Monitoring and mitigating methane: Danish lessons for global action

27/06/2023

inspiring change

WEBINAR INFORMATION

the international water association
CLIMATE SMART UTILITIES

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WEBINAR INFORMATION

- **‘Chat’ box**: please use this for general requests and for interactive activities.
- **‘Q&A’ box**: please use this to send questions to the panelists.

(We will answer these during the discussions and in post-webinar materials.)

Please Note: *Attendees’ microphones are muted. We cannot respond to ‘Raise Hand’.*

AGENDA

- Welcome and introductions

  Amanda Lake (moderator)

- Introduction to the Danish methane national monitoring programme

  Charlotte Scheutz, Danish Technical University

Q&A

- Legislation and rules implemented based on the national monitoring programme

  Thomas Sørensen, Danish Water and Wastewater Association

Q&A

- Case study – mitigating methane from PRVs

  Anders Fredeslund, DTU

Q&A

- Case study – the methane journey at VCS Denmark

  Per Henrik Nielsen, VCS Denmark

- Q&A Discussion
- Final remarks and conclusion

MODERATORS & PANELISTS

Amanda Lake
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United Kingdom

Charlotte Scheutz
Danish Technical University
Denmark

Thomas Sørensen
DANVA
Denmark

Anders Fredeslund
Danish Technical University
Denmark

Per Henrik Nielsen
VandCenter Syd
Denmark

Introduction to the Danish methane national monitoring programme

ANDERS FREDENSLUND & CHARLOTTE SCHEUTZ, DTU, DENMARK

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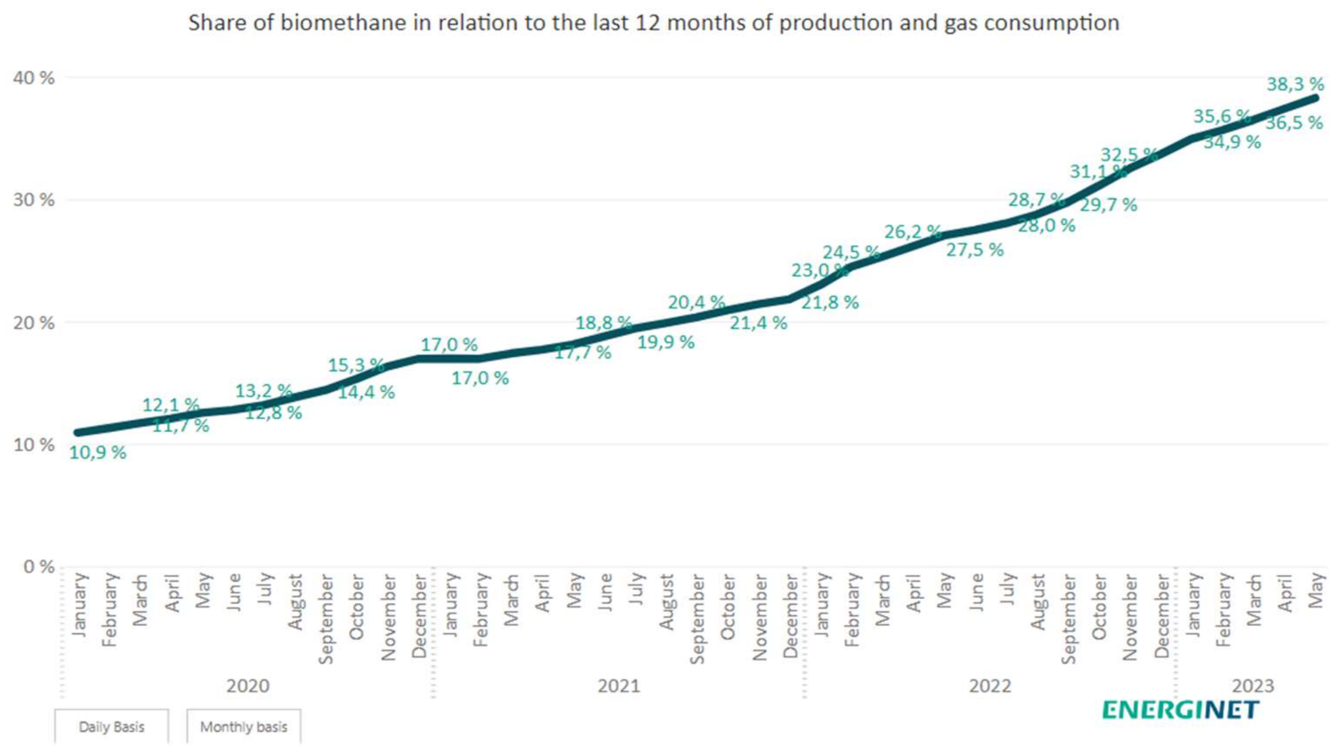
DTU

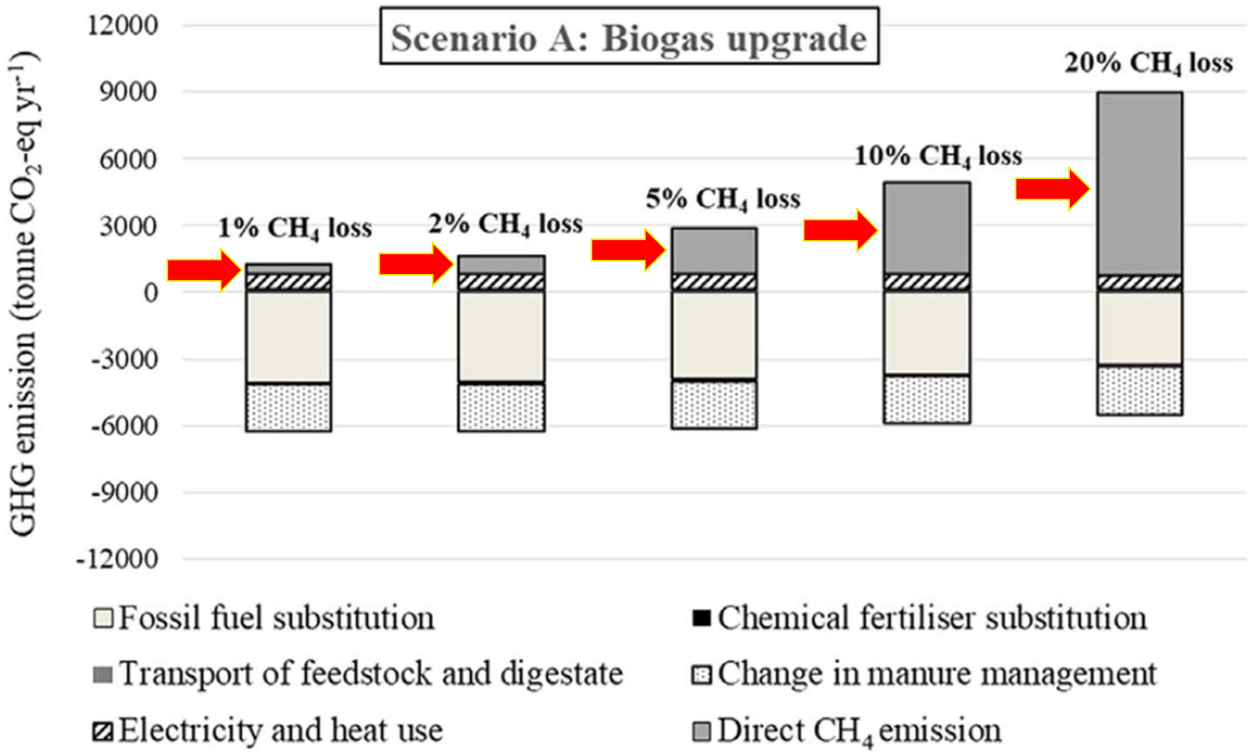
SHARE OF BIOMETHANE IN THE DANISH GAS SYSTEM



~ 40%

METHANE LOSS AND CLIMATE IMPACT

CLIMATE SMART UTILITIES



Scheutz & Fredenslund, 2019. Total methane emission rates and losses from 23 biogas plants. Waste Manage. 97, 38-46

PROJECT OBJECTIVE


Til
Energistyrelsen
Dokumenttype
Rapport
Dato
August, 2021

MÅLRETTET INDSATS FOR AT MINDSKE METANTAB FRA DANSKE BIOGASANLÆG

Biogas plants:

- Assistance in self-control monitoring program
- Assistance in leak finding
- Quantification of methane loss from the plant
- Assistance in minimizing leaks/methane loss

Industry and government:

- Improved knowledge in the field
- Reduction of the total methane loss from biogas to 1%
- Revision of national emission factors for Danish biogas

RAMBOLL Bright ideas. Sustainable change. DTU Miljø Institut for Vand og Miljøteknologi FORCE TECHNOLOGY TEKNOLOGISK INSTITUT Energistyrelsen

PROJECT CONTENT

- **Task 1: Build and disseminate knowledge to reduce methane loss**
  - Development of self control programs for biogas facilities and determination of BAT
  - Guidance materials for the biogas industry to reduce methane loss
  - Facilitate experience between biogas producers on reduction options
  - Feasibility studies, individual plants

- **Task 2: Measurement program**
  - Development, QA, best practice regarding measurements of methane emission
  - Leak search on biogas plants
  - Quantification of methane emissions (total emission and selected point sources)
  - Establishment of a national database on emissions for national GHG reporting
  - Contribute with suggestions regarding regulation / conditions for subsidies in the future

PARTICIPATING BIOGAS PLANTS

- 60 biogas plants – 35 agricultural plants and 25 wastewater treatment (WWTP) and industrial plants
- 45% of the Danish biogas production
- Previous measurements from additional nine plants included in calculating emission factors
- Variety of plants:
  - Type of plant (agricultural, WWTP)
  - Size (magnitude of gas production)
  - Gas utilization (CHP, biomethane, off-site utilization)
  - Construction year

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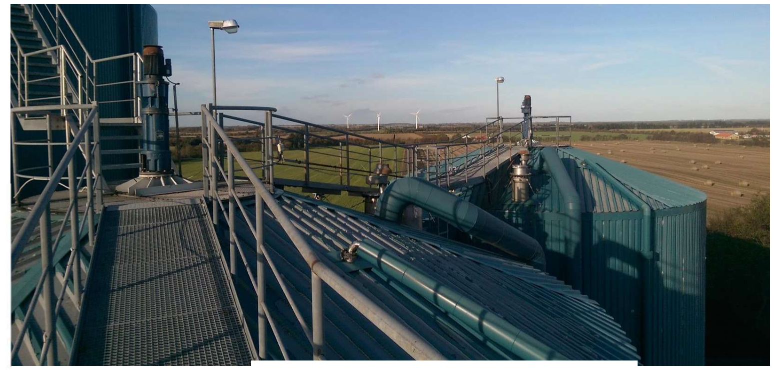
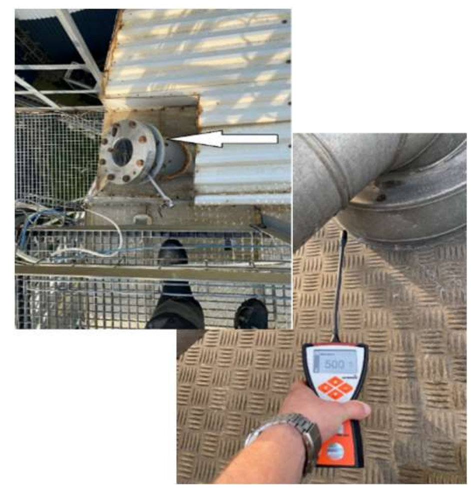
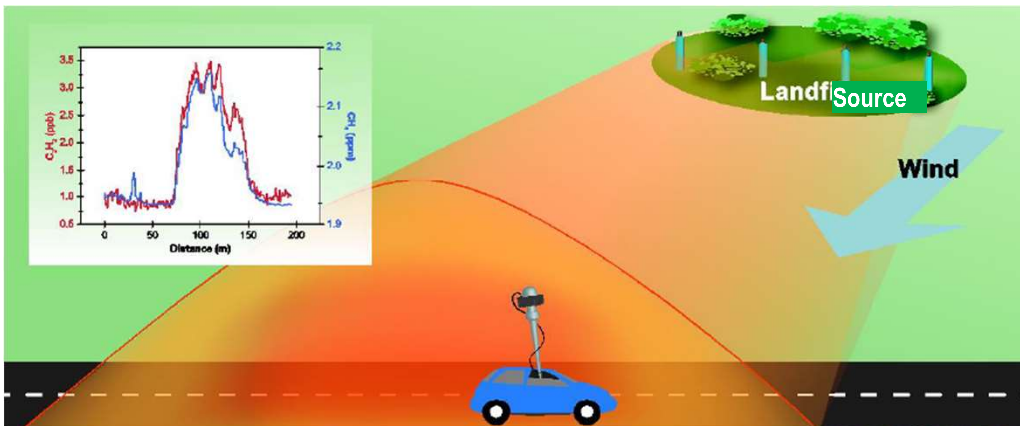
METHANE LEAK SEARCH

