Methane Emission from Danish Biogas Plants

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Agenda

- Brief introduction to AgroTech and DGC
- Biogas Plants in Denmark – a brief overview
- Background and aim of the Danish project
- Methodology
- Results

AgroTech
Institute for Agri Technology and Food Innovation

- Danish consultancy company offering impartial consultancy and technological services.
- Headquarters is in Agro Food Park, Aarhus, and a department at the Taastrup campus of the University of Copenhagen.
- Founded in 2007 and has 80 employees
- AgroTech is one of Denmark's 9 Approved Technological Service Institutes.
- The only institute for agriculture and food innovation. Authorized by the Danish Ministry of Higher Education and Science.

AgroTech – business areas

- Focus is the agricultural and food industry
- Core areas:
  - environmental technology
  - food innovation
  - plant innovation and technology
- Carry out field and laboratory tests of new crops, species and fertilizers
- Offers expert knowledge in technologies to reduce pollution caused by intensive livestock production systems
- Specialists in agriculture-based biogas production

Danish Gas Technology Centre

- DGC is a consulting and development organisation within energy and environment focusing on energy gases
- DGC was established in 1988 by the Danish gas companies.
- DGC works with all energy gasses: natural gas, town gas, LPG, biogas and hydrogen, but also with combinations of gas and renewable energy.
- DGC has 30 employees

Business areas

1. Domestic boilers and small-scale gas appliances
2. CHP, large boiler plants and industrial gas utilisation
3. Certification, safety and training
4. Environment and combustion
5. Gas grid service and consulting
6. Hydrogen, biogas and other renewable energy technologies

   [Laboratory + Green Gas Test Centre]

Biogas plants in Denmark

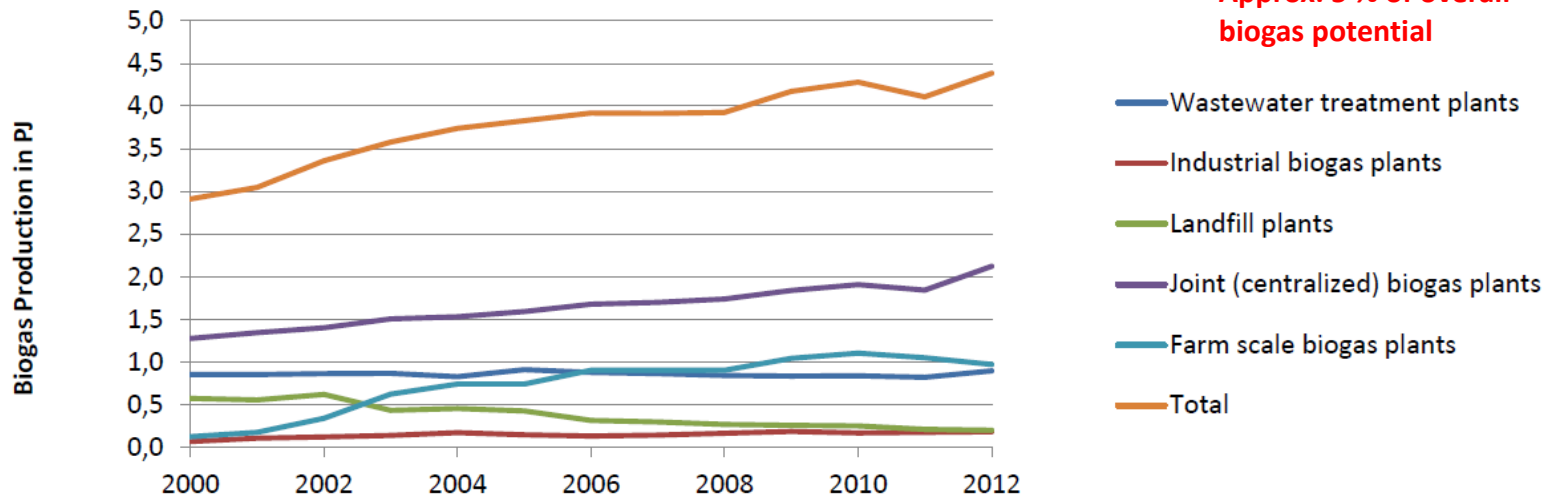
- Farm scale biogas plants, approx. 60
- Joint (or centralized) biogas plants, approx. 22
- Landfill plants, approx. 30
- Municipal plants, approx. 65

