Water infrastructure systems: Adapting to new challenges in urban and rural areas

Greet De Gueldre, Manager Strategic Innovation and Climate, Aquafin (Belgium)
“I want you to find a bold and innovative way to do everything exactly the same way it’s been done for 25 years!”
Flemish Region

13,512 km²
6 million inhabitants
470 inh/ha
Large impervious surface
Responsibilities of sewage infrastructure in Flemish Region

Aim 98% collective treatment
Current connection rate: 89%
Currently treated: 82.3%

Separated systems
Combined systems

Local sewerage

Supra-municipal sewage transport and treatment

Surface water

Aim 2% individual treatment
Current: 12% ready

Aquafin
Responsibilitis sewage treatment infrastructure in Flemish Region

Aquafin NV

Supra-municipal sewage transport and treatment

Separated systems
Combined systems

Local sewerage

Municipalities

Citizens

Remote dwelling

Collector Sewer

Overflow (Storage basin)

WWTP

Surface water
Current assets

- Separated systems
- Combined systems

- 87%
- Estimate overflows 2,000
- 32,000 km
- 3,000 PS
- > 13,000 trenches

- 5,743 km
- 1,548 PS / storage basins
- Estimate 4,304

- 7,000 individual treatment installations

Surfaces water

Estimate overflows 2,000

32,000 km

3,000 PS

> 13,000 trenches

87%

Estimate 4,304

5,743 km

1,548 PS / storage basins

293

Surface water

WWTP

7,000 individual treatment installations

Aquafin
Our Challenges

- Budgets vs. increasing costs and demands (assets, growth, operations)
- Compliance with UWWTD, WFD, tighter regulation (enhanced treatment)
- Climate change
- Circular economy perspective

Transition of wastewater treatment infrastructure and operations
Started now
Sustainable solutions
This presentation

Share some sustainable solutions Flanders uses to tackle new challenges
- Adaptation and anticipation to CC
- Combined sewer overflows
- Energy management
- Recovery of phosphorous and other resources
Climate change in Flemish Region

Temperature rise
Annual increase of precipitation of 1-2 %
Change in heavy rainfall conditions of 5-40%
- Winter conditions: more rain
  Days / weeks
  Insufficient conveyance capacity of rivers & streams
  Threat to natural water system
- Summer conditions: more extreme rain events
  Minutes / hours
  Insufficient conveyance capacity of sewer systems
  Threat to urban drainage system
Adaptation and anticipation to CC

Water quantity / stormwater main topic in ongoing further expansion / renovation of wastewater infrastructure

Flemish policy

- Giving space to water key to anticipate stormwater flooding
- Separate sewers mandatory in new/renovation projects unless stated otherwise (2/3 roofed area, 1/3 paved area)
Adaptation and anticipation to CC

Flemish policy (cont.)
- Design of combined sewers, at the latest by 2017, for storm event with return period of 20 years (instead of 5 years)
- Guiding principle for urban drainage/sewerage systems

- Infiltration
- Buffering
- Transport

Solutions rainwater
Integrated stormwater plans

Cities/municipalities urged to develop plans to achieve optimal drainage of sewage and stormwater that also integrate adjacent areas and involve stakeholders

Typical procedure

1. Consultation/communication with local government and stakeholders - Field visits
2. (GIS) Inventarisation local situation/existing drainage
3. Digital terrain mapping
4. Modeling combined sewerage system
5. Expert judgment
6. STORM WATER PLAN
Tailor-made local stormwater plan

Advice on short/middle term solutions to current problems with flooding
Holistic global vision for the future

Examples from case Wetteren (1/19)
Combined sewer overflows (CSOs)

Impact CC on surface water quality due to CSOs
Estimated 6,000 CSOs in Flemish Region
- Intermittent discharges of untreated albeit with storm water diluted wastewater (compliance issue)
- Complex challenge with some CSOs

Case study sewerage system Kessel-lo (Flanders)
- 6% of wastewater flow discharged untreated
- Discharged load vs. treated effluent:
  SS 174%, BOD 154%, COD 30%, nutrients < 10%
CSO management

Flemish policy CSOs
- Design of combined sewers: standards on max number of overflows i.f.o. vulnerability of receiving water
- Environmental performance indicator on CSOs
- Monitoring network of CSOs (since 2003), data on duration and water level of 400 CSOs on supramunicipal sewerage

Current operations supramunicipal CSOs:
- Sewerage network managed as a whole, storage capacity used as much as possible
- Integrated modelling used as a tool
Diverse measures for tackling CSOs

- **REAL TIME CONTROL**
- **DETENTION TANKS**
- **CSO TREATMENT**
- **WWTP/PS UPGRADE**
- **DISCONNECTION**
- **SUDS**
Estimated costs of measures
Energy management

Energy policy declaration of Aquafin of 2011 (hence only applies for supramunicipal infrastructure):

By 2020
- Save 20% primary energy
- Generate 13% green electricity
- Save 20% on transportation (sludge transport and company cars)
as compared to 2010
Total consumption: $790 \, \text{GWh}_{\text{primary}} = 2.6 \, \text{PJ}$