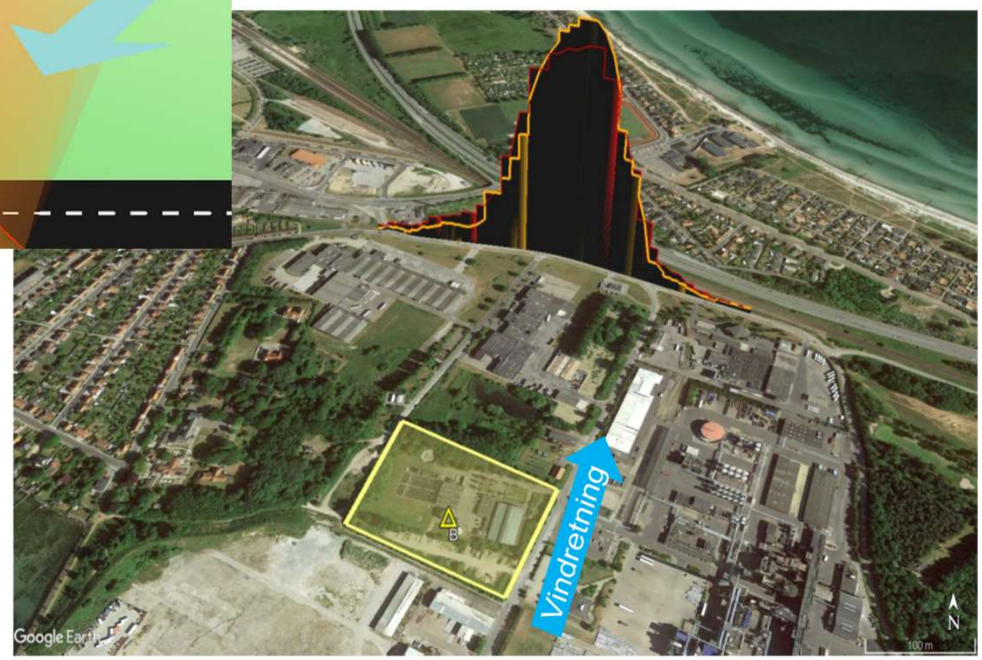


Methane sniffer



QUANTIFICATION OF WHOLE SITE METHANE EMISSION





The method is:

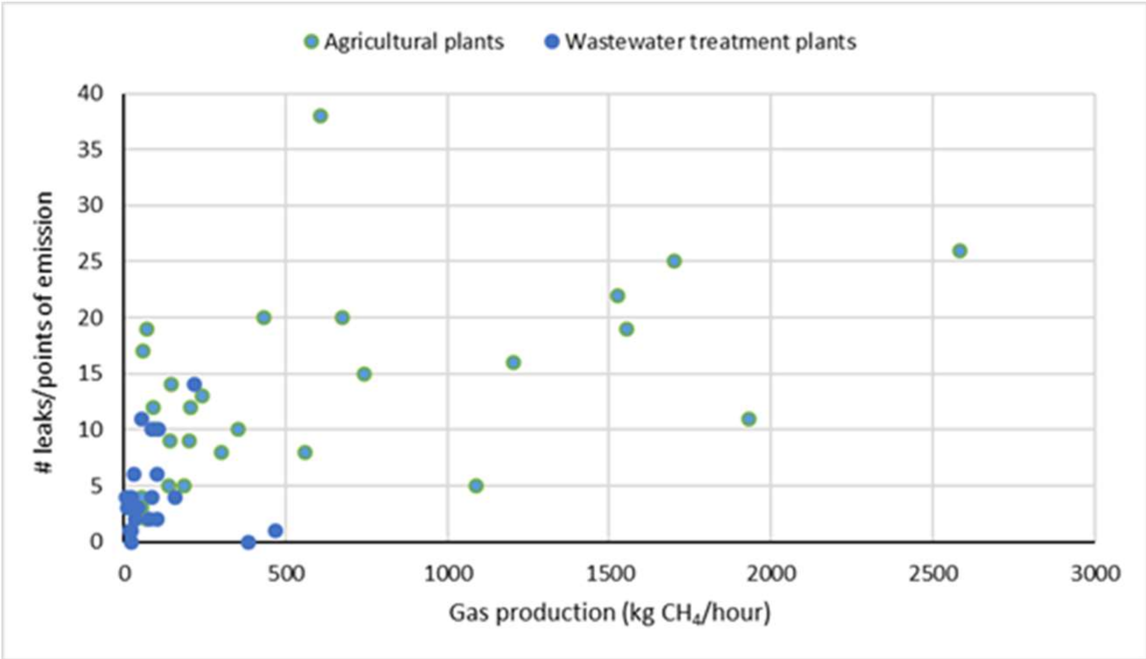
- Well-documented (control test and international comparison tests)
- Certified
- Applied at many different sources

IDENTIFIED METHANE LEAKAGES

Most common leaks

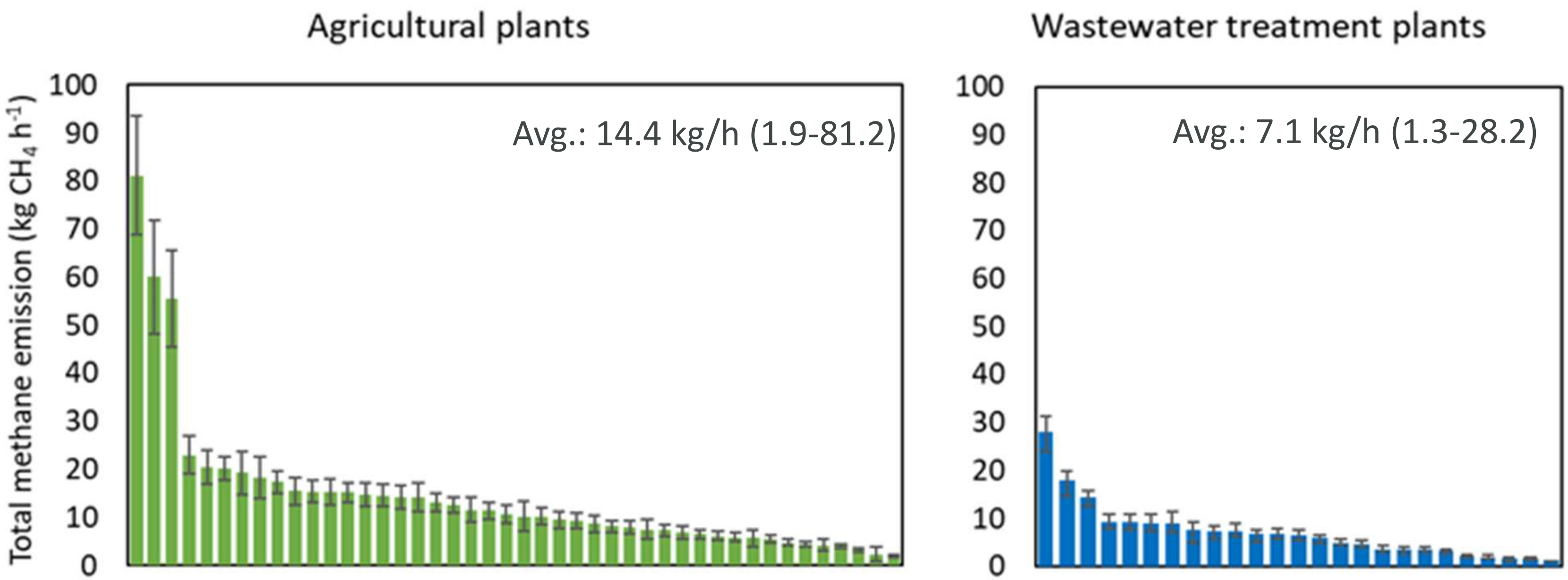
- Pressure relief valves on digesters
- Biomass storage w/o gas collection (especially WWTP)
- Leakages at gas bearing components

(gas storage, piping, inspection hatches and more)



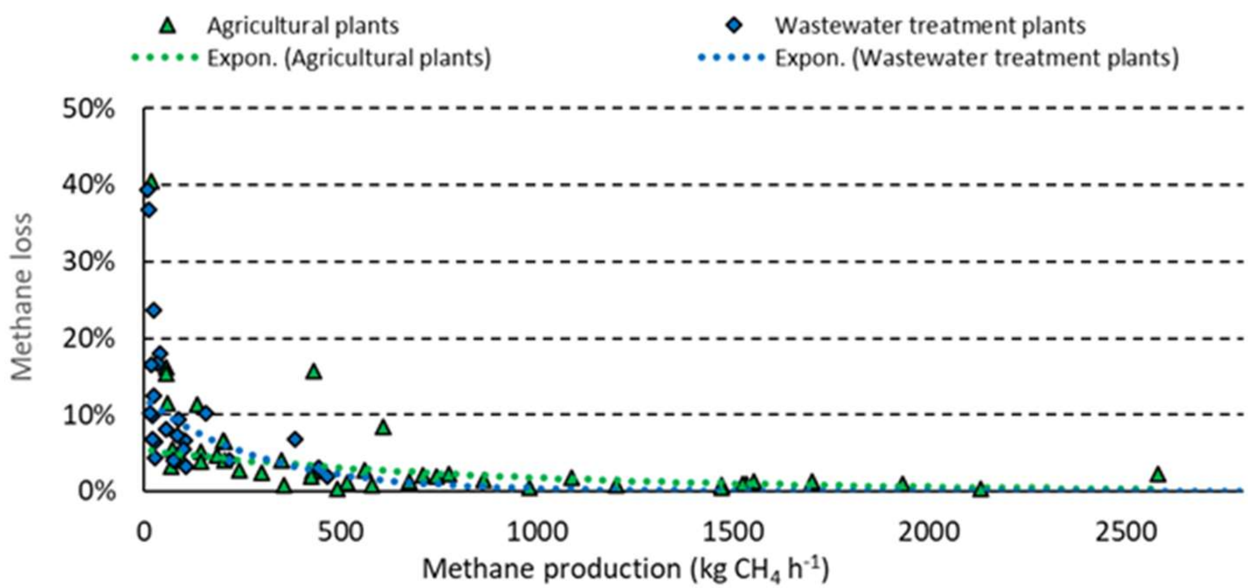
Fredenslund, A.M., Gudmundsson, E., Falk, J.M., & Scheutz, C. 2023. Waste Manage. 157, 321-329.

WHOLE PLANT METHANE EMISSIONS (KG CH_4/H)



Fredenslund, A.M., Gudmundsson, E., Falk, J.M., & Scheutz, C. 2023. Waste Manage. 157, 321-329.

