Climate change and wastewater management – a two-way street

49th Central Canadian Symp. on Water Quality

Niagara -on-the-Lake

05 MAR 2014

Peter VANROLLEGHEM

Canada Research Chair in Water Quality Modelling

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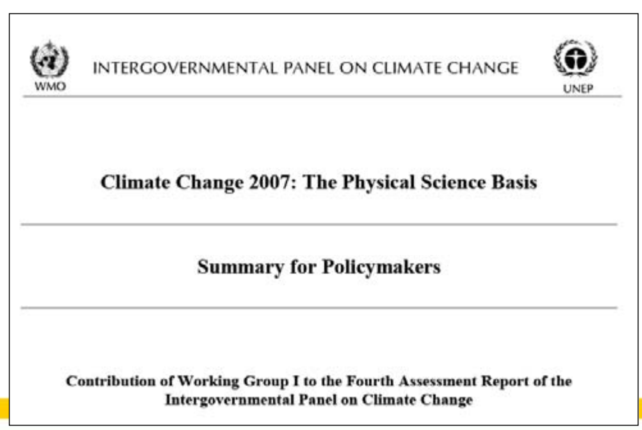
Climate change

- IPCC reports …


INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WMO UNEP

Climate Change 2007: The Physical Science Basis

Summary for Policymakers

Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change

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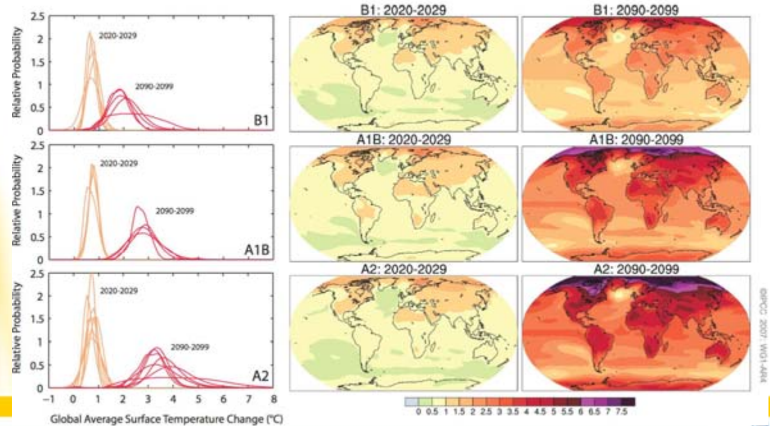
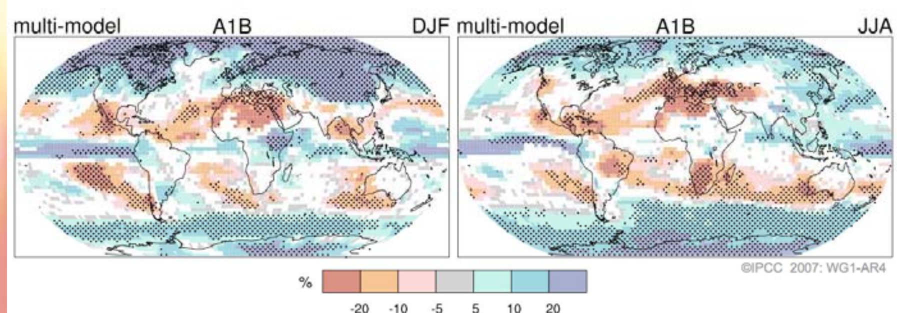
Climate change (cont'd)

- Global warming… (3 scenarios)



Climate change (cont'd)

- … and precipitation (winter - summer)



Potential effects of climate change

- Higher temperatures
  => Faster reaction rates
  - More important algae growth
  - Increased biodegradation activity
  - Faster oxygen depletion

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Potential effects of climate change

- More intense rains
  - More important erosion, more run-off
  - Higher flow rate in (combined & storm) sewers
    - Resuspension and transport of sediments
    - Increased number/volume of overflows

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Copenhagen
Lyngbyvej
16 Aug. 2010
Photo: Bente Schou
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Potential effects of climate change

