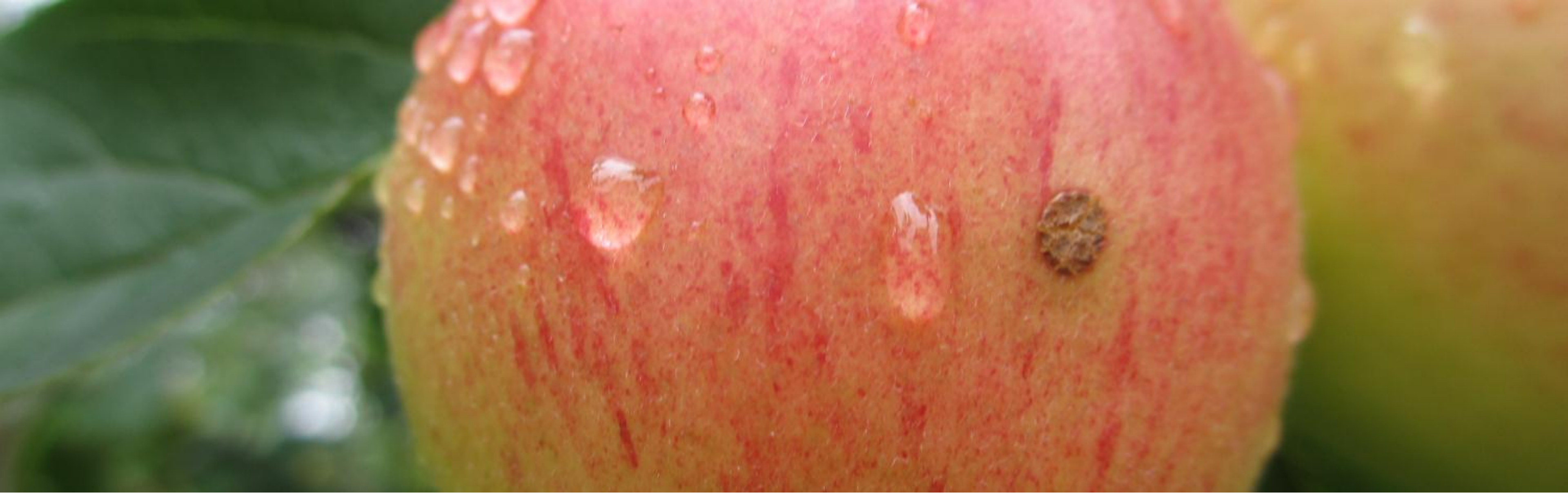


MAKING WASTEWATER TREATMENT ENERGY EFFICIENT – GOOD PRACTICES AND NEW IDEAS

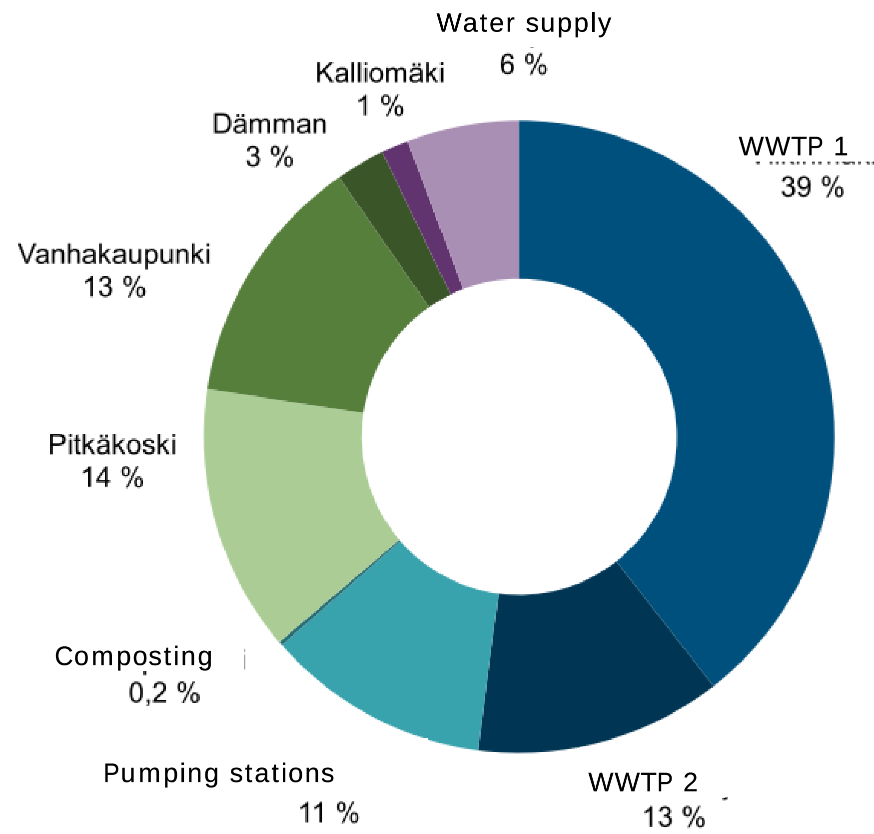
D.SC. (TECH) ANNA MIKOLA

RAMBOLL

ENERGY EFFICIENCY IN WATER SUPPLY AND SANITATION

- Typically 60% of the energy demand goes to wastewater treatment and 40% for drinking water (in case of surface water)
- Nutrient removal and possible new requirements for hygienization and micropollutant removal increase the energy demand further.

→ **Focus on wastewater treatment plants!!**



Kuva: Mari Heinonen

HSY

HSY 2013	Electricity kWh/m^3	Heat kWh/m^3
Wastewater treatment	0,47	0,33
Drinking water treatment	0,43	0,10

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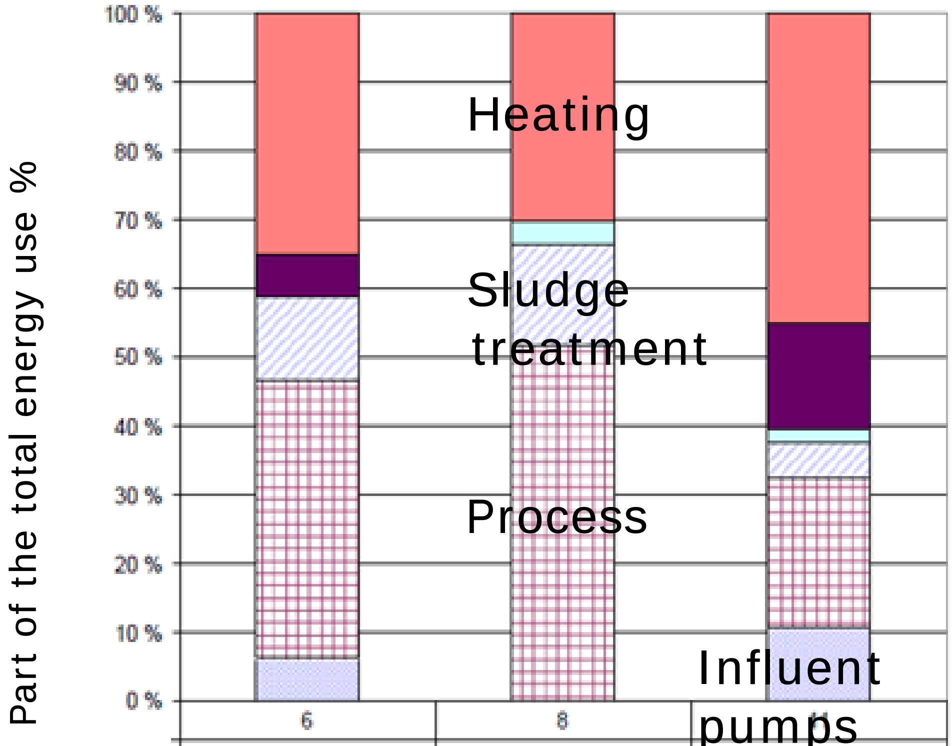
ENERGY CONSUMPTION IN WASTEWATER TREATMENT PLANTS



6	8	11
1 435 000	1 697 000	32 900 000
239 547	0	11 161 731
0	200 000	1 424 381
500 000	820 000	3 608 286
1 650 000	2 918 000	15 876 291
250 000	0	7 836 066

Out of total energy need:

- Process + influent pumping 40-70 %
- Heating 30-45 %
- Other energy use in buildings (e.g. lights) 5-15 %

THE INFLUENCE OF NUTRIENT REMOVAL ON ENERGY DEMAND

- Nitrification increases significantly the energy consumption of the process
- Nitrification approximately doubles the energy demand in biological process compared to only BOD removal
- Long sludge age also decreases the potential for methane production in digestion
- Denitrification allows some energy savings, but sludge recycles cause some increase
- Enhancement of phosphorus removal by adding a tertiary treatment increases the energy demand by 5 – 10%
- BioP also requires additional recycles and increases energy consumption