PLANT METHANE LOSS (% OF METHANE PRODUCTION)



Average plant methane loss (%)

Plant type	Number of plants	Methane loss (%)
Agricultural plants	44	4.7
Wastewater treatment plants	25	11.3
All types	**69**	**8.0**

Fredenslund, A.M., Gudmundsson, E., Falk, J.M., & Scheutz, C. 2023. Waste Manage. 157, 321-329.

METHANE EMISSION FACTOR (%, WEIGHT-BASED PRODUCTION)

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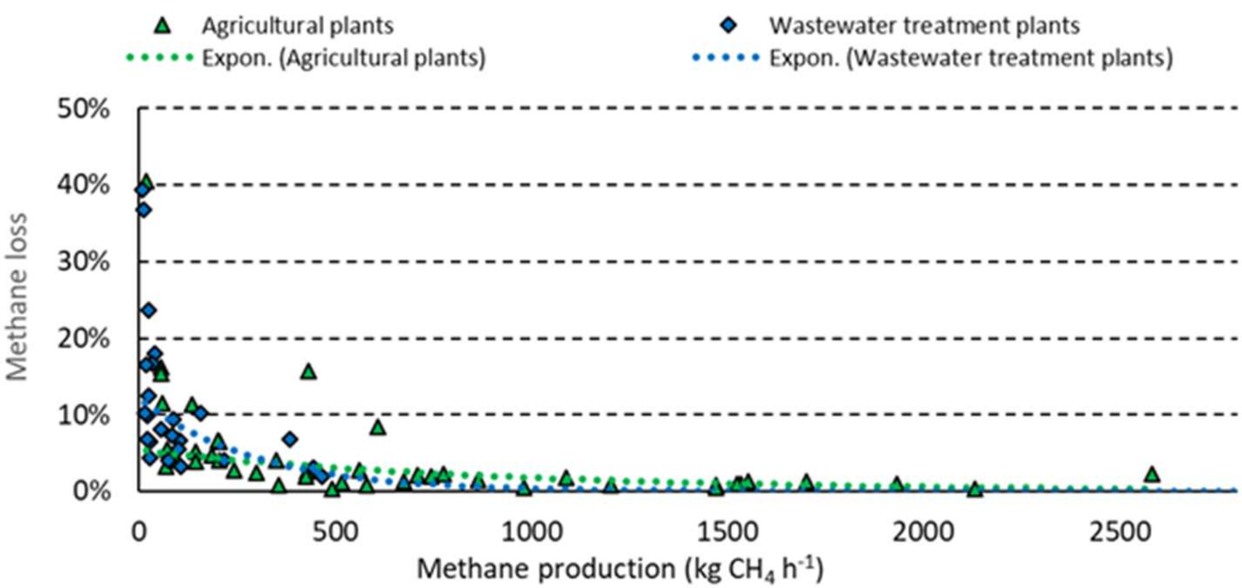


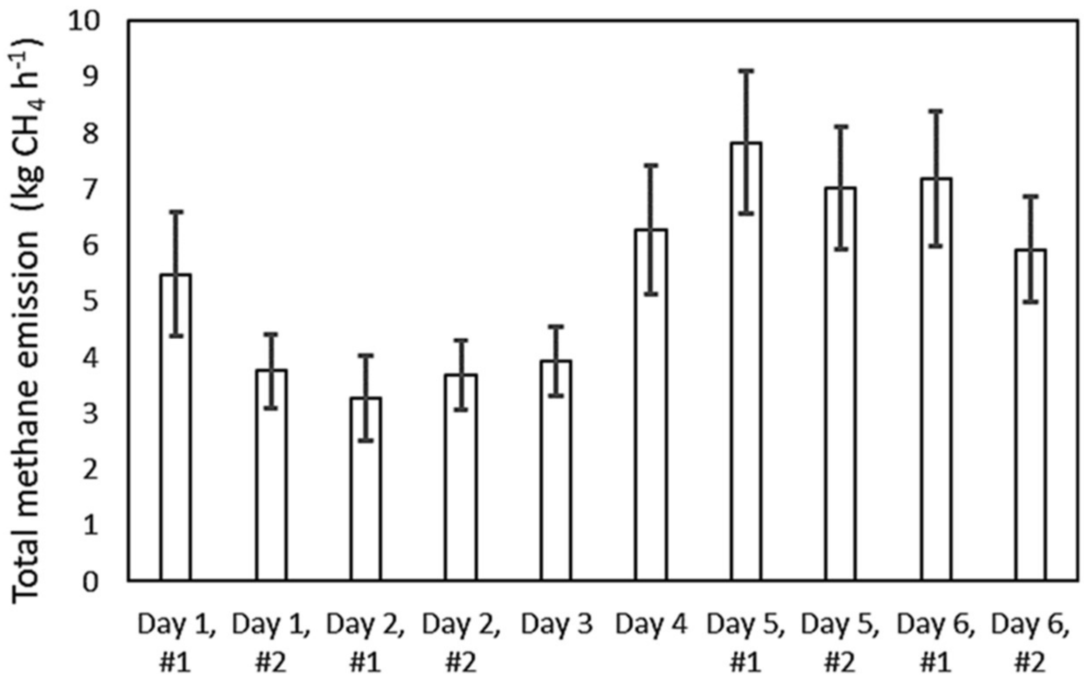
Production weight-based methane EF (%)

Plant type	Number of plants	Emission factor (%)
Agricultural plants	44	2.1
Wastewater treatment plants	25	6.7
All types	**69**	**2.5**

Current EFs are 1.3% for WWTPs and 4.2% for agricultural

Fredenslund, A.M., Gudmundsson, E., Falk, J.M., & Scheutz, C. 2023. Waste Manage. 157, 321-329.

METHANE EMISSION DYNAMICS AT A WWTP



Fredenslund, A.M., Gudmundsson, E., Falk, J.M., & Scheutz, C. 2023. Waste Manage. 157, 321-329.

CONCLUSIONS

- High variation in methane emissions (kg CH_4/h) and methane loss (% of production) between biogas plants
- Smaller plants had higher losses than bigger and more recently built plants
- WWTPs had higher methane losses than agricultural plants
- Important contributors to methane emission from biogas production:
  - Pressure relief valves on digesters
  - Biomass storage w/o gas collection (especially WWTP)
  - Leakages at gas bearing components (gas storage, piping, inspection hatches and more)
- Methane losses were higher than expected
- It is technically possible to operate a plant with a loss less than 1% (national target set by Danish biogas producers)
- More insight into methane emission dynamic is needed

CONTACT INFORMATION

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Anders Fredenslund

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What to know more

- Fredenslund, A. M., Gudmundsson, E., Falk, J. M., & Scheutz, C. 2023. The Danish national effort to minimise methane emissions from biogas plants. Waste Management, 157, 321-329.
- Scheutz, C., Fredenslund, A.M. 2019. Total methane emission rates and losses from 23 biogas plants. Waste Management, 97, 38-46.
- Delre A., Mønster J., Scheutz C., 2017. Greenhouse gas emission quantification from wastewater treatment plants, using a tracer gas dispersion method. *Science of the Total Environment*, 605–606, 258–268.
- Samuelsson, J., Delre, D., Tumlin, S., Hadi, S., Offerle, B., Scheutz, C. 2018. Optical technologies applied with on-site and remote approaches for climate gas emission quantification at a wastewater treatment plant. *Water Research*, 131, 299-309.
- Delre A., Mønster J., Samuelsson J., Fredenslund A. M., Scheutz C., 2018. Emission quantification using the tracer gas dispersion method: the influence of instrument, tracer gas species and source simulation. *Science of The Total Environment*, 634, 59-66.
- Delre A., ten Hoeve M., Scheutz C., 2019. Site-specific carbon footprints of Scandinavian wastewater treatment plants, using the life cycle assessment approach. *Journal of Cleaner Production*, 211, 1001-1014.
- Yoshida, H., Mønster, J., Scheutz, C. 2014. Plant integrated measurement of methane and nitrous gas from a municipal wastewater treatment plant. *Water Research*, 61, 108-118.

Link to the report on methane losses from Danish biogas plants:
https://ens.dk/presse/ny-rapport-om-metantab-fra-danske-biogasanlaeg

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Q&A

MODERATOR: AMANDA LAKE

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LEGISLATION AND RULES IMPLEMENTED BASED ON THE NATIONAL MONITORING PROGRAMME

THOMAS SØRENSEN, DANISH WATER AND WASTEWATER ASSOCIATION (DANVA)

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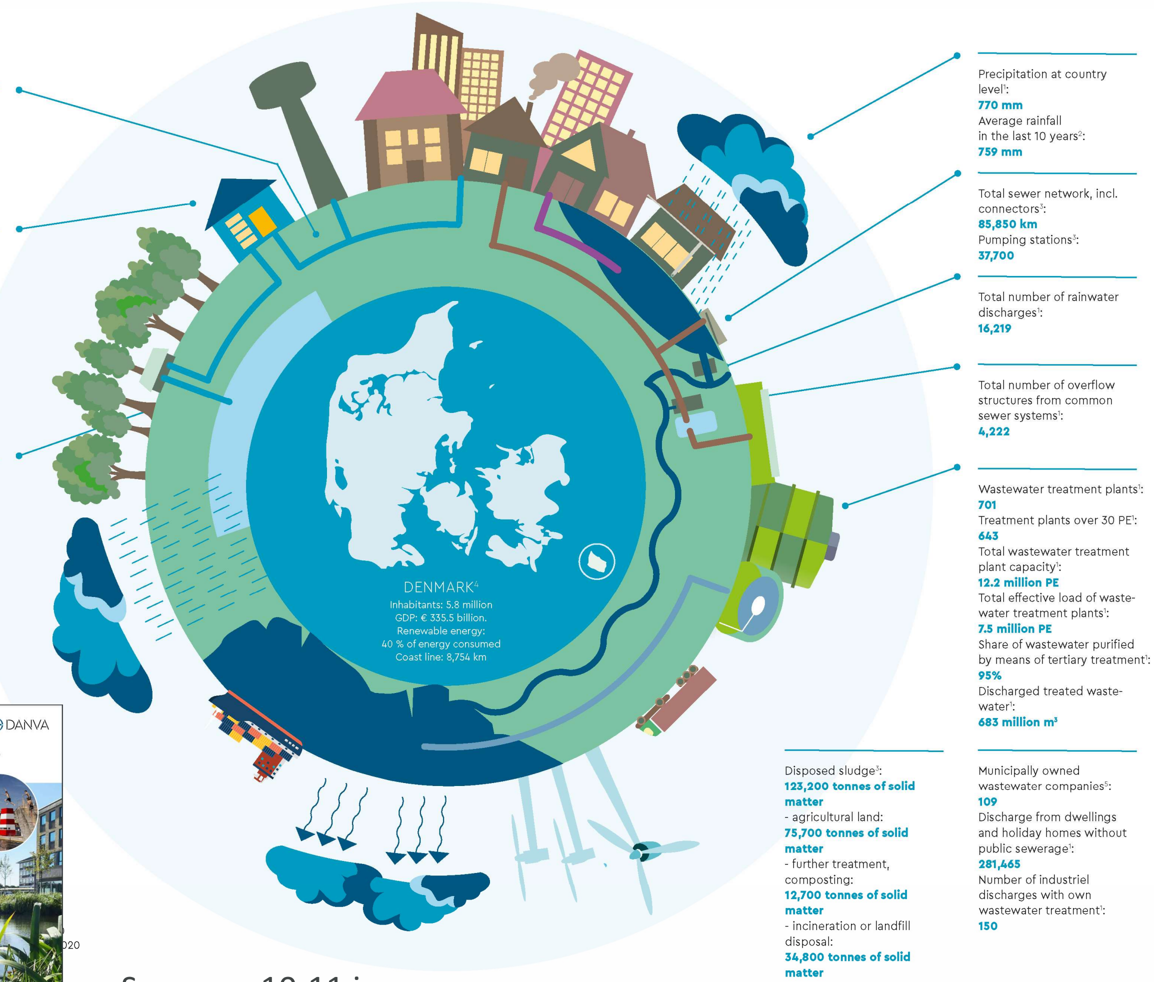
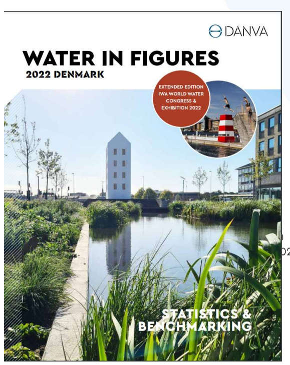
Danish Watersector





See page 10-11 in
www.danva.dk/waterinfigures

Inhabitants in Denmark: ~ 5.8 million

Drinking water:
Number of waterworks: 2.400
Annual extraction ~ 370 million
100% groundwater, simply treated, no chlorine added

Wastewater:

- 102 Companies
- 643 WWTP above 30 PE
- Annual treatment of Wastewater: 7-800.000.000 m3
- Biogasplants situated at WWTP: ~ 50

- Total annual turnover water services: 2.3 billion euro
- 100 % public owned
- Financed exclusively through tariffs

STORYLINE FOR METHANE REGULATION

2020: The Danish government has set a target of a 70% reduction in CO_2 in 2030, based on the state's national climate accounts.