- More intense rains
  - More important erosion, more run-off
  - Higher flow rate in (combined & storm) sewers
    - Resuspension and transport of sediments
    - Increased number/volume of overflows
    - Overloads on treatment plants (wet weather operation)
  - Higher flow rate in rivers
    - Resuspension and transport of sediments
    - Hydromorphology affected, « eco-hydraulics »

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Potential effects of climate change

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Potential effects of climate change

Questions to be answered:

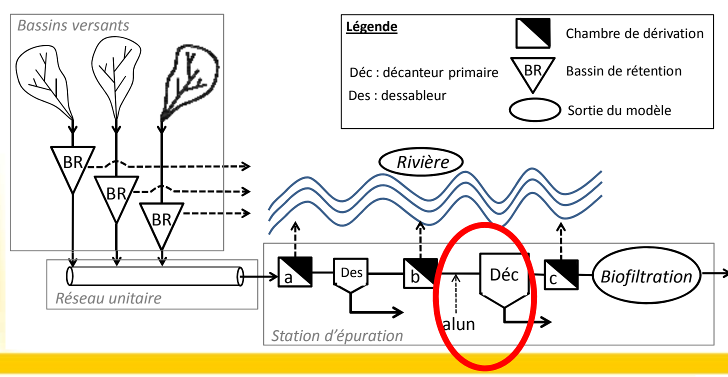
- How to manage infrastructures that have a lifetime of 30 years (wastewater treatment), or even 100 years (storm and combined sewers)?
- What characteristics of these infrastructures must we focus on and develop <u>now</u> in view of the changes (climate and others) we anticipate?
- What can we do?

What can we do? RTC!

- Improved combined sewer retention tank operation

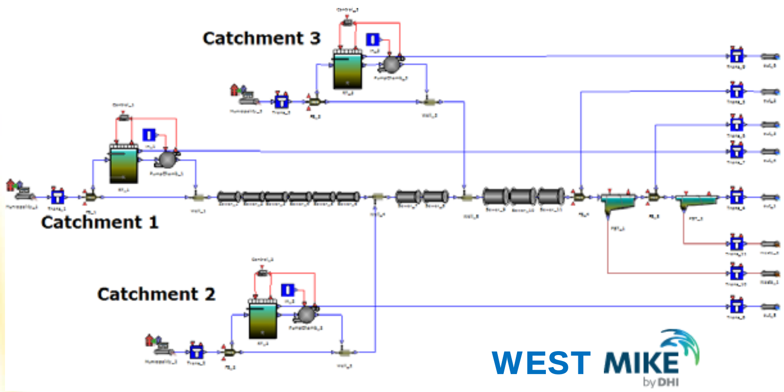
What can we do? RTC!

- Improved retention tank operation to minimize WWTP overload

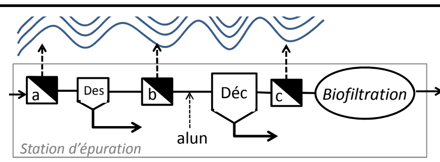


What can we do? RTC!

- Evaluation through integrated WQ simulation



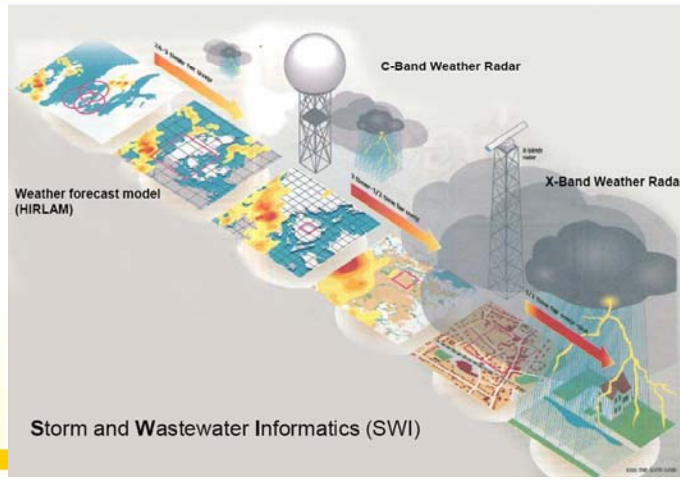
What can we do?