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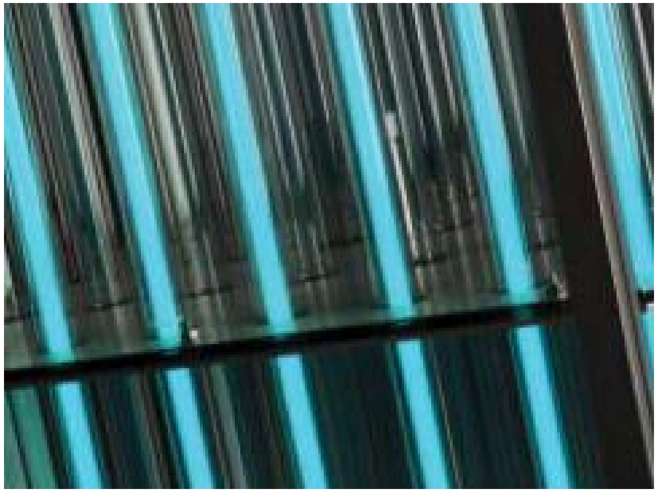
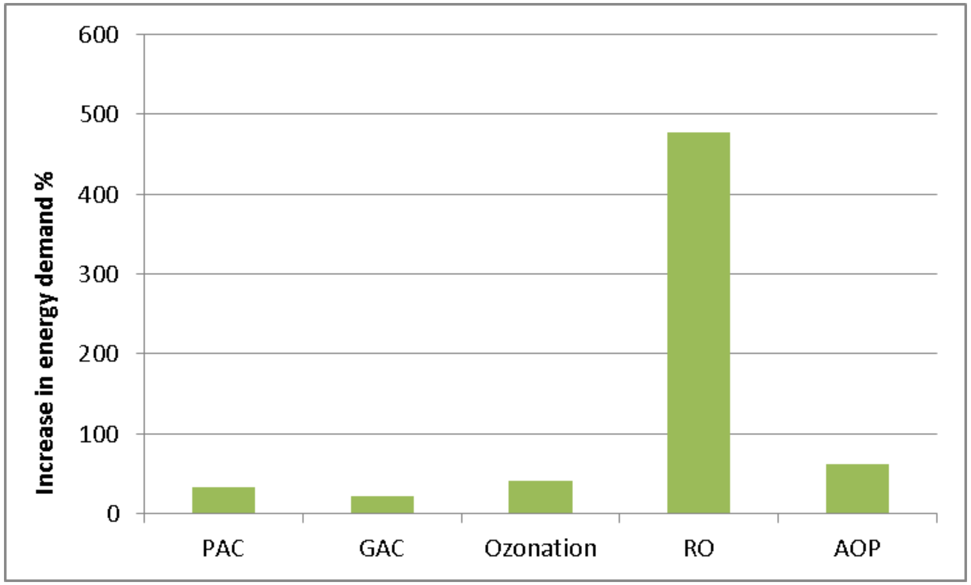
INFLUENCE OF NEW TREATMENT REQUIREMENTS ON ENERGY DEMAND

- Hygienization
  - Chemical processes have very small energy demand
  - UV → 5 % increase in energy demand of the WWTP process
- Micropollutants
  - Ozonation and other oxidation processes have fairly high energy demand
  - Reverse osmosis is very energy intensive