- Approx. 8 % of the animal manure is digested in biogas plants

Ribe Biogas Plant

Biogas production in Denmark

Biogas production in PJ	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Wastewater treatment plants	0,86	0,86	0,87	0,87	0,83	0,91	0,88	0,87	0,84	0,84	0,84	0,82	0,90
Industrial biogas plants	0,07	0,11	0,12	0,14	0,17	0,15	0,14	0,15	0,17	0,19	0,17	0,18	0,18
Landfill plants	0,58	0,56	0,62	0,44	0,46	0,43	0,32	0,30	0,27	0,26	0,26	0,21	0,20
Joint (centralized) biogas plants	1,28	1,35	1,40	1,51	1,53	1,59	1,68	1,70	1,74	1,84	1,91	1,84	2,12
Farm scale biogas plants	0,13	0,18	0,34	0,63	0,75	0,75	0,91	0,90	0,91	1,05	1,11	1,05	0,97
Total	**2,91**	**3,05**	**3,36**	**3,58**	**3,74**	**3,83**	**3,92**	**3,91**	**3,93**	**4,17**	**4,28**	**4,11**	**4,38**



Approx. 5 % of overall biogas potential

Source: Danish Energy Agency

The Danish project

- Funded by Energinet.dk under the ForskEL Progamme
- Energinet.dk is a non-profit enterprise owned by the Danish Climate and Energy Ministry.
- Energinet.dk owns the natural gas transmission system and the 400 kV, 150 kV and 132 kV electricity transmission system and is the co-owner of the electrical interconnections to Norway, Sweden and Germany.
- ForskEL is a PSO-financed research program, the purpose of which is to support the development and integration of environmentally friendly power generation technologies for grid connection.

Aim of the project

1. Reducing greenhouse gas emission from biogas plants in terms of methane losses.
2. Ensuring sustainability of biogas production.

Approach – to develope a cheap, operational, flexible and accurate method for identification and quantification of methane leakages/losses from biogas plants.

The method can be used as a part of the periodical maintenance routine in order to keep focus on emissions and leakages.

The main focus is on biogas production facilities.

Outcome of the project

- Determination of methane emission factors (methane emissions relative to the energy content of the gas production in g methane/GJ) for biogas plants in Denmark.
- Development of a maintenance book describing the general leakage problems, their significance and their repair.
- Improvement of the economic profitability of biogas plants due to reduced methane losses from the production.

Method

Literature study

- Scanning for suitable methods

Identification of leakages

- Optical - IR camera

Subsequent quantification of losses from leakages

- Flow
  - Orifice plate
  - Pitot tube
- Concentration of CH_4
  - FID
  - Micro GC
  - Photo acoustic infrared

Safety concerns

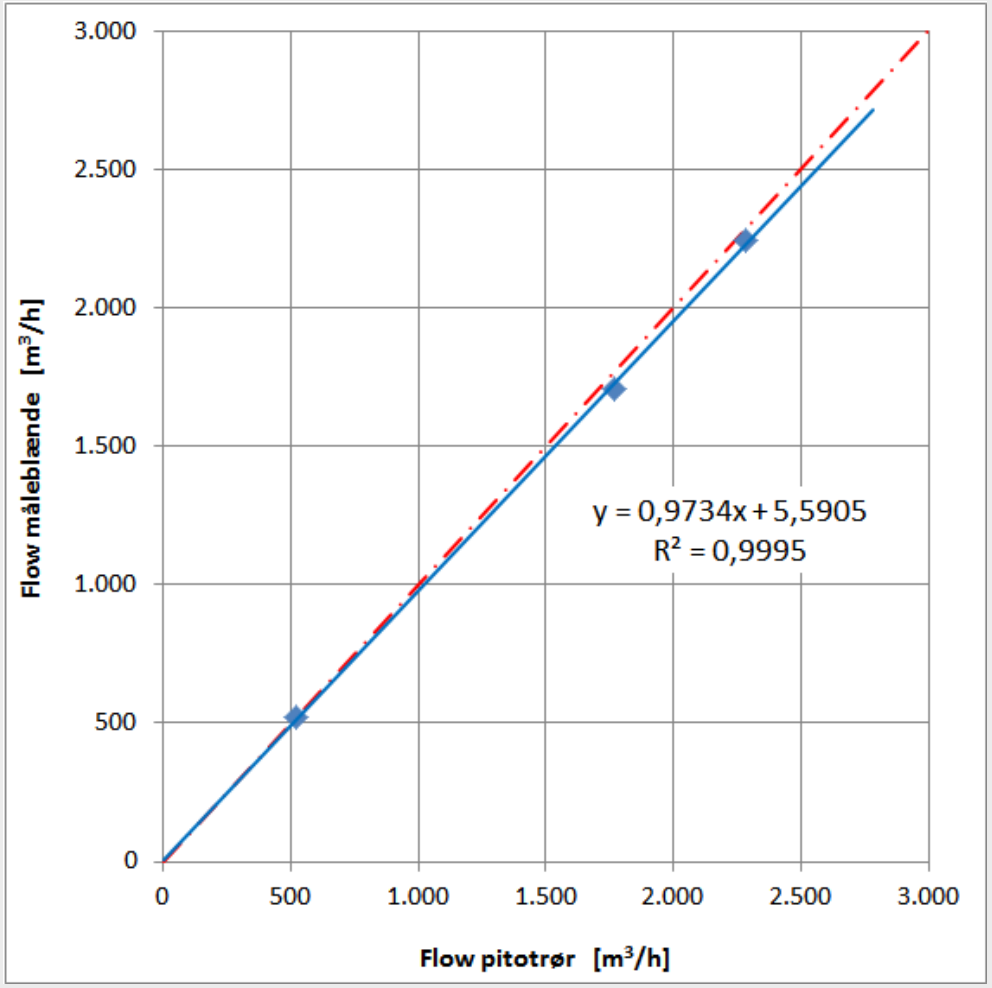
- Outlet of sample gas contains H_2S and is led away from workspace
- Gas sensors – alarm if C_{CH4} > 10000 ppm ($\approx$ 25 % of LEL)
- Gas velocity > flame speed
- ATEX blower