2021: The Danish Minister of the Environment set a goal of energy and climate neutrality in 2030 for the Danish water sector. The biggest scope 1 emission is nitrous oxide, followed by methane.

2021: New methane report on biogas plants: Average emission: 7,7 % based on 25 WWTP.

National CO_2 accounting: Emission from biogas plants set to 1,3 % of production.

2021: COP 26 Glasgow: Agreement om methane reduction by 30 % signed by the Danish Minister of energy.

2022: Climate agreement on green electricity and heat 2022: “Denmark Can Do More II”:

- The government will advance and increase biogas production.
- A regulation of methane loss from biogas production is introduced, which limits methane loss as much as possible.

2023: **On January 1. new rules for methane loss from biogas plants were implemented**

LEGISLATION AND RULES

CLIMATE SMART UTILITIES

The Ministry of Climate, Energy and Supply implemented a new set of requirements starting from 1. january 2023.

- Requirements for a self-monitoring program
- An annual review and leak detection of all biogas plants in Denmark
  - There is a requirement for the rectification of errors/leaks that are listed in the report.

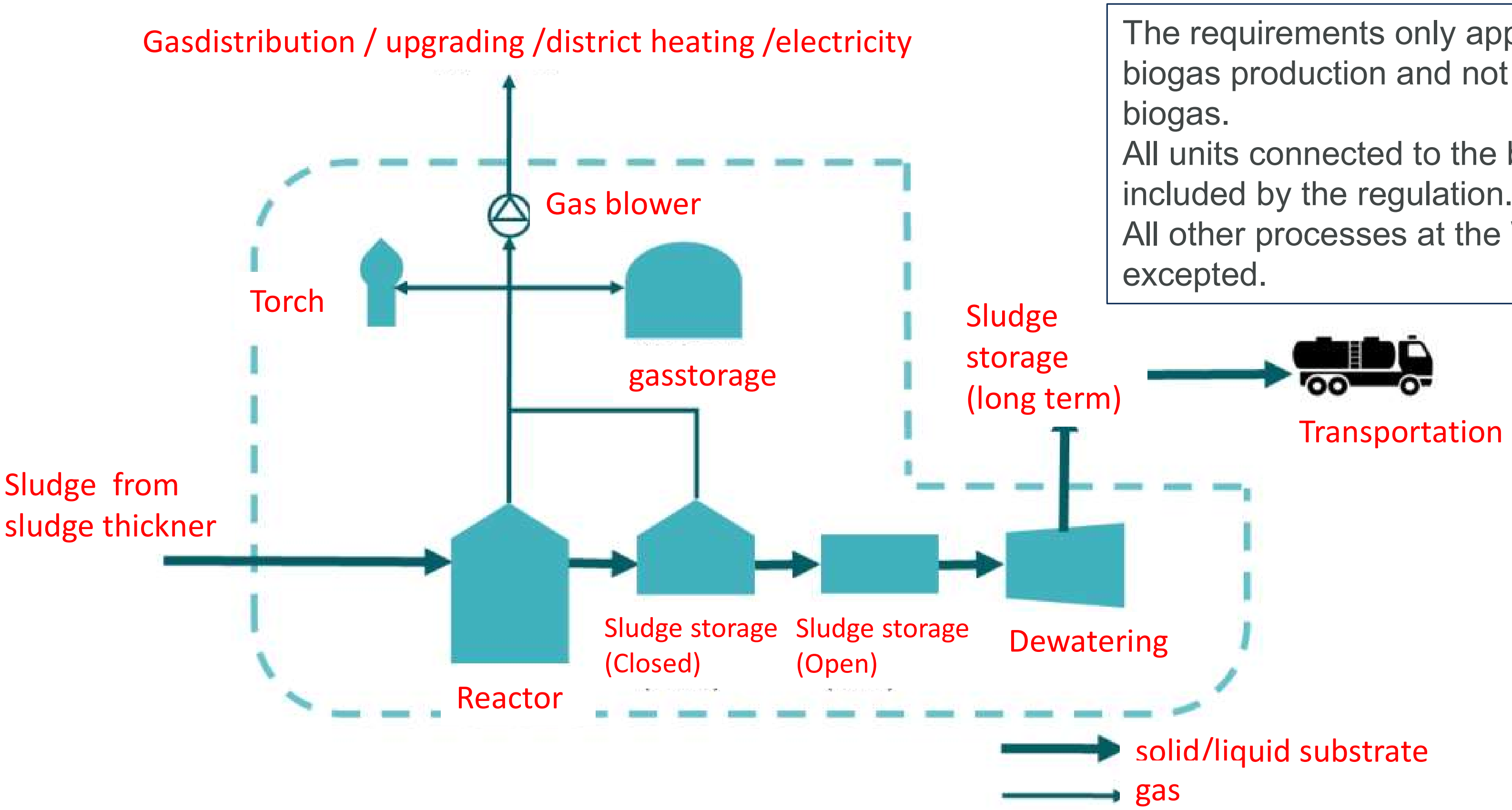
And maybe later:

- The emission from gas engine and methane upgrading plants: max. 1 %

The goal is to manage the operation and maintenance of facilities and thereby not to have a specific measurement from each plant.

The goal is an emission of 1 % of production from the biogas plants in Denmark.

BOUNDARY AT THE WWTP



The requirements only apply to WWTP with biogas production and not to WWTP without biogas.
All units connected to the biogas plant are included by the regulation.
All other processes at the WWTP are excepted.

REQUIREMENTS FOR A SELF-MONITORING PROGRAM:

Purpose:

Minimizing methane loss by

Weekly, monthly and annual self-monitoring program.

A template has been prepared to help the Biogas plant who did not already have an adequate self-monitoring program.

The program must be prepared in collaboration with an external company

Focus points:

- Coverings
- Pipe penetrations
- Valves
- Fittings

Methods:

- Gas sniffer
- Gas chamber
- Visual and auditory control
- Soapy water
- Closeness

AN ANNUAL REVIEW AND LEAK DETECTION PROGRAM

The annual review should be carried out by <u>an external independent company</u>

The companies shall be pre-approved by the Danish Energy Agency.

- There is a list of approved companies at the Agency's website. (7 companies)

The Agency has published a template for reporting and a guidance on how the review should be carried out.

The review results in a report on methane emissions and requirements for improvement.

The report shall be sent to the WWTP and to the Danish Energy Agency.

The review must be carried out every year - however with the possibility of a reduced frequency if the WWTP are doing well.

AN ANNUAL REVIEW AND LEAK DETECTION PROGRAM

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An annual review and leak detection program of all biogas plants by <u>an external company</u>:

- Leak detection on all gas-carrying components
  - Valves, pipes, covers, fittings
- Identifying any other sources of methane loss
  - Open sludge storage is probably the biggest problem on WWTP

The report must contain:

- That the self-control program has been reviewed and checked
- Findings below the “signifikant - limit“ added to the self-monitoring program.
- Findings above the “signifikant - limit and recommendations for rectifying these.
- Other sources and recommendation for improving these.

Issues:
- Definition of ”Signifikant limit”
- Responsibility for recommendations

- The WWTP is obliged to implement the listed leakage/findings/errors.

EMISSION FROM GAS ENGINE AND UPGRADING PLANTS

In the initial legislative work, there was a desire to set requirements for the emissions from the gas engine and methane upgrading plants to maximum 1 % of the gas production.

Problems:

- The goal was very ambitious because it is almost impossible to have a gas engine with emission below 1 % - applies to both for new or newly refurbished engines.
- Two different agencies will set different requirements for the same emission from the same gas engine:
  - The Danish Energy Agency will set requirement for methane (new requirement)
  - The Danish Environmental Agency already have requirement for Nox (existing requirements)

The 2 agencies have to discuss in more details how a claim can be made. Requirement will be introduced later.

From 1. January 2024 a requirement is introduced for upgrading plants on maksimum 1 % emission.

Only one or two WWTP have upgrading plants for biogas.

SUMMARY: LEGISLATION AND RULES

- The new regulation is based on the concept that a maintained plant and on-going review of the facilities will ensure as little methane leakage as possible.
- It is chosen not to make a requirement for measuring “The total methane emission from the plant”.
- Point sources:
  - Upgrading plants: < 1%, Gas engine: Demands are coming later
  - Open sludge storage: Perhaps a requirement for cover

The Danish Energy Agency has a website with the related material as “Guideline for review and leak detection”, “Template for reporting the review” and “Template for self-monitoring program”. And the list of pre-approved external independent companies. Link (only in Danish)

QUESTIONS?

Thomas Sørensen
Manager of data and Benchmarking
Mail: TS@danva.dk

Water in figures

(always latest version):

www.danva.dk/waterinfigures

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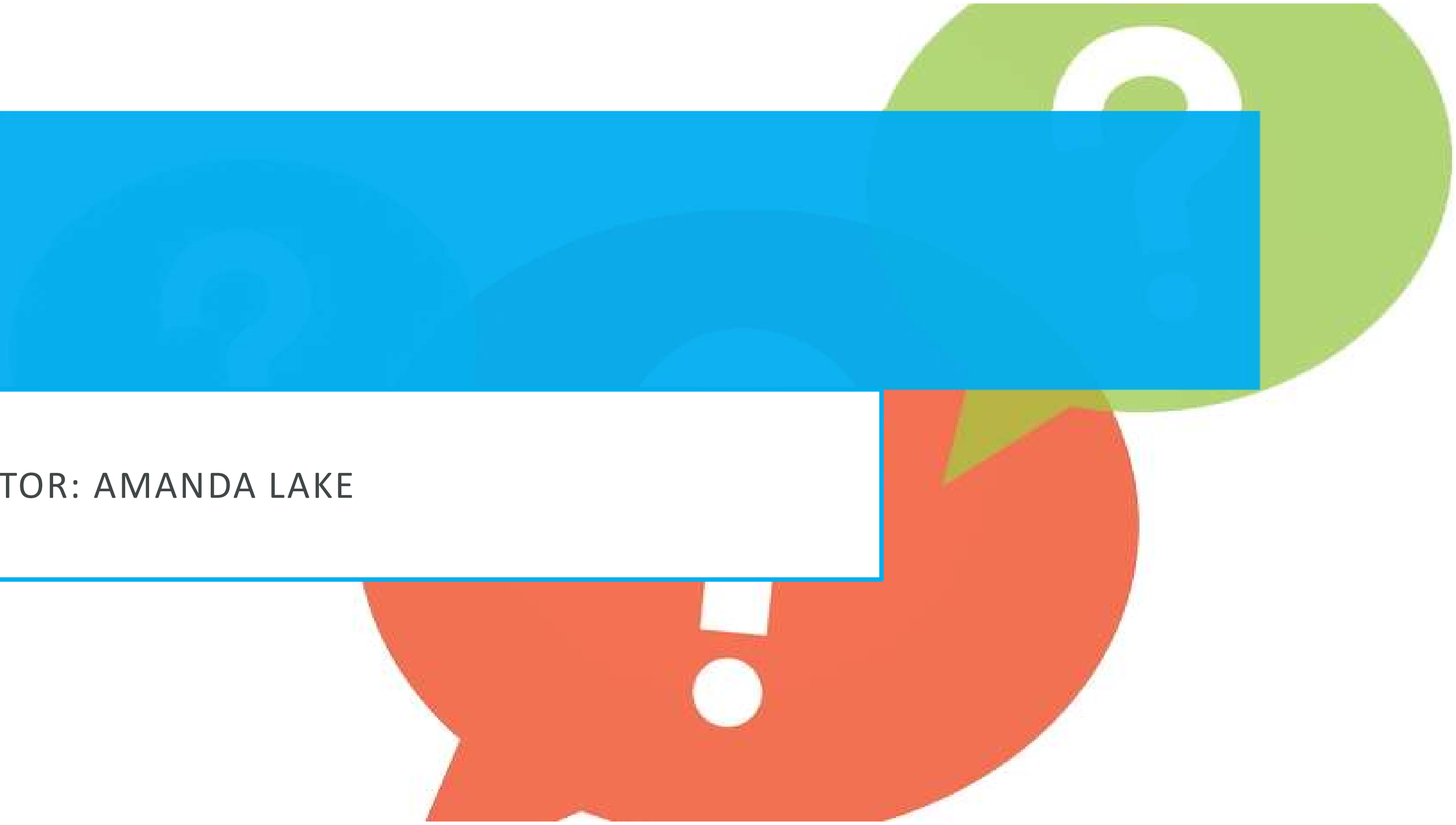