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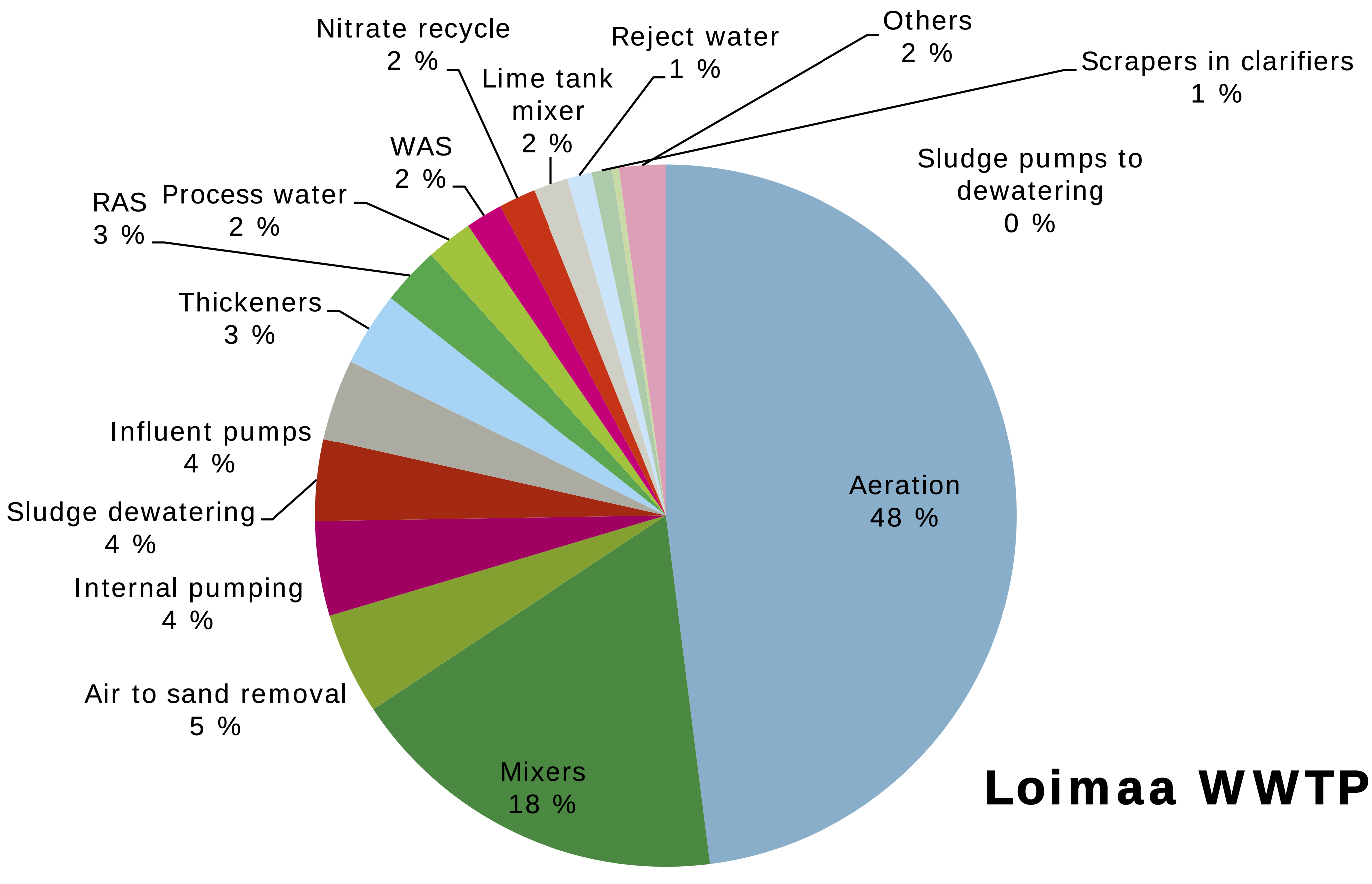
ENERGY DEMAND IN ADVANCED TREATMENT PROCESSES



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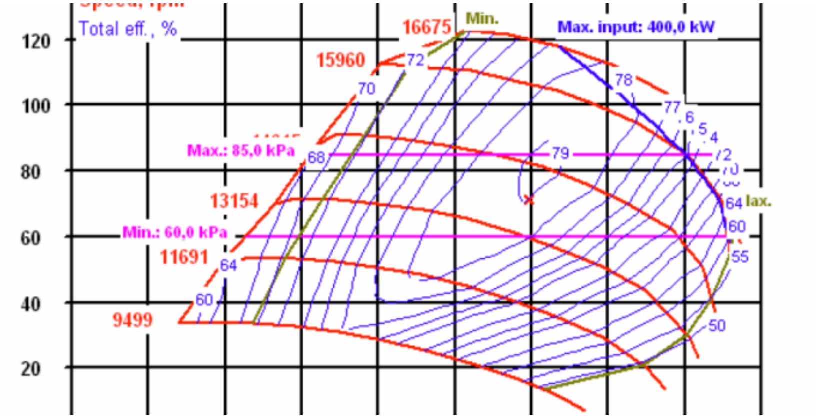
POSSIBILITIES TO SAVE OR PRODUCE ENERGY AT THE WASTEWATER TREATMENT PLANT