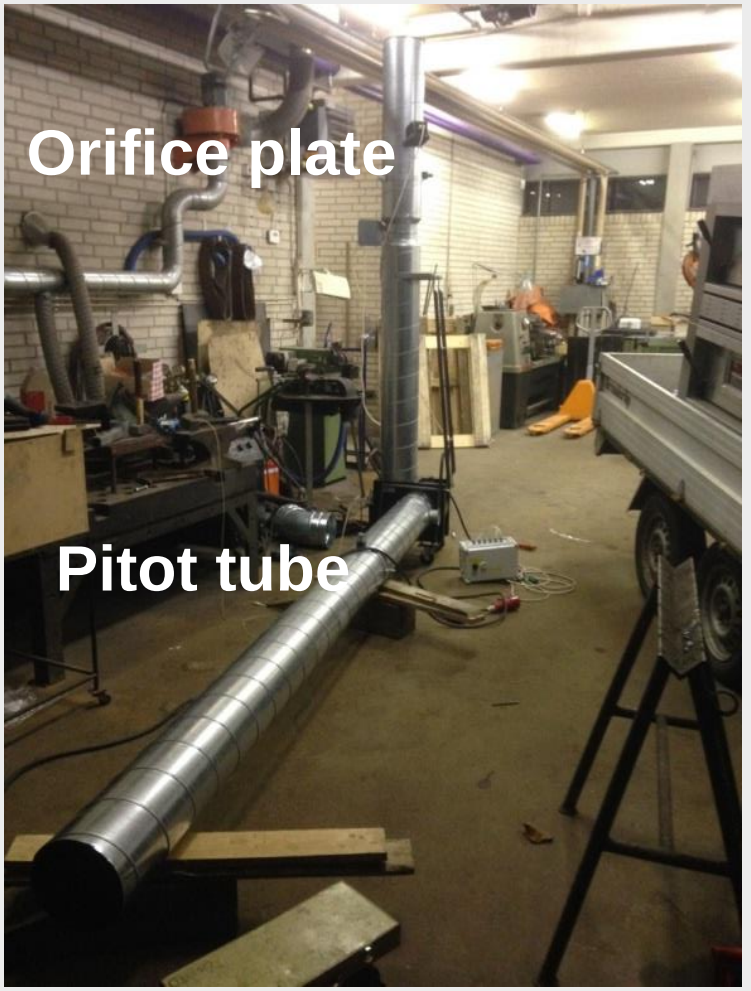
- Safety issues when working at heights (ladders, scaffolding, raillings, fall protection)

Sampling equipment

- ATEX blower
- Reject gas pipe with flow measurement
- Towers for storage of ventilation hoses
- Suction units with pressure measurement
- Suction unit for crevices etc.