Total cost (transport excluded): 31 million EUR

- **Electricity from grid**: 86.4%
- **Fuel sludge transports/company cars**: 2.3%
- **Natural gas**: 4.2%
- **Purchased steam**: 3.1%
- **Biogas to heat**: 2.2%
- **Biogas to electricity**: 1.5%
- **Transport**: 13 dryers
- **WWTP**: 44 dewatering
- **PS**:
- **17 digestors**:
State of affairs energy plan

Current results: primary energy – 4%, self-produced 4,2%
More investments/budgets needed
- Allow payback time > 10 years
Diverse energy measures

**Reduction primary energy**

- Energy modelling
- Aeration
  - on-line nutrient analysers and control
  - Fine bubble aeration
  - Screw blowers, high speed turbos

**Green electricity production**

- Sludge waters Anammox, Sharon
- Gasification
- Other tech

**Other techn**

- electroporation
  - Innenelektrode
  - BioCrack-Gehäuse
  - Elektrodenkopf

**Cheap digestors**

- From biogas of sludge digestion with CHP optimised
- Cambi

**Co-digestion organic waste not allowed**

- New digestors currently not cost-effective
- Few actions to recover heat
Relation energy - sludge treatment

Further energy from sludge depends on sludge end disposal.
Aquafin produces about 110,000 tonnes DM/year sludge.
Sludge disposal cost about 30 million EUR.
Current disposal route follows Flemish policy:
- Disposal of liquid sludge to agriculture, the cheapest way in many countries, forbidden in Flanders since end 1999 (heavy metals (Zn/Cu!) and/or organic pollutants).
- Sludge to landfill prohibited since 1997.
Sludge line revision in 2020.
Dilemma carbon vs. costs

Thickened sludge 110,000 TDS

Digestion
OM reduction 35%

Dewatering 96,000 TDS

Drying

Electricity/heat from biogas
- Increase with pretreatment
- Sludge lower caloric value

New technologies that produce energy
Not yet proven

Mono-incineration
Authothermal point

Co-incineration
Gate fee function of ODM

Co-incineration cement kiln
10 MJ/kg pellets

Current end-of-sludge contracts
Wastewater as a resource

Recovery of organic material
- Methane: implemented (direct of transformed into electrical energy)
- Sludge pellets:
- Cellulose: research
- Transformation products volatile fatty acids, bioplastics, …: research

Recovery of nutrients
- N potentially interesting
- P depleting essential element, 20% of P used on land ends up in human excreta
- Recovery of P via struvite or from ashes under study

Recovery of heat

Reuse of effluent
P recovery as struvite

PO₄⁻⁻-recovery as struvite possible for 20% of incoming P
1,5 year full-scale at WWTP Leuven (120,000 PE) from sludge after digestion (8m³/h sludge)
- Possible (80%)
- Struvite crystals high degree of purity (Authorisation fertilizer)
- Increased dewaterability
- Harvesting crystals bottleneck
- Currently not financially feasible
Relation P-recovery – sludge treatment

- Thickened sludge
  - Mono-incineration
    - P-recovery from ashes possible
  - Digestion
    - P-recovery in sludge line
    - Co-treatment
  - Increase PO₄ with pretreatment of digestion
  - Research for new technologies

Research for new technologies
Effluent reuse

Flemish Region one of the most ‘water-stressed’ areas in Europe
- Available water resources 1.000 – 1.700 m3/inh/year
- Renewable water estimate 817 m3/inh/year

Water use in Flemish Region (data 2010)

<table>
<thead>
<tr>
<th>Million m³/year</th>
<th>Drinking water</th>
<th>Ground water</th>
<th>Surface water</th>
<th>Storm water</th>
<th>Other water</th>
<th>Total*</th>
<th>Cooling water</th>
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<tbody>
<tr>
<td>Domestic use</td>
<td>226,1</td>
<td>20,0</td>
<td>0,0</td>
<td>25,2</td>
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<td>Industry</td>
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<td>294,5</td>
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<td>Energy production</td>
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<td>1,8</td>
<td>2,2</td>
<td>51,6</td>
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<td>Agriculture</td>
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<td>67,8</td>
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<td>Trade and services</td>
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<td>4,6</td>
<td>1,6</td>
<td>1,7</td>
<td>0,6</td>
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<td>1,4</td>
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<td>Total</td>
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<td>158,0</td>
<td>42,0</td>
<td>34,0</td>
<td>725,2</td>
<td>2923,0</td>
</tr>
</tbody>
</table>

* Total exclusive of cooling water
Current reuse of WWTP effluent

Available volume effluent: 800 million m$^3$/year
Reused: 16.2 m$^3$ = 2% of current water use (cooling water excluded)

- Cost effluent (0.061 EUR/m$^3$) not competitive with surface water
- Often supplementary costs for piping and/or treatment
Conclusions

Building and operating wastewater treatment infrastructure to comply to environmental legislation is main objective of sector

No greenfield situation

Already steadily implementing sustainable solutions

- Solutions are complex and case/site specific, hence general demands might not apply (level of region, EU level)
- All direct stakeholders involved, but not yet link with other sectors
- Available budgets driving factor (total cost of ownership)
- Need for research and demonstration of cost effective solutions