- Efficient aerators
- Control of oxygen concentration in the aeration basin
- Efficient compressors
- Efficient sludge dewatering
- Efficient pumps and mixers
- Flow balancing
- Optimization of primary clarifier
- Optimization of digestion

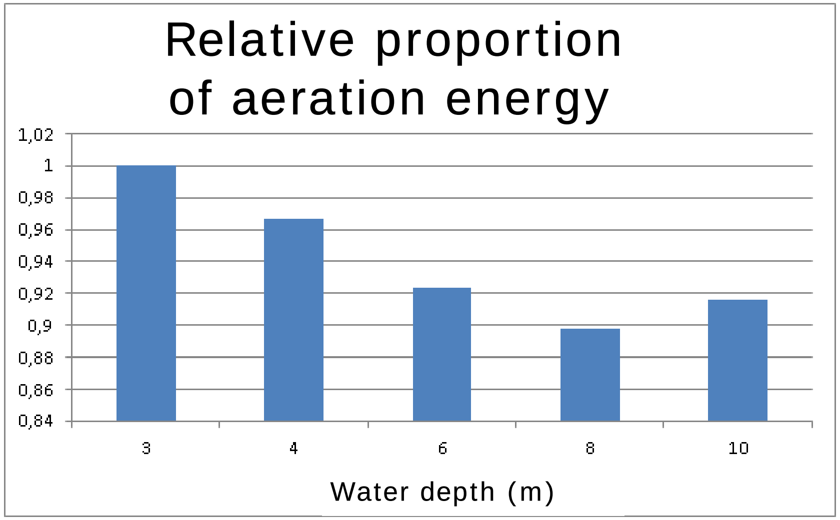


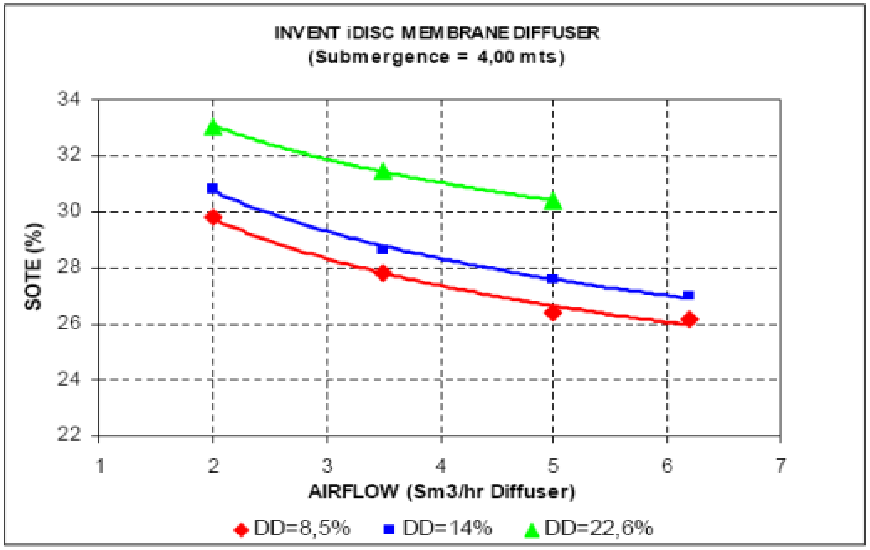
OPTIMIZATION OF AERATION

Factors affecting aeration efficiency:
- Aerators and their condition
- Diffuser density and layout
- Basin depth
- Compressor type
- Control system
    - Basin divided into zones
    - Control in each zone
    - DO control
    - NH_4-N + DO control

50 % of the process energy is typically used in aeration

→ Big potential for savings!