Calibration of orifice plate

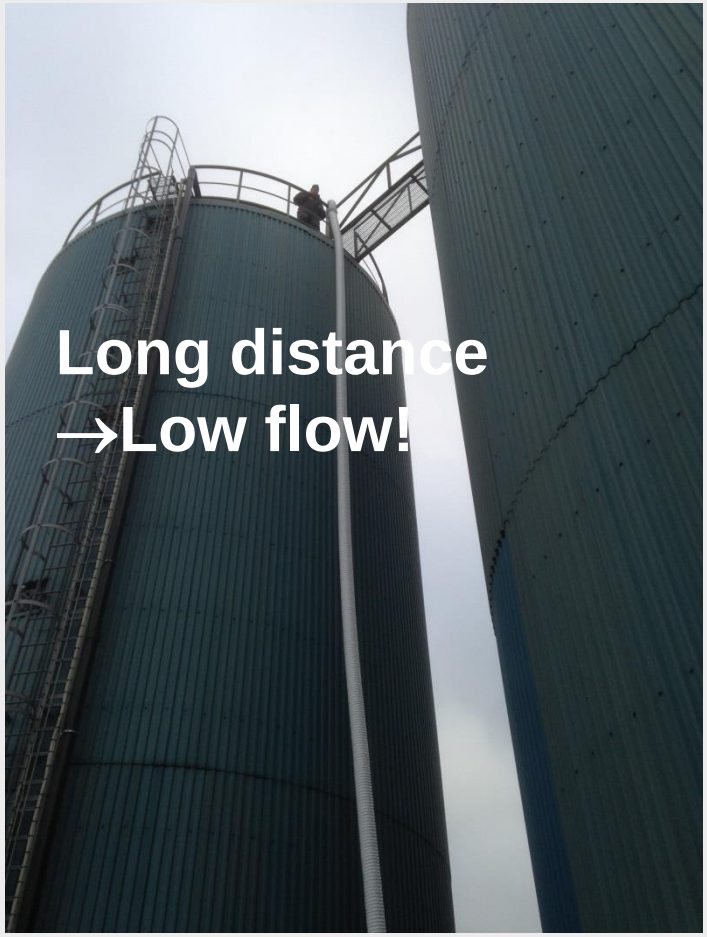




Sampling

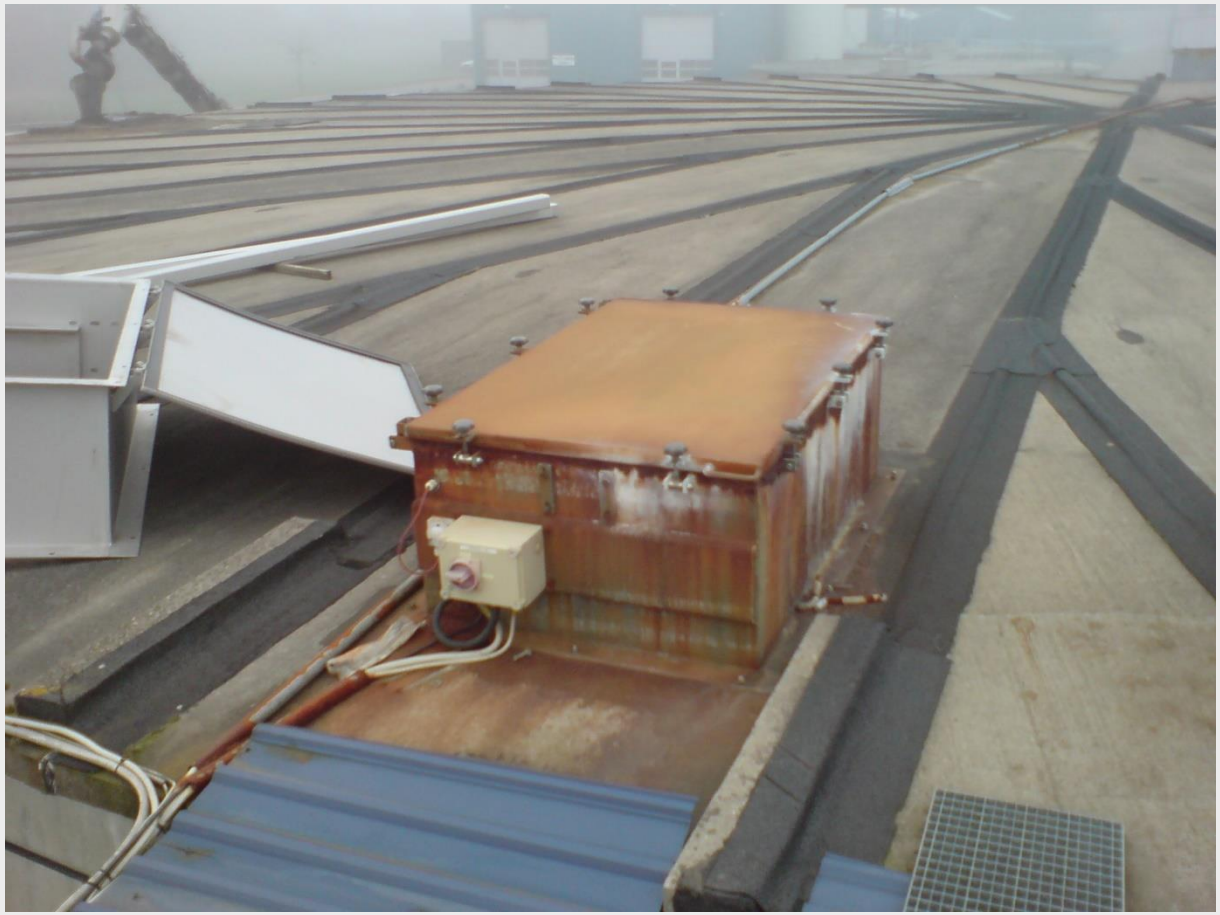

Safety
valve


Crevice on
curved surface


Long distance
→Low flow!