Q&A

MODERATOR: AMANDA LAKE

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Case study – mitigating methane from PRVs

ANDERS FREDENSLUND & CHARLOTTE SCHEUTZ, DTU, DENMARK

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DTU

AGENDA

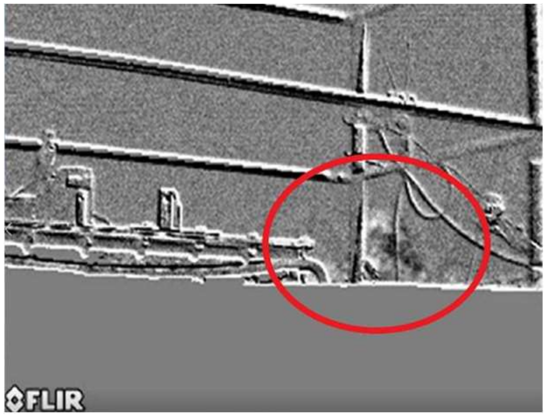
CLIMATE SMART UTILITIES

1. What are pressure relief valves (PRVs), and why are they a focus point?
2. Methods and results regarding PRVs – Danish national effort to minimise CH_4 emissions from biogas plants
3. Observed emission rates from installed PRVs
4. Tested leakage from new valves
5. Conclusions
6. Additional information

WHAT ARE PRVS, AND WHY ARE THEY A FOCUS POINT?

- PRVs (or “breather valves”) ensure a set, maximum pressure difference between a tank and the atmosphere to prevent rupture or implosion
- Ensures that air can flow in or out, when liquid levels are changed, or relieve pressure, in case of excess gas production
- Two types of gaseous emission: (1) functional and (2) leakage
- An often-observed cause of leakage from top of biogas reactors
- Leakage of CH_4 contributes to climate change, and reduces energy production (and thus revenue)

NATIONAL EFFORT – PRV RELATED RESULTS



- Leak search was done at 50 biogas plants using gas cameras (FLIR GF320) and “sniffers” in combination
- Leakage from PRVS was observed at 53% of facilities (89 times observed)
- Rates of leakage were not quantified

Location of observed leak/ point source of emission	Times observed	Frequency of observation among plants
Pressure relief valves	89	53 %
Reactors – other leaks[a]	100	59 %
Biomass storage tanks[b]	129	67 %
Gas storage units	7	12 %
Other gas bearing components[c]	137	65 %

METHANE LOSS BEFORE AND AFTER MITIGATING ACTIONS

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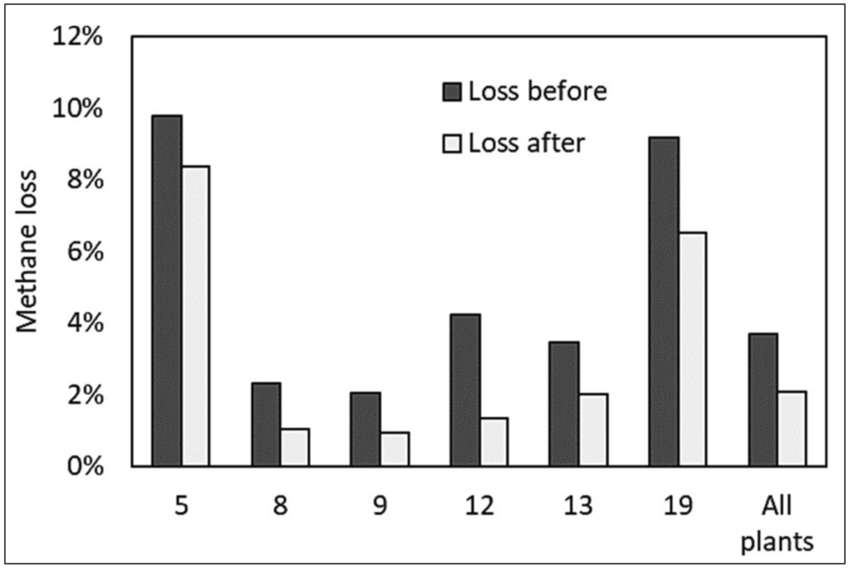
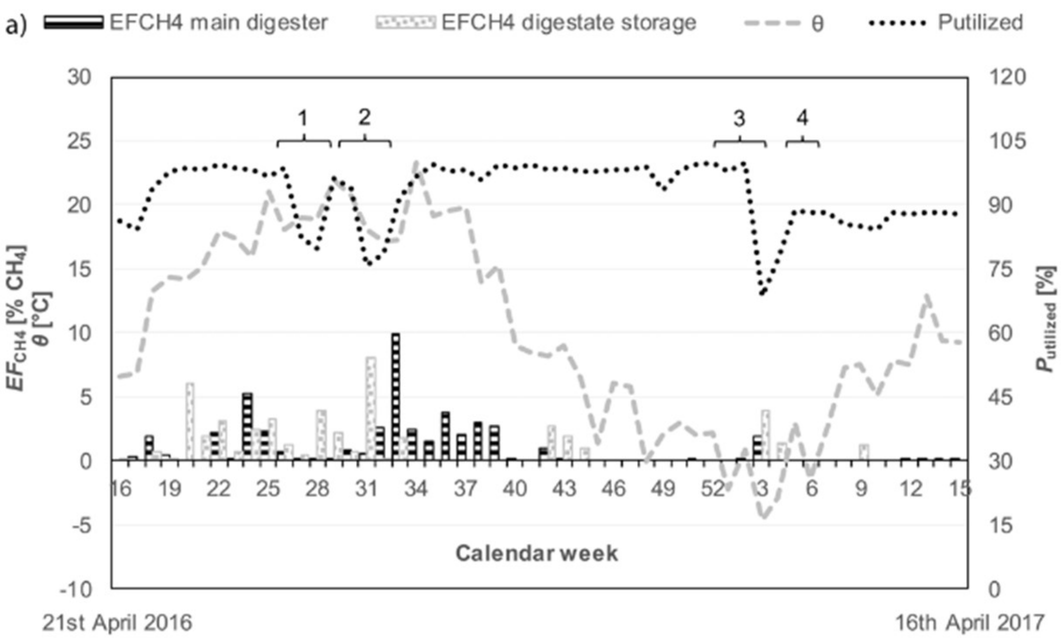
- At six plants, methane emission was measured both before and after GHG mitigation actions
- Loss before: 3.7%, loss after: 2.1%
- Avoided GHG: 29,400 ton CO_2 eq./yr.
- Avoided loss of CH_4: 1.5 million Nm^3/yr. (≥ production increase)
- At all six plants, PRVs were replaced, but other mitigation actions were also taken



Source: Fredenslund, A. M., Gudmundsson, E., Falk, J. M., & Scheutz, C. (2023). The Danish national effort to minimise methane emissions from biogas plants. *Waste Management*, *157*, 321-329

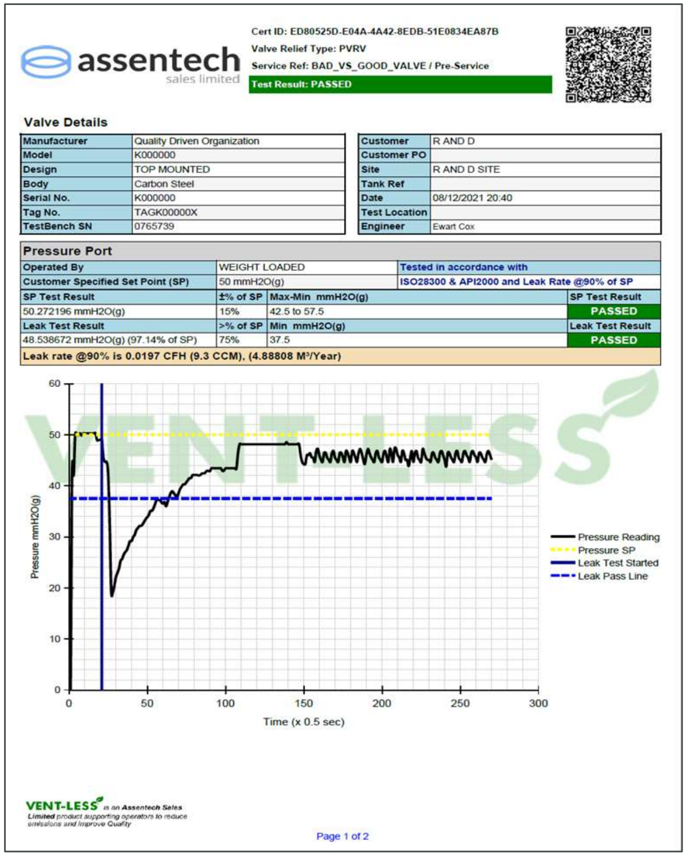
OBSERVED EMISSION RATES FROM INSTALLED PRVS

- DBFZ study by Torsten Reinelt & Jan Liebetrau: 2-years, continuous measurement of leakage from PRVs
- Emission rate measured using flowmeter on PRV's exhaust combined with measured gas composition
- Emission factor varied – up to 10% loss in connection to maintenance works, and affected by fast temperature change
- Overall emission factors: 1.8% and 0.6% for the first and second years, respectively
- Emissions lowered after mitigation effort



Source: Reinelt, T., Liebetrau, J. (2020). Monitoring and mitigation of methane emissions from pressure relief valves of a biogas plant. Chemical Engineering & Technology, 43, 1, 7-18

TESTED LEAKAGE FROM NEW VALVES



Cert ID: ED80525D-E04A-4A42-8EDB-51E0834EA87B
Valve Relief Type: PVRV
Service Ref: BAD_VS_GOOD_VALVE / Pre-Service
Test Result: PASSED

assentech sales limited

Valve Details

Manufacturer	Quality Driven Organization
Model	K000000
Design	TOP MOUNTED
Body	Carbon Steel
Serial No.	K000000
Tag No.	TAGK00000X
TestBench SN	0765739

Customer	R AND D
Customer PO	
Site	R AND D SITE
Tank Ref	
Date	08/12/2021 20:40
Test Location	
Engineer	Ewart Cox

Pressure Port

Operated By	WEIGHT LOADED	Tested in accordance with	
Customer Specified Set Point (SP)	50 mmH2O(g)	ISO28300 & API2000 and Leak Rate @90% of SP	
SP Test Result	±% of SP	Max-Min mmH2O(g)	SP Test Result
50.272196 mmH2O(g)	15%	42.5 to 57.5	PASSED
Leak Test Result	>% of SP	Min mmH2O(g)	Leak Test Result
48.538672 mmH2O(g) (97.14% of SP)	75%	37.5	PASSED

Leak rate @90% is 0.0197 CFH (9.3 CCM), (4.88808 M³/Year)

VENT-LESS is an Assentech Sales Limited product supporting operators to reduce emissions and improve Quality

Page 1 of 2

- Test results provided by Ewart Cox, Assentech
- Two new PRVs were tested for leakage: “good PRV” and “bad PRV”…
- Leakage measured at 90% of SP
- Leakage from “good PRV”: 4.9 M^3/yr.
- Leakage from “bad PRV”: 1700 M^3/yr.