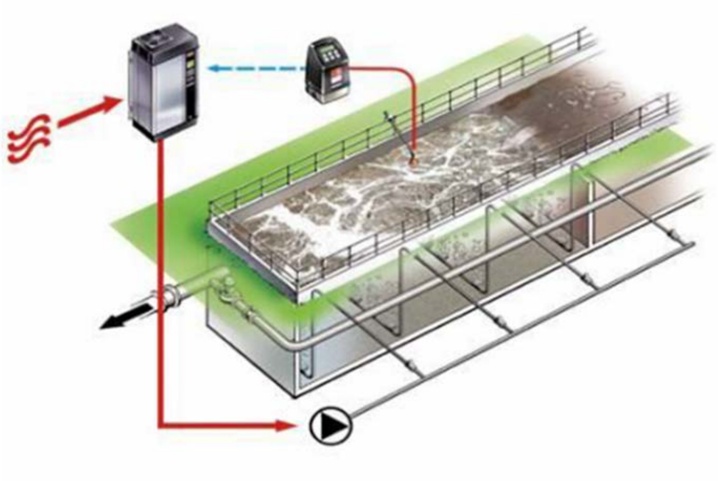


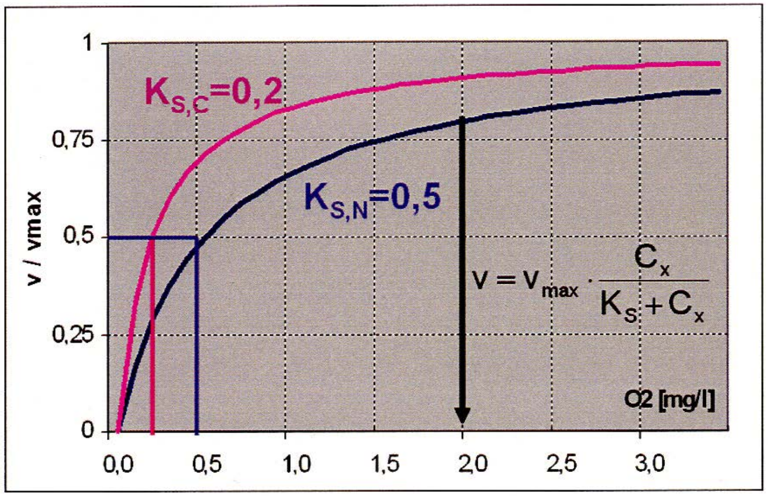


OPTIMIZATION OF AERATION

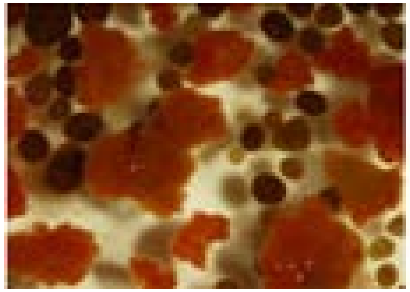
Benefits of NH_4-N control:

- Up to 20% less energy consumption for aeration
- Higher total nitrogen removal performance
- Better removal performance based on good adaptation to process changes e.g. influent quality
- Real-time information of the process → rapid response to problems
- During low loading oxygen concentration can be 0,5 mg/l
- During high loading concentration can be up tp 2,5-4,0 mg/l and enhance nitrification by 5…10 %