Detected types of leakages

Methane leak #1



Source: AgroTech

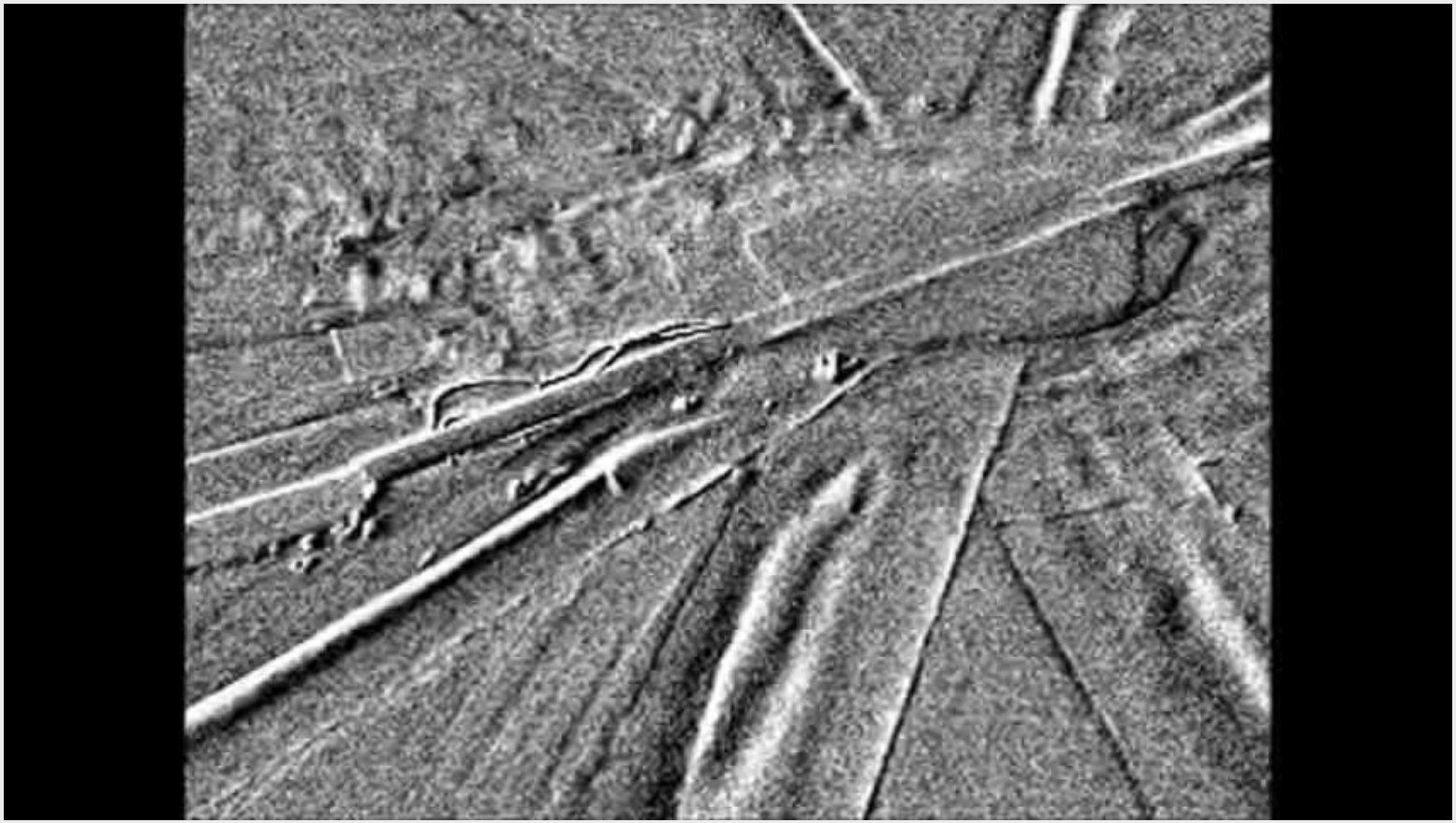
Methane leak #1

Source: AgroTech

Methane leak #2

Source: AgroTech

Methane leak #2

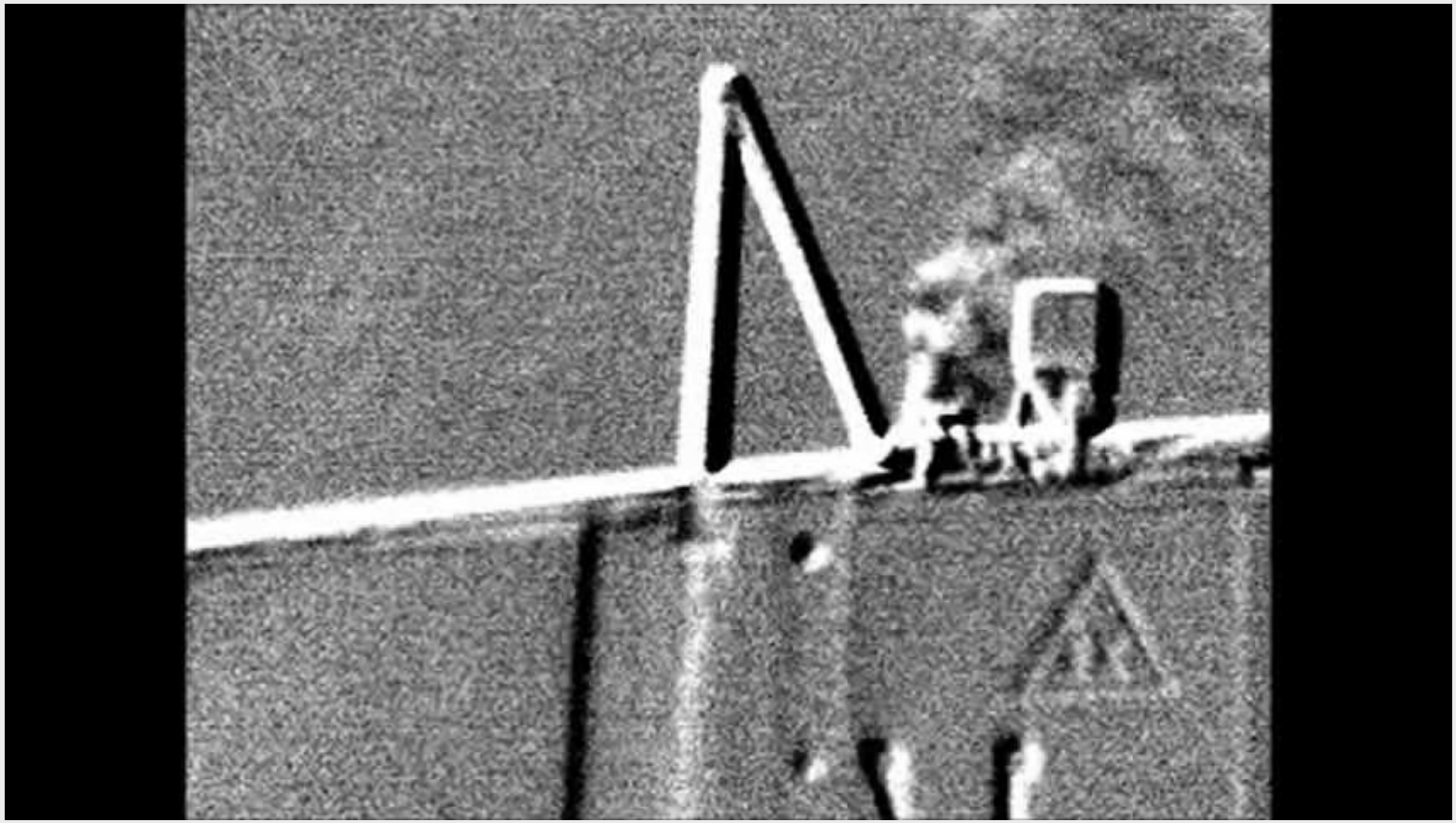


Source: AgroTech

Methane leak #3

Source: AgroTech

Methane leak #3



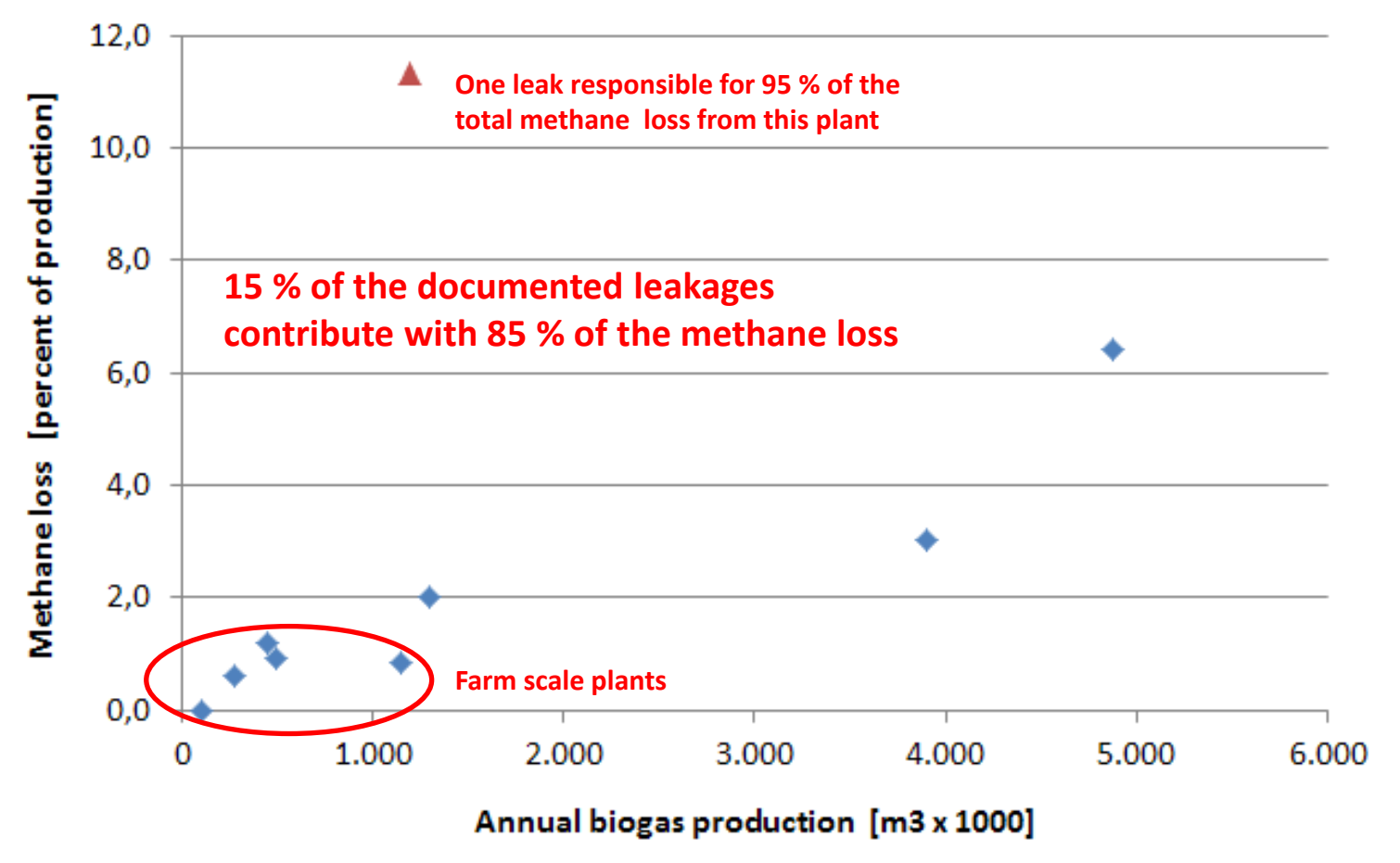
Source: AgroTech

Results of performed measurements – phase 1

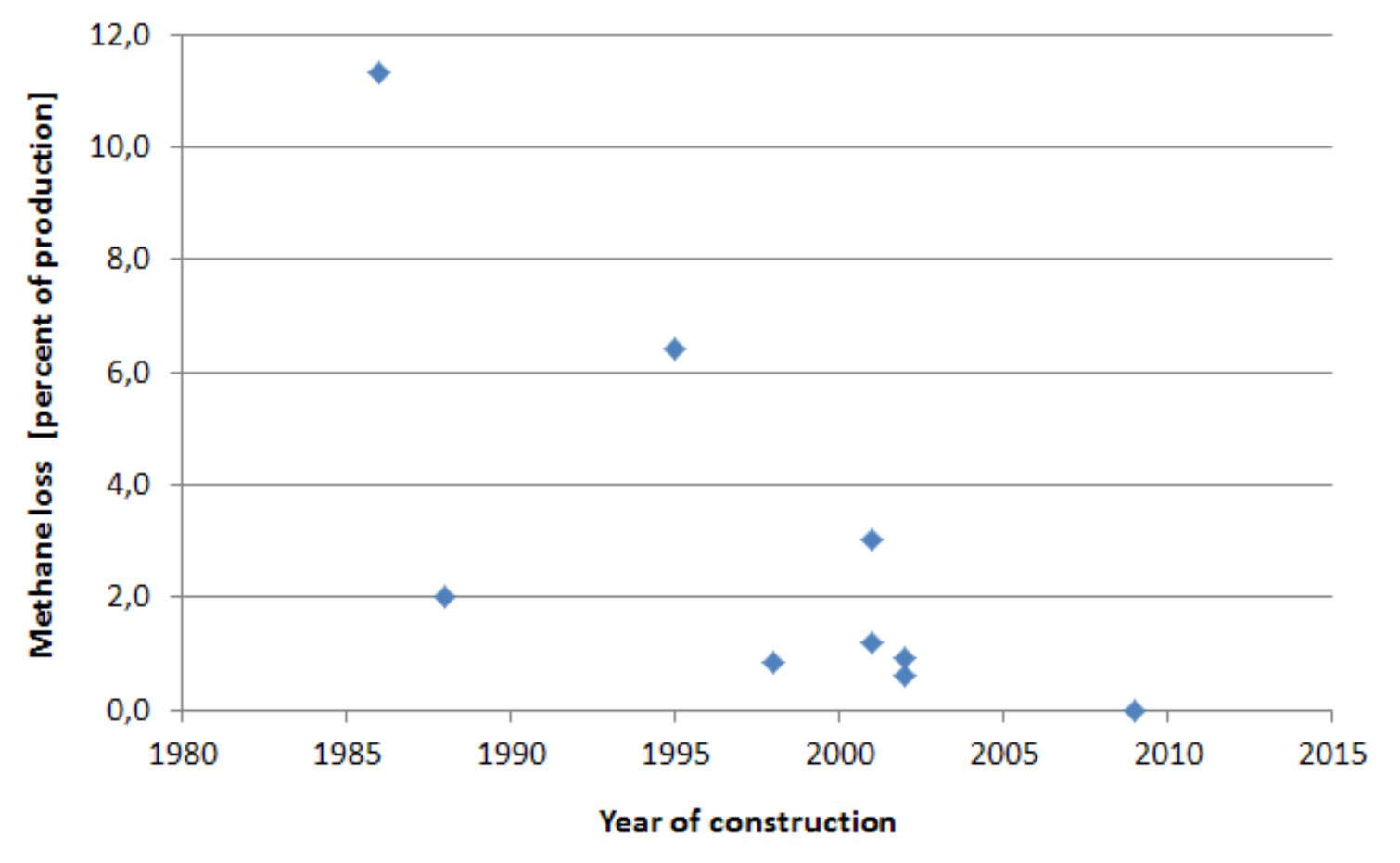
Biogas Plant #	Type of biogas plant	Number of leakages	Total annual methane emission [1000 m3/year]	Annual biogas production [mio. m3]	Methane loss [percent of production]	Lost income due to methane loss [DKK/year]	Lost income due to methane loss [€/year]