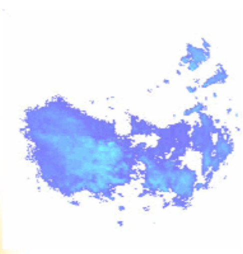
- Discharges for different operating scenarios
  - Optimal emptying scenario depends on
    - Weather forecast
    - Current treatment capacity

	Location of overflow	*Scenario*								
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Discharged Volume (m³)	a	2430	2430	2430	0	0	0	0	0	0
	b	2038	2038	2038	1943	1943	1943	0	0	0
	c	8041	8041	4394	8997	8997	4777	9691	9691	5187
	Total	12509	12509	8862	10940	10940	6720	9691	9691	5187
Discharged Solds (kg)	a	259	259	259	0	0	0	0	0	0
	b	211	211	211	188	188	188	0	0	0
	c	441	136	68	478	147	71	500	154	76
	Total	911	606	538	666	335	259	500	154	76

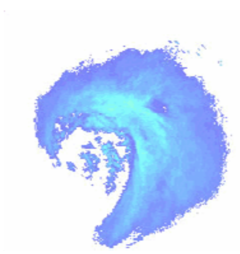
What can we do? RTC!



What can we do? RTC!



Event 1, Stratiform event
Nov 18, 2009 09:10



Event 2, Cyclonic rotation
Nov 18, 2009 16:10

Event 3, Convective event
May 28, 2010 14:00

Source: Michael Rasmussen and Søren Thorndahl

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Wastewater utility GHG

- Greenhouse gases in wastewater systems:
  - CO_2 (Biodeg., energy, chemicals) 1 CO_{2eq}
  - CH_4 (Anaerobic digestion) 18 CO_{2eq}
  - N_2O (Nitrogen removal) 300 CO_{2eq}

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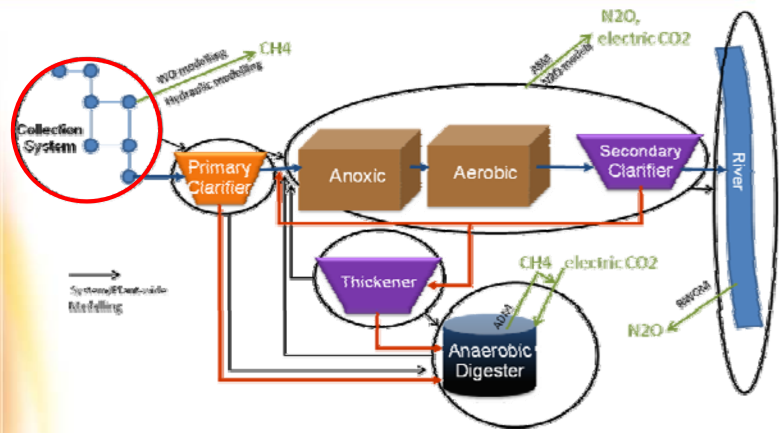
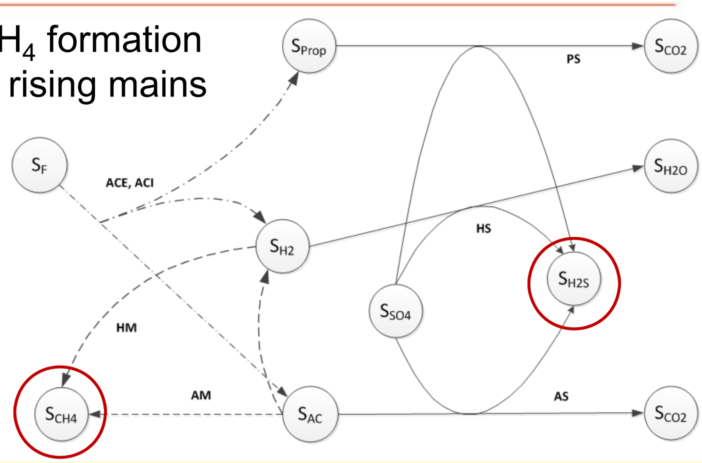
Wastewater utility GHG