<u>Example of financials provided:</u>

“*The cost of the cheap valve was £3000. That was a 12 inch size unit in carbon steel from a British manufacturer. The replacement valve cost £6500 from a high quality international manufacturer.*

The saving from one valve position was over £8000 in 1 year so ***payback was approximately 10 months***.” (Ewart Cox)

CONCLUSIONS

- Leakage from PRVs is an often observed source of CH_4 emission from biogas production
- Emission can be both a result of the PRVs function and from leakage
- Rate of leakage varies highly between valves, where “good PRVs” can have near 0 leakage
- Leakage from PRVs can cause significant loss of revenue and greenhouse gas emission

ADDITIONAL INFORMATION

Research paper:

- Fredenslund, A. M., Gudmundsson, E., Falk, J. M., & Scheutz, C. (2023). The Danish national effort to minimise methane emissions from biogas plants. *Waste Management*, *157*, 321-329. https://doi.org/10.1016/j.wasman.2022.12.035

Research paper:

- Reinelt, T., Liebetrau, J. (2020). Monitoring and mitigation of methane emissions from pressure relief valves of a biogas plant. *Chemical Engineering & Technology, 43, 1,* 7-18. https://doi.org/10.1002/ceat.201900180

Emission calculator + services:

- *http://www.assentech.co.uk/anaerobic-digestion-biogas-pressure-and-vacuum-relief-valves-with-flame-arresters/#breatherventleakagebiogas*

Contact:

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Charlotte Scheutz: chas@dtu.dk

Q&A

MODERATOR: AMANDA LAKE

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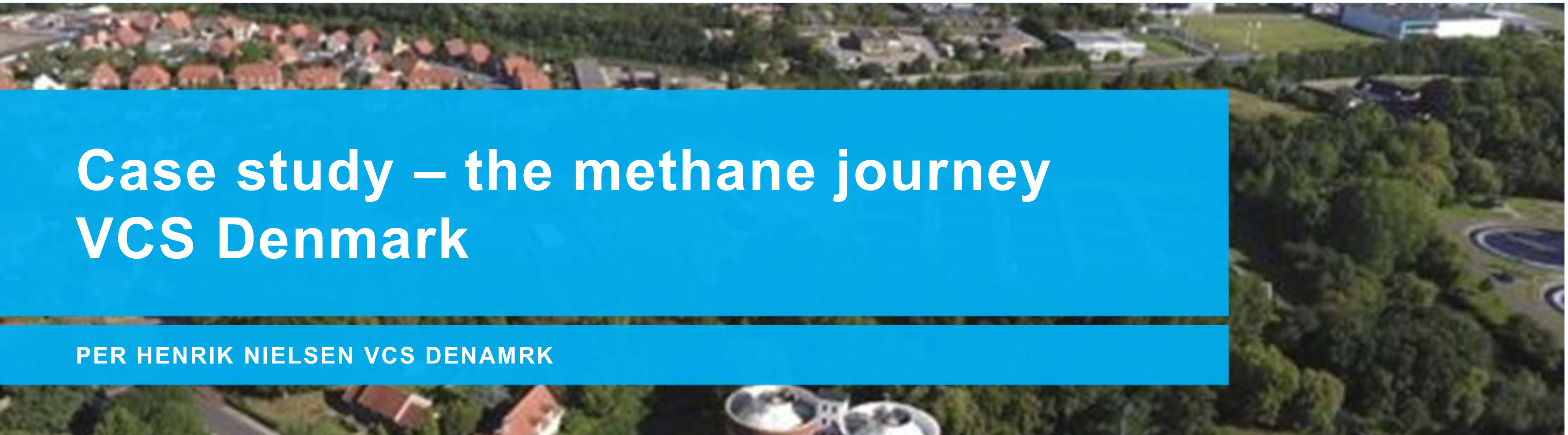
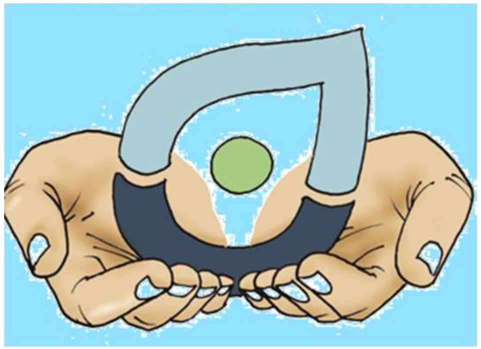


Case study – the methane journey VCS Denmark

PER HENRIK NIELSEN VCS DENAMRK



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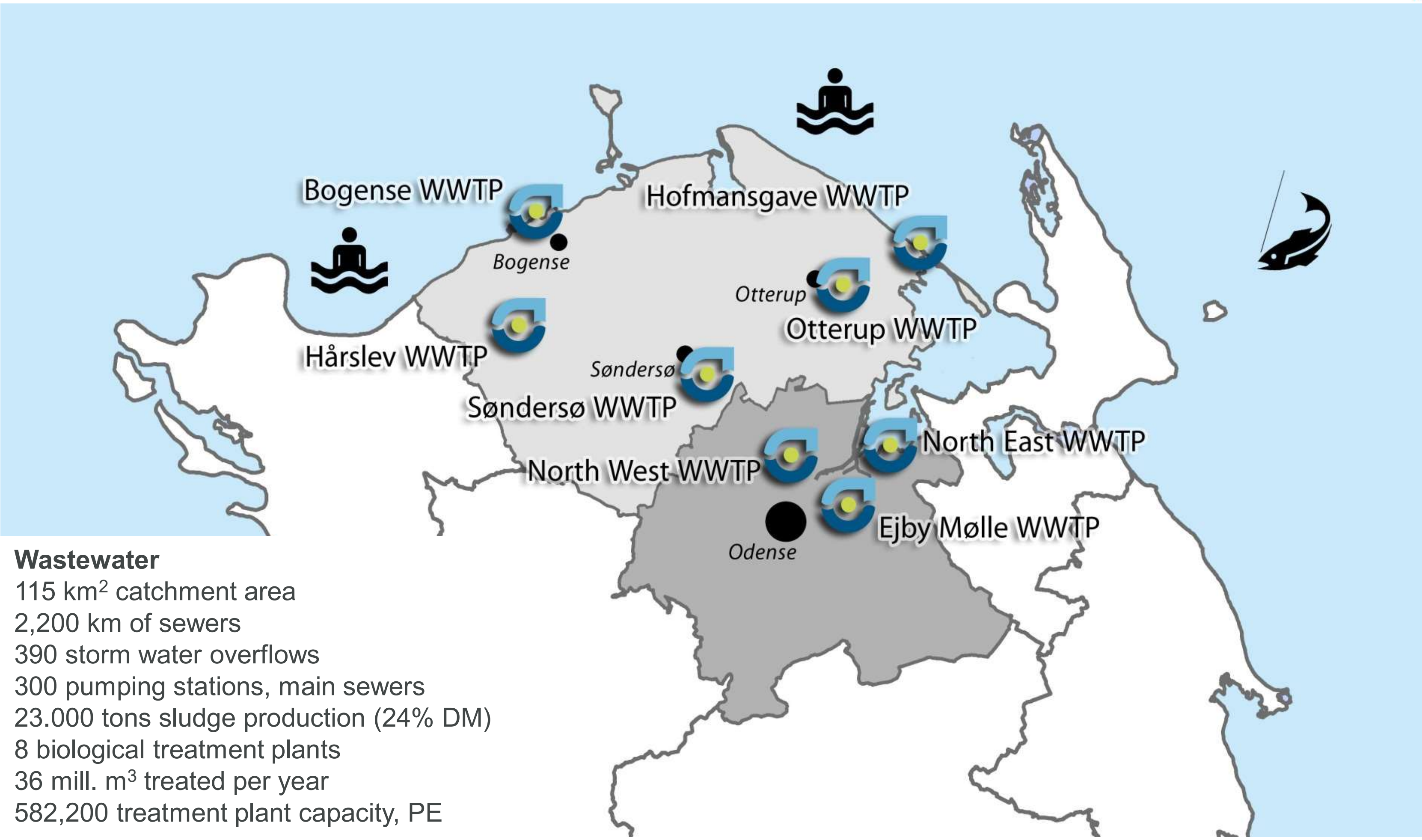
VCS Denmark

- Established 1853
- Odense – 3rd largest city in Denmark
- 6 WTPs ~180,000 customers
- 8 WWTPs ~235,000 customers
- Energy neutral utility since 2019
- Committed to innovation

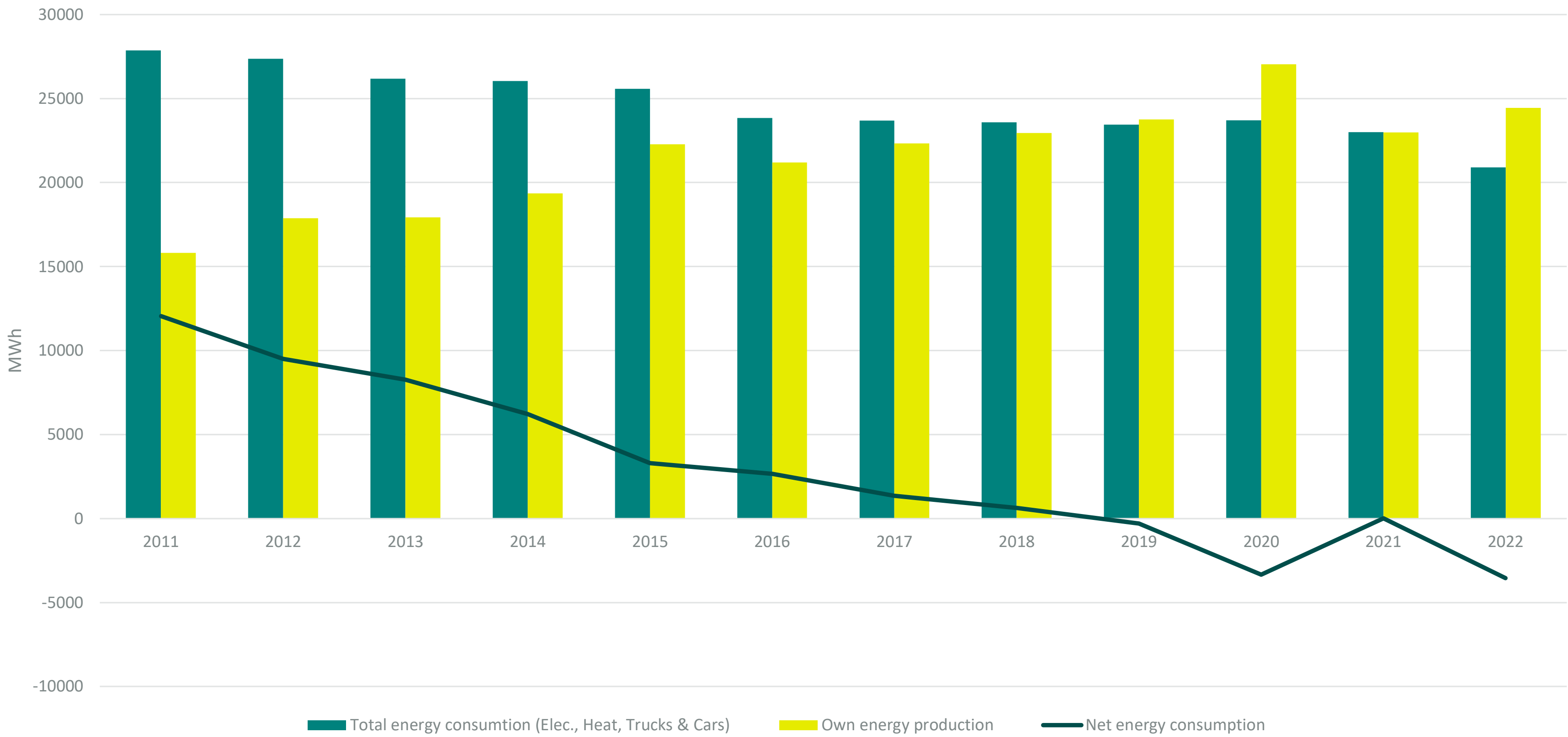
IWA the international water association CLIMATE SMART UTILITIES