1	Farm scale plant	2	10	1,2	0,9	49.000	6.600
2	Farm scale plant	8	2	0,3	0,6	8.300	1.100
3	Farm scale plant	4	5	0,5	1,2	27.000	3.600
4	Farm scale plant	5	5	0,5	0,9	23.000	3.000
5	Farm scale plant	0	0	0,1	0,0	0	0
6	Joint/centralized plant	3	26	1,3	2,0	1.300.000	17.000
7	Joint/centralized plant	14	310	4,9	6,4	1.600.000	210.000
8	Joint/centralized plant	3	140	1,2	11	680.000	90.000
9	Joint/centralized plant	11	120	3,9	3,0	590.000	80.000
10	Joint/centralized plant	----------No measurements----------					
total		**50**	**618**	**14**		**4.300.000**	**410.000**

Source: AgroTech and DGC

Results – phase 1



Results – phase 1



Phase 2

- Leakages found in phase 1 are reported to biogas plants (brief measurement reports)
- Biogas plants rectify and repair leakages
- AgroTech and DGC perform measurement campaign no. 2
- Calculation and analysis
- Methane emission factors
- Maintenance book

Evaluation of method

We can determine leakages from:

- Point sources on flat and curved surfaces
- Columns on flat and curved surfaces
- Leaks at penetrations
- Ventilation flow
- Any sub-assemblies that can be packed in plastic film

We cannot:

Determine methane leaks from diffuse sources, such as open degased manure storage

Evaluation of method

Conditions and parameters that affects the measurement result:

- Concentration measurement of methane
- Magnitude of methane concentration
- Flow determination of biogas / air mixture
- Magnitude of biogas / air mixture
- Ambient temperature and humidity
- The relationship between the pressure in the reactor and the pressure in the hood
- Wind conditions around the hood
- The operating conditions including variation of pressure in the digester/reactor (which has a direct impact on the size of the leak)
- Measuring duration