GHG in sewer systems

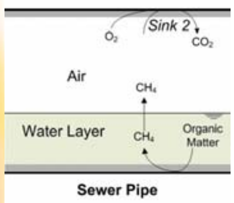
- CH_4 formation in rising mains



Guisasola et al. (2009) Water Res. 43: 2874-2884

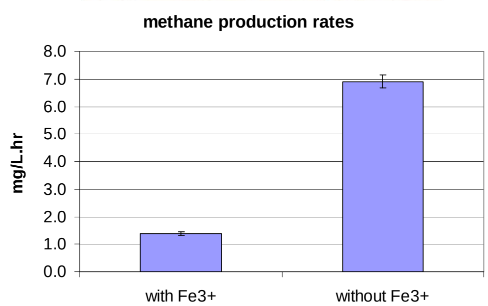
GHG in sewer systems

- CH_4 formation in gravity sewers (with O_2 transfer)



What can we do? Add chemicals!

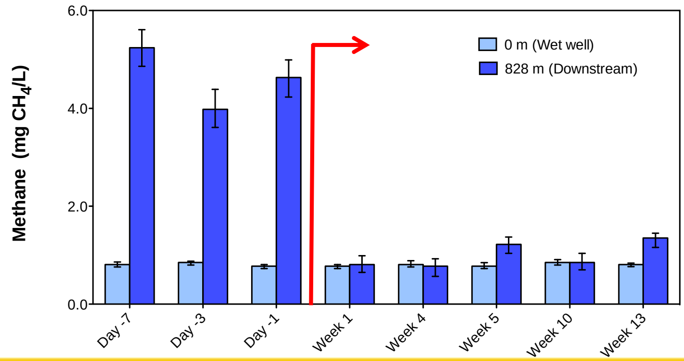
- Chemicals used for sulfide control
  (Brisbane: 6 M$/yr repair → 1 M$/yr chemical addition)
  also reduce methane formation



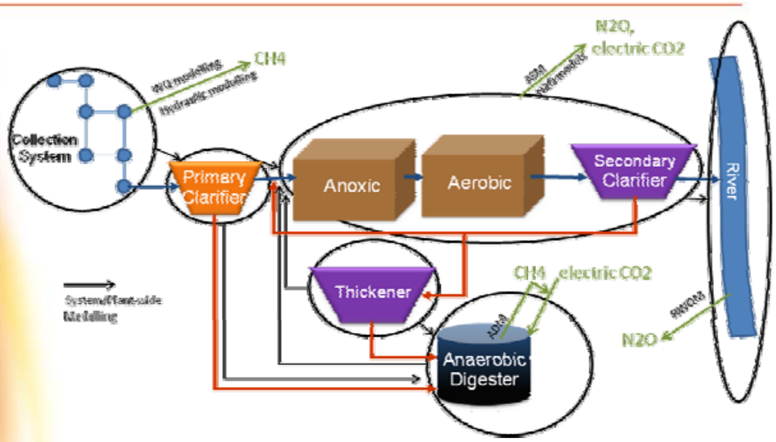
Zhang et al. (2009) Water Res 43(17): 4123

What can we do? Add chemicals!

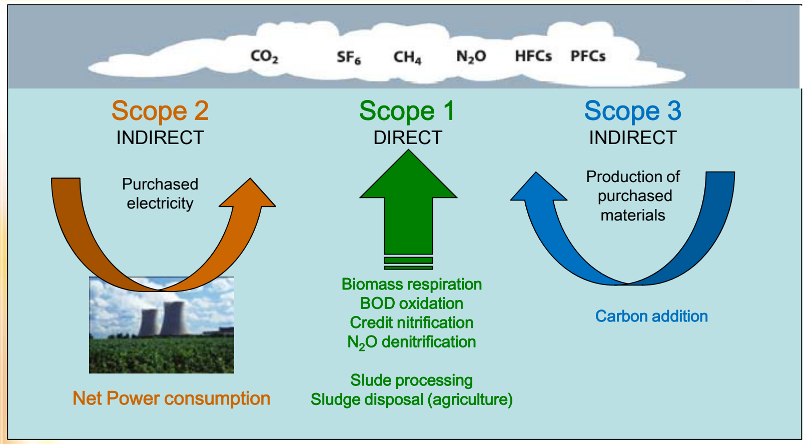
Acidified nitrite was added in the sewer intermittently at 100 mg N/L during Day 0–2 (for 33 hours)



Wastewater utility GHG



GHG emissions from WWTP



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Evaluation of GHG emissions

- Different approaches to estimate GHG emissions:
  - Empirical factors:
    - e.g. IPCC, 2006; LGO, 2008; NGER, 2008
  - Simple comprehensive models:
    - e.g. Cakir and Stenstrom, 2005; Monteith *et al.*, 2005; Bridle *et al.*, 2008; Foley *et al.*, 2009
  - Dynamic deterministic models:
    - ASMG1 (Guo & Vanrolleghem, 2014) → N_2O
    - ADM1 (Batstone et al., 2002) → CH_4

+ complexity

BSM2G benchmarking platform

Corominas et al. (2012)
Biotechnol. Bioeng., 109, 2854-2863

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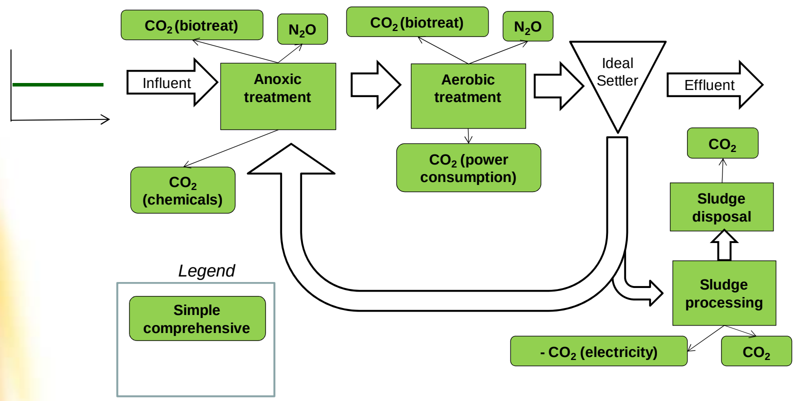
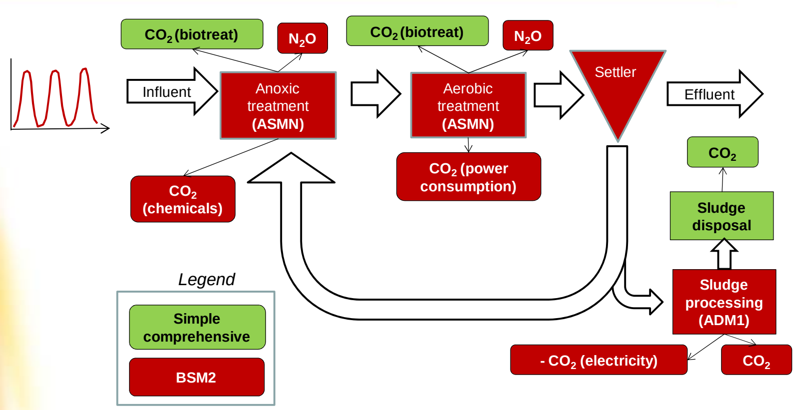
Evaluation of GHG emissions



Evaluation of GHG emissions



Corominas et al. (2012)
Biotechnol. Bioeng., 109, 2854-2863

Evaluation of GHG emissions

- Comparison of ***no control*** and ***yes control*** (DO control in aerobic reactors, DO = 2mg·L^{-1})

Breakdown of GHG emissions (kg CO_2e·m^{-3})	No control	Yes control	%
Bio-treatment GHG emissions	0.451	0.376	-17
Biomass respiration	0.179	0.178	-1
BOD oxidation	0.212	0.212	0
Credit nitrification	-0.168	-0.167	-1
N_2O emissions	0.228	0.152	-33
Sludge processing GHG emissions	0.231	0.231	0
Net power GHG emissions	0.000	-0.038	-
Power	0.311	0.272	-13
Credit power GHG emissions	-0.311	-0.310	0
Embedded GHG emissions from chemical use	0.099	0.099	0
Sludge disposal and reuse GHG emissions	0.193	0.193	0