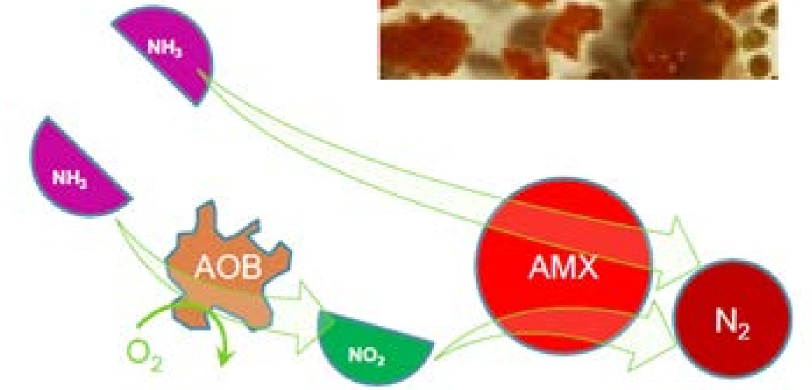




EMERGING NITROGEN REMOVAL TECHNOLOGIES



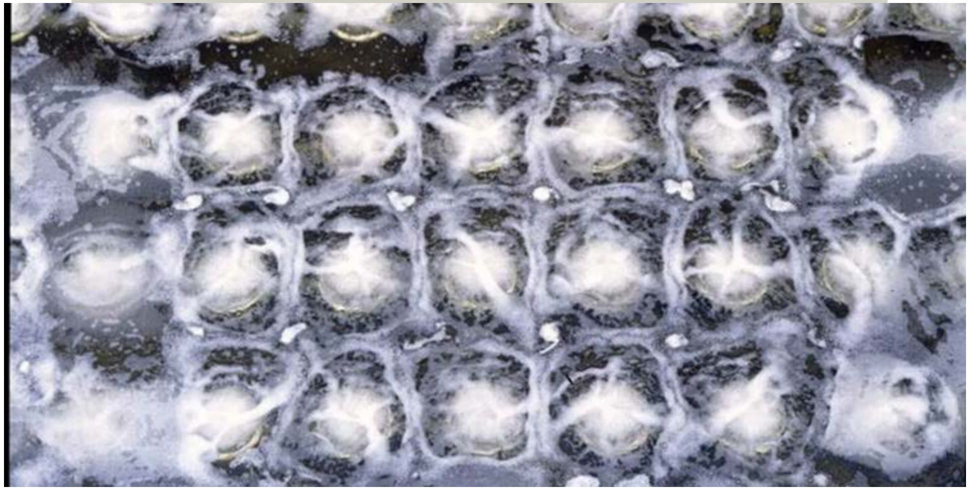
- Anammox is a type of bacteria discovered in the 90s
  - capable of making a “short-cut” in nitrogen removal process
  - very slow growing and sensitive to process conditions
- Many full scale application in reject water treatment
- Pilot tests in main treatment line
- Anammox requires about 40% of the energy of conventional DN process
- Potentially even more energy efficiency with nitrogen recovery processes



CASE EXAMPLES ENERGY SAVINGS ACHIEVED WITH PROCESS OPTIMIZATION AND RIGHT KIND OF EQUIPMENT

CASE HUITTINEN – AERATION SYSTEM

- New aeration system: fine bubble diffusers, diffuser density 10 – 15 %
- Savings achieved→ 865 MWh per year, about 0,2 kWh/m^3
- Oxygen measurement in each zone and zones controlled independently
- NH4-control of oxygen concentration
- Elimination of over aeration
- Savings achieved 200 MWh/a, about 0,05 kWh/m3



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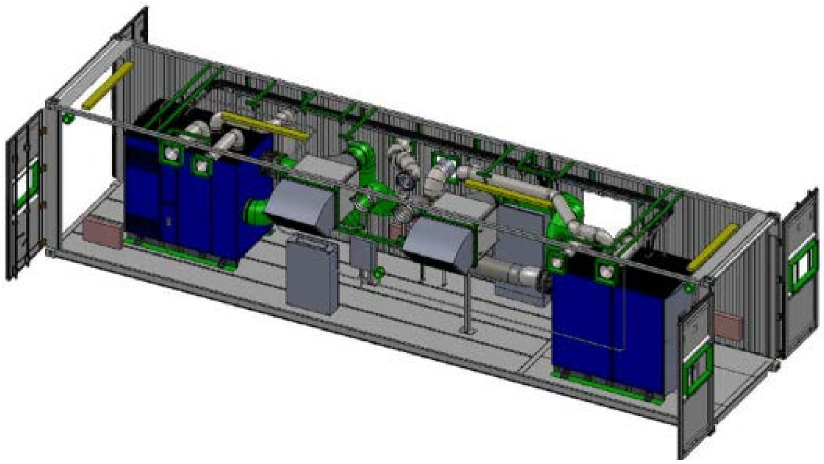
CASE LAPPEENRANTA - COMPRESSORS

- New compressor station
- Purchase criteria was life cycle cost which was calculated with investment price + 10 years of operation costs.
- Good compliance to criteria was verified with tests after start-up.
- 10 years of operation costs equaled to 5 times the investment!!
- The most energy efficient compressor consumed only 60% of the least efficient.
- Pay-back time about 4 years!



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CASE LOIMAA - ENERGY SAVINGS...

- **Screw compressors** vs rotary lobe → saving 14-29 % → 62-158 MWh/a → 15a 90000-230000 € = 2-5 times the investment
- **Aerators** → saving 7-19 % → 28-95 MWh/a
- **Vertical shaft vs horizontal shaft agitators** → saving n. 50 % → n. 138 MWh/a
- **Better efficiency in pumps** → saving n. 10 % → n. 11 MWh/a
- **Control of centrifuge based on suspended solids measurement** → shorter dewatering time → savings n. 10 % → 3 MWh/a

→Savings totally 23-33 %

Heat pump → decrease in heating energy need of about 75 %

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CASE EXAMPLES OF ENERGY RECOVERY ON WASTEWATER TREATMENT PLANTS

CASE KAKOLANMÄKI, TURKU- HEAT RECOVERY

- Heat pump station using WWTP effluent
- Produces district heat and cold for City of Turku in Finland, 15 – 20% of the demand
- Water temperature 5 – 10 ° C
- Energy balance in Kakolanmäki
  - Consumption 17 000 MWh
  - Production 184 000 MWh
    - Digestion 1250 MWh
    - Heat pump 183 000 MWh