Wastewater
115 km^2 catchment area
2,200 km of sewers
390 storm water overflows
300 pumping stations, main sewers
23.000 tons sludge production (24% DM)
8 biological treatment plants
36 mill. m^3 treated per year
582,200 treatment plant capacity, PE

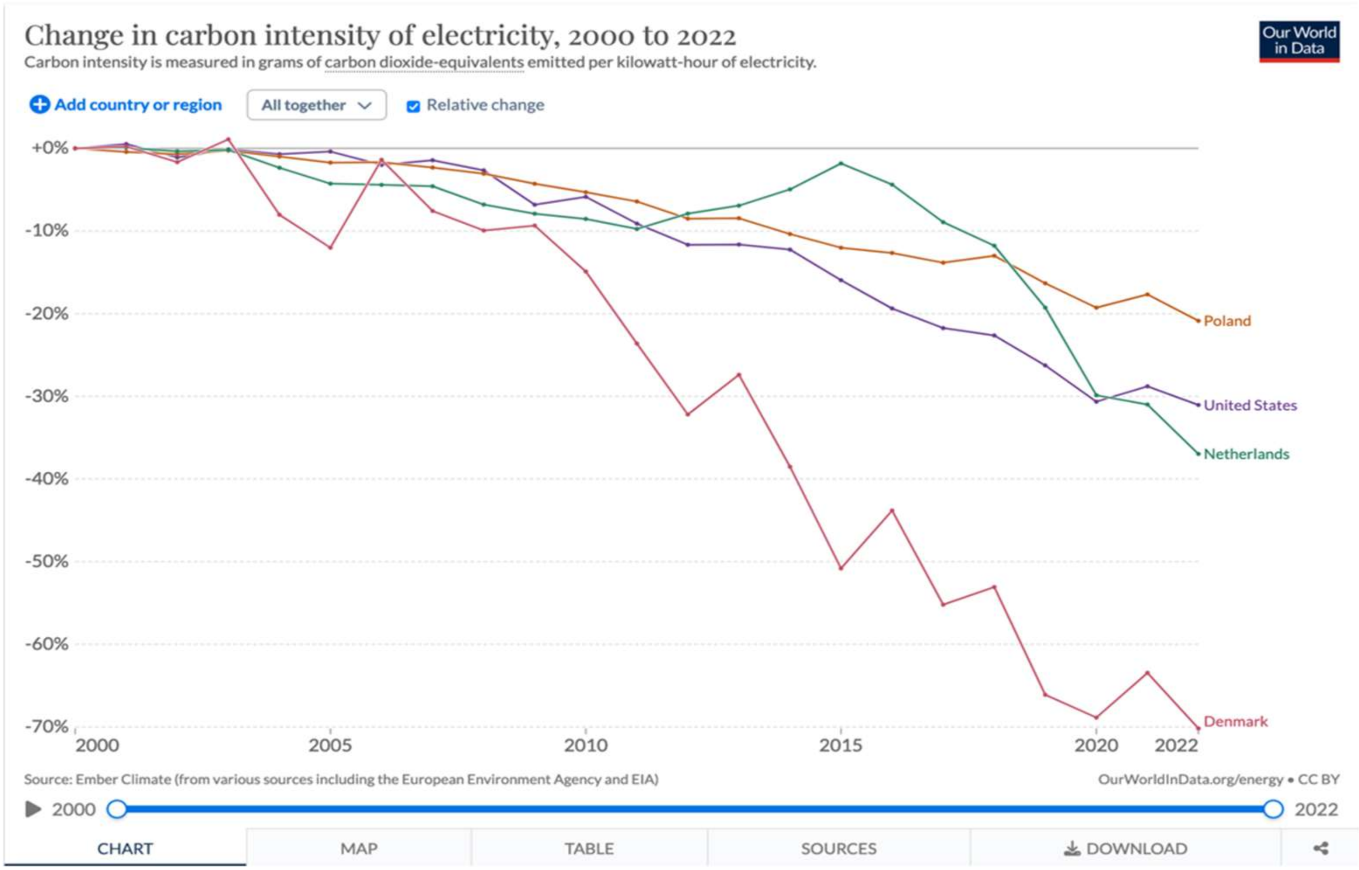
ENERGY BALANCE

CLIMATE SMART UTILITIES



ENERGY MIX

CLIMATE SMART UTILITIES



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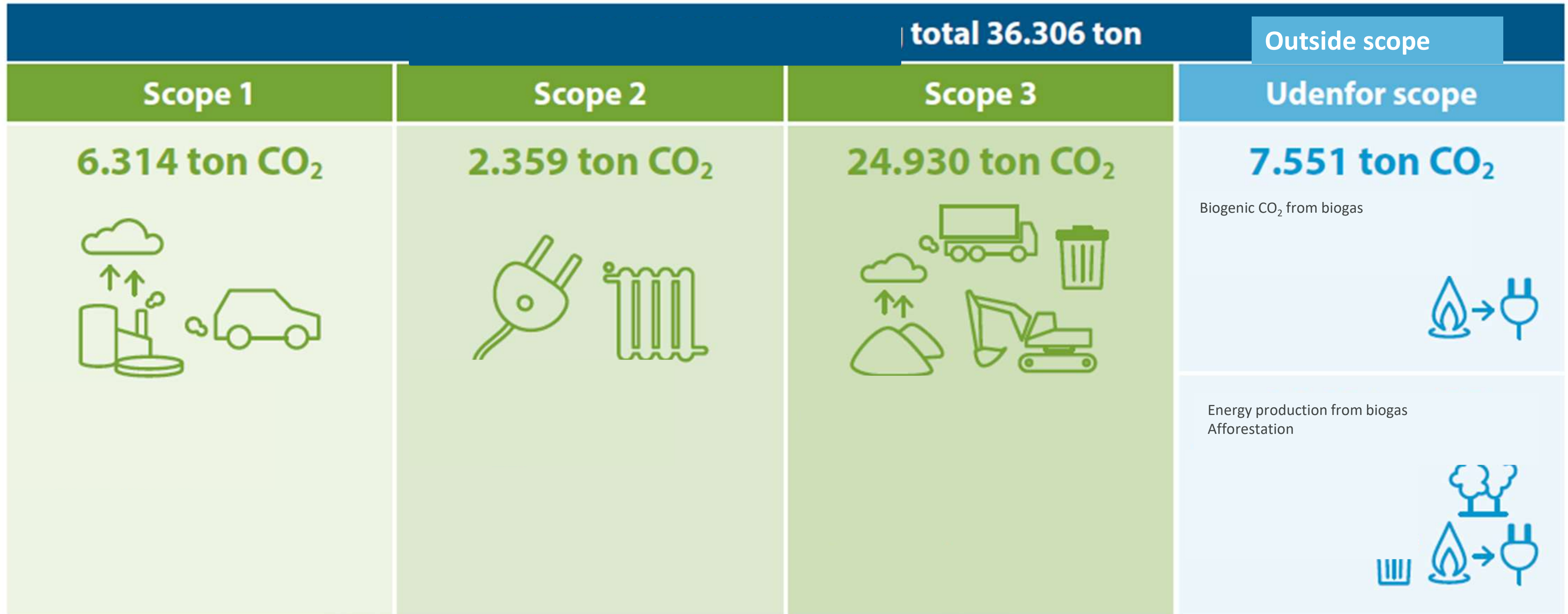
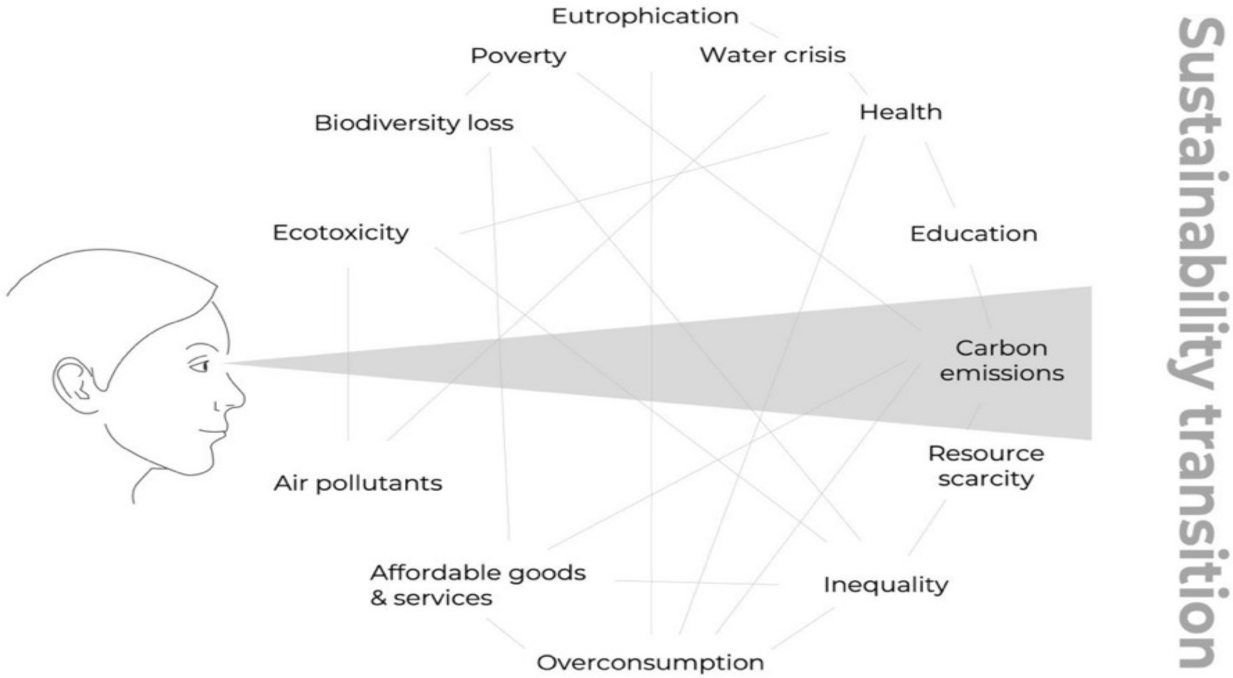
CLIMATE SMART UTILITIES