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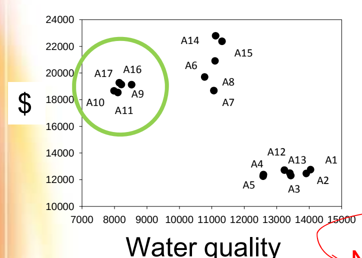
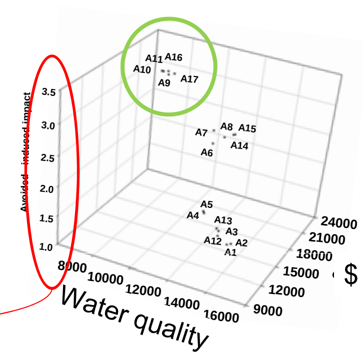
Benchmarking control strategies

- Overall result of our studies so far:
- Compromise between:
  - Effluent quality
  - Treatment costs
  - GHG emissions





New dimension: Greenhouse gases

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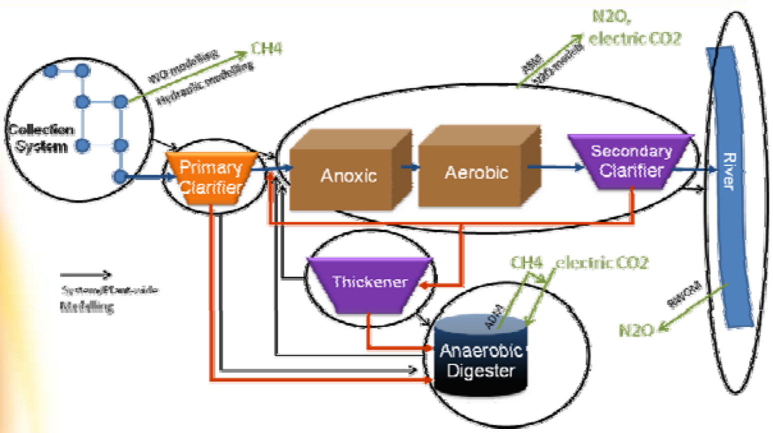
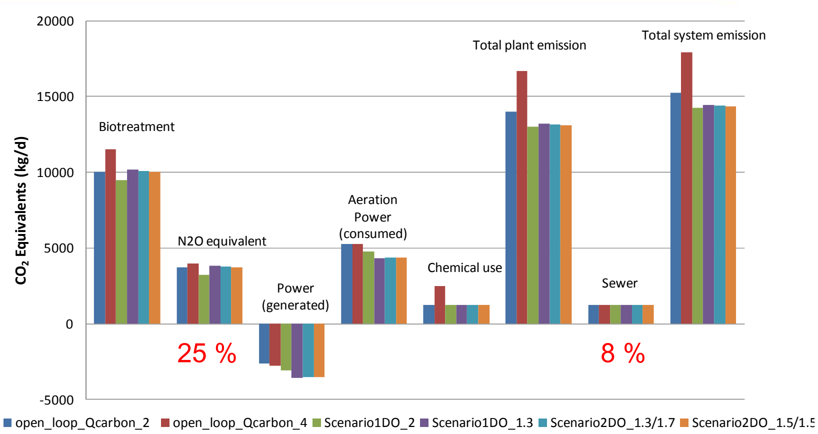
Wastewater utility GHG



GHG emissions from WW utility

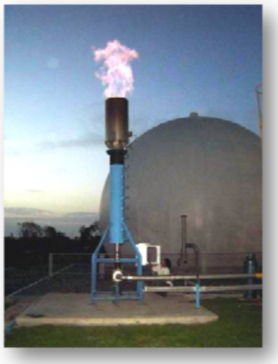


Conclusions

- Climate change and wastewater management - A two way street

Conclusions

- Wastewater systems emit greenhouse gases



The revenge …

Conclusions

- Climate change and wastewater management - A two way street:
  - Mitigation
  - Adaptation

Conclusions

- Mitigation
  - Reduce GHG emissions
    - Sewer → chemical addition
    - WWTP → improved operation, but compromise with effluent quality
- Adaptation
  - Pursue flexibility in long-living WW systems
    - Sewer → Retention tank operation – RTC
    - WWTP → Wet weather handling – RTC

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Acknowledgements

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BIOMATH

Waterschap De Dommel

NORDEA FONDEN

SEVENTH FRAMEWORK PROGRAMME

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