Picture: Turku Energia

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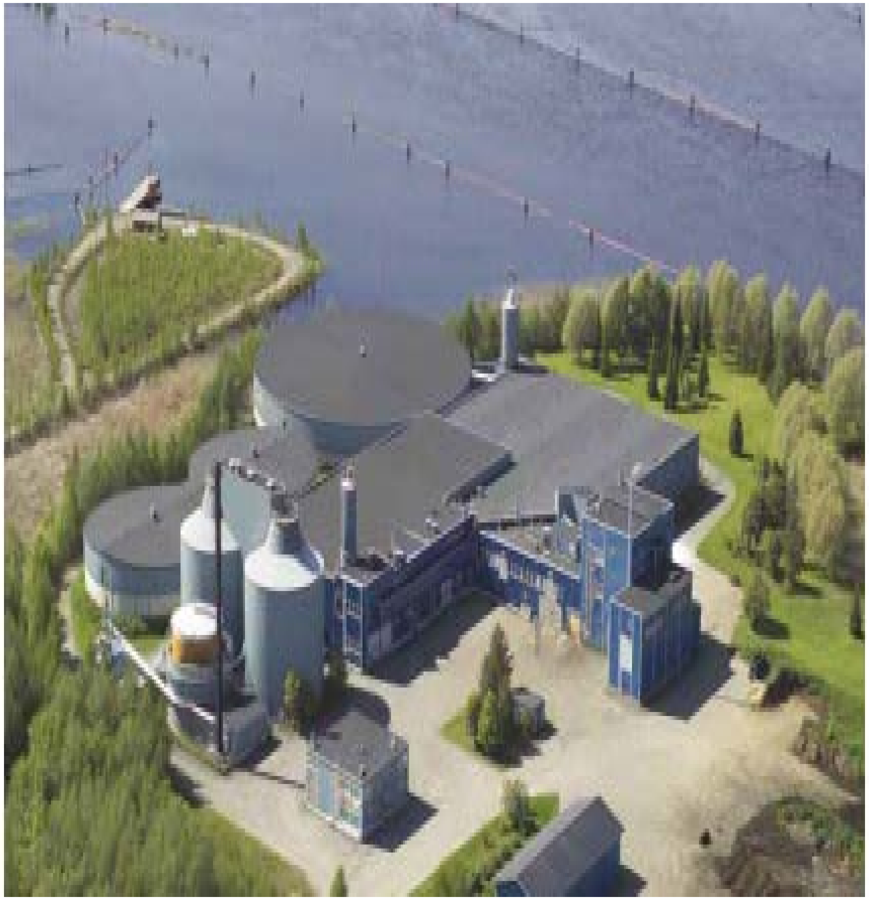
CASE JOENSUU – HEAT RECOVERY

- New district in Joensuu not far away from the treatment plant
- A feasibility study was carried out with the heating from recovery from WWTP effluent
- 50 % less carbon footprint compared with other heating options!
- → no agreement with the energy company
- Example of challenges when working with water and energy sector



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CASE OPTIMIZATION OF DIGESTION, CHP AND ORC

- Digestion
  - Optimization of process conditions
  - Optimization of capacity and external loads
- Combined heat and power
  - Optimization of heat storage
- ORC = organic rankine cycle
  - Produces electricity out of gas engines exhaust gas
  - 15 – 20% recovery to electricity


Picture: Pirjo Rantanen

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EXAMPLES OF DIFFERENT ENERGY INVESTMENTS IN WWTPS

- Solar panels
  - Installed on the roof in Helsinki WWTP
    - Yearly production n. 260 MWh (0,7 % plant's consumption)
    - Fifth largest station in Finland
  - In old treatment plants orientation and position are important
- Wind power
  - Examples e.g. in Germany


HSY


Hamburg Wasser

HOW FORWARD?

- Very big potential in heat recovery
  - Challenges in cooperation with energy side
  - Lack of demand in a right place at the right time
- Where do we consume energy? → Increased metering
- More information and training
- Including energy efficiency in the purchase criteria

  → life cycle costs + analysis on development of energy price
- Energy audits

THANK YOU! QUESTIONS?