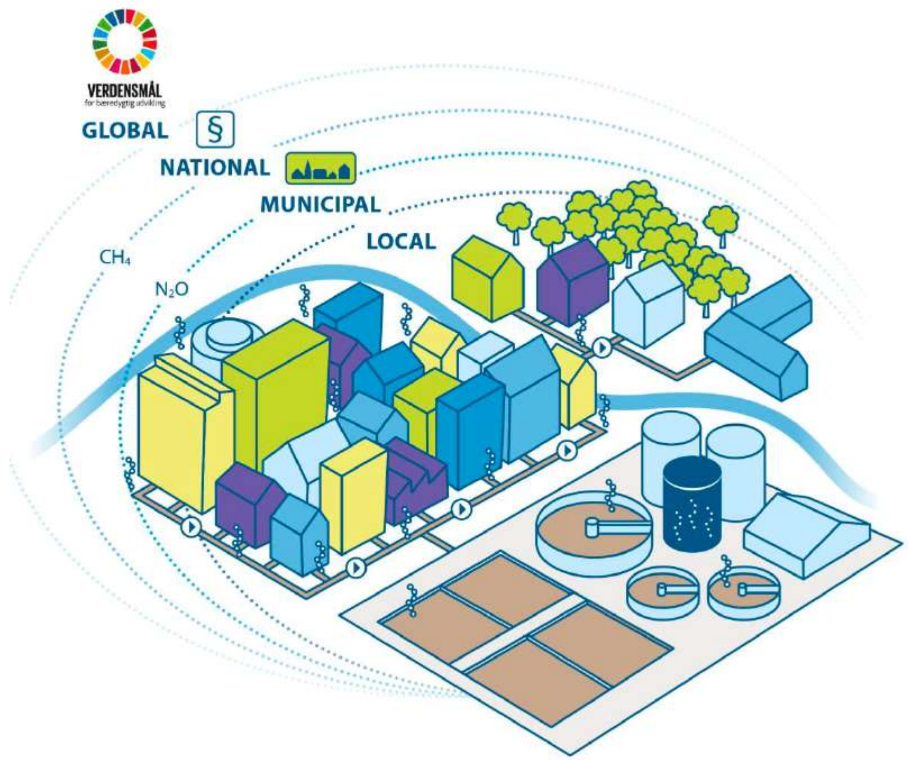
Carbon Tunnel Vision



Graphic by Jan Konietzko

ARES

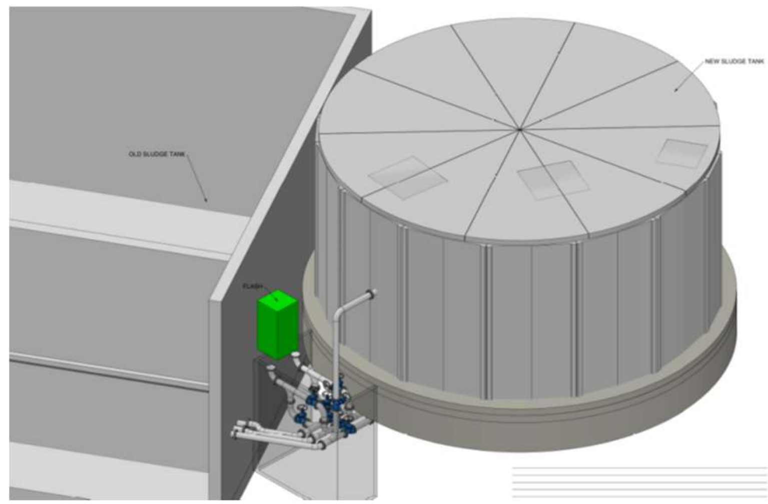
- Project goal - Reduced emissions from wastewater treatment
- Methane CH4 and Nitrous oxide N2O – are the main problems
- A co-operation between leading utilities, universities, consultant and partly funded by the EPA
- The project includes:
  - New advanced sludge handling
  - Advanced measurements at treatment plants
  - Advanced measurements in sewer systems
  - Pilot plant testing of new and enhanced control strategies
  - Online measurement – new approach



REDUCTION OF EMISSION FROM SLUDGE STORAGE

Development and test of closed sludge storage tank including vacuum technology for maximized methane extraction

- New closed sludge storage.
- Maximizing gas production from the plant



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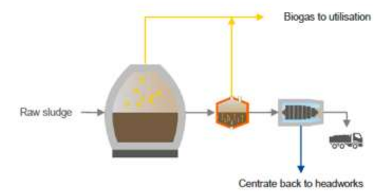
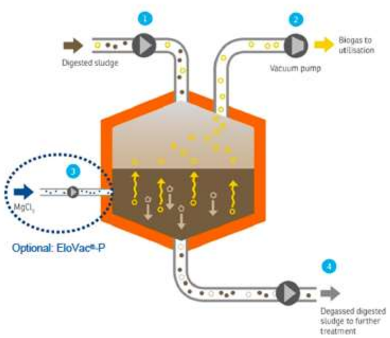
VACUUM ENHANCED SYSTEM - ELIQUO

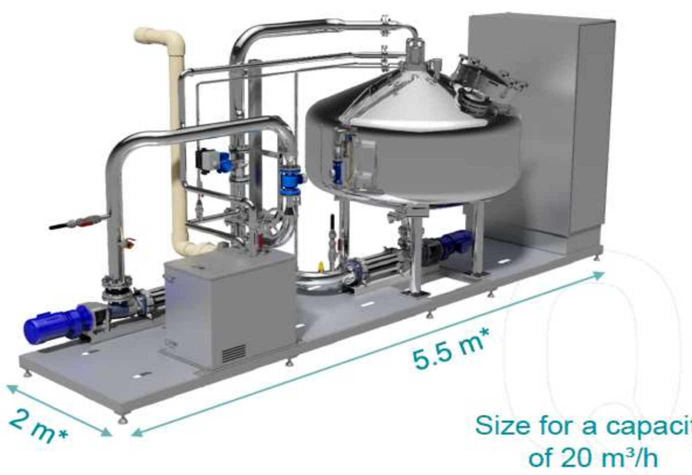
- Inclusion of vacuum technology to remove dissolved methane from the sludge
- Possible addition of magnesium or iron to enhance controlled phosphorus precipitation

Implementation EloVac®-P:



- EloVac®: Vacuum Degassing
- EloVac®-P: Vacuum Degassing with simultaneous P-precipitation





CLIMATE SMART UTILITIES

FINDING THE EMISSIONS

- Identification and quantification of emissions of methane and N2O from WWTP using trace gas method

- Measurement of methane and N2O from the sewer system in Odense using trace gas method

CONCLUSION

- The project will put focus on emissions from our industry
- Minimizing a well-known source of methane emissions
- Give new insights on overall emissions from treatment plants and sewer systems
- Test of new control strategies and low emission operation
- New approach for measuring N2O emissions
- Evaluate validity of Denmark's IPCC reporting

A GREAT TEAM

Miljøministeriet
Ecoinnovation - MUDP

aarhusvand

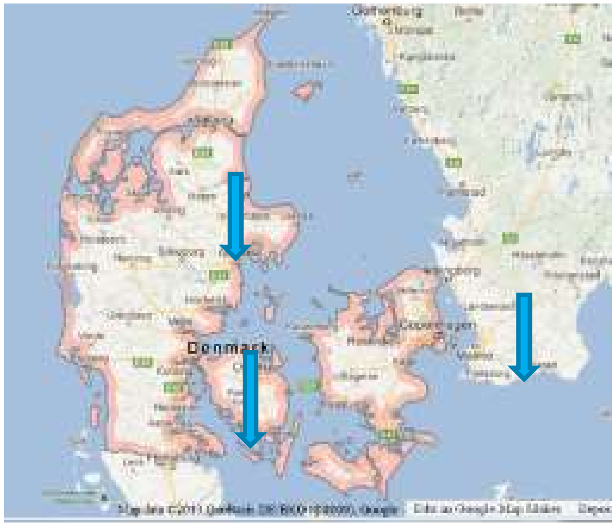
BIOFOS

EnviDan

AARHUS UNIVERSITET

DTU Environment
Department of Environmental Eng

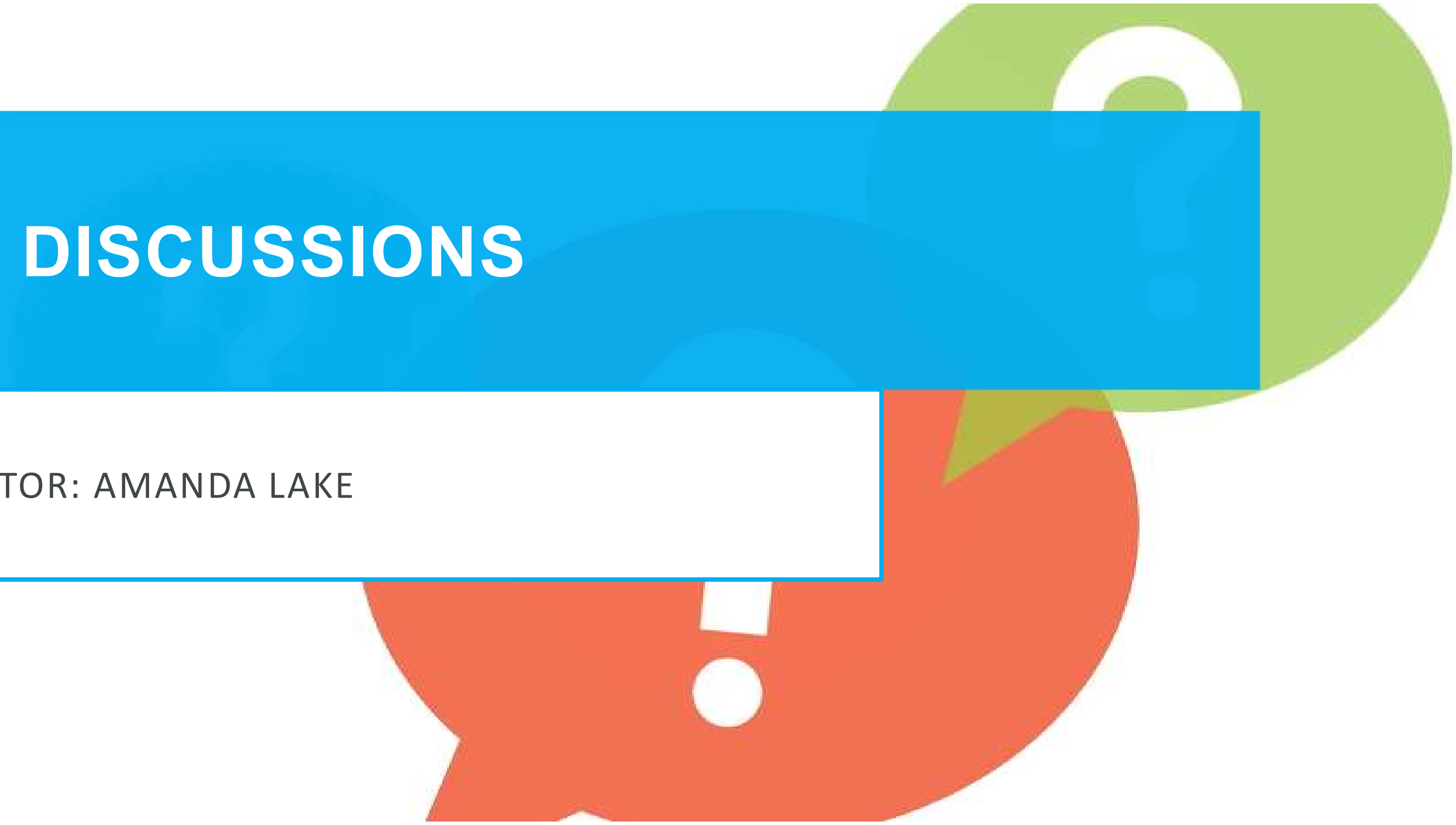
VandCenterSyd
DIT VAND · VORES ELEMENT



[The case of VCS Denmark – progress beyond net energy production - The Source (thesourcemagazine.org)]

Q&A DISCUSSIONS

MODERATOR: AMANDA LAKE



inspiring change

WHAT NEXT: 2 FURTHER WEBINARS

Monitoring and mitigating nitrous oxide: Danish lessons for global action- Anna Katrine, Envidan

- 04 September

Climate Smart Water Futures within Planetary Boundaries- IWA GHG working group

- 03 October

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UPCOMING IWA WEBINARS & EVENTS

Learn more about future online events at
http://www.iwa-network.org/iwa-learn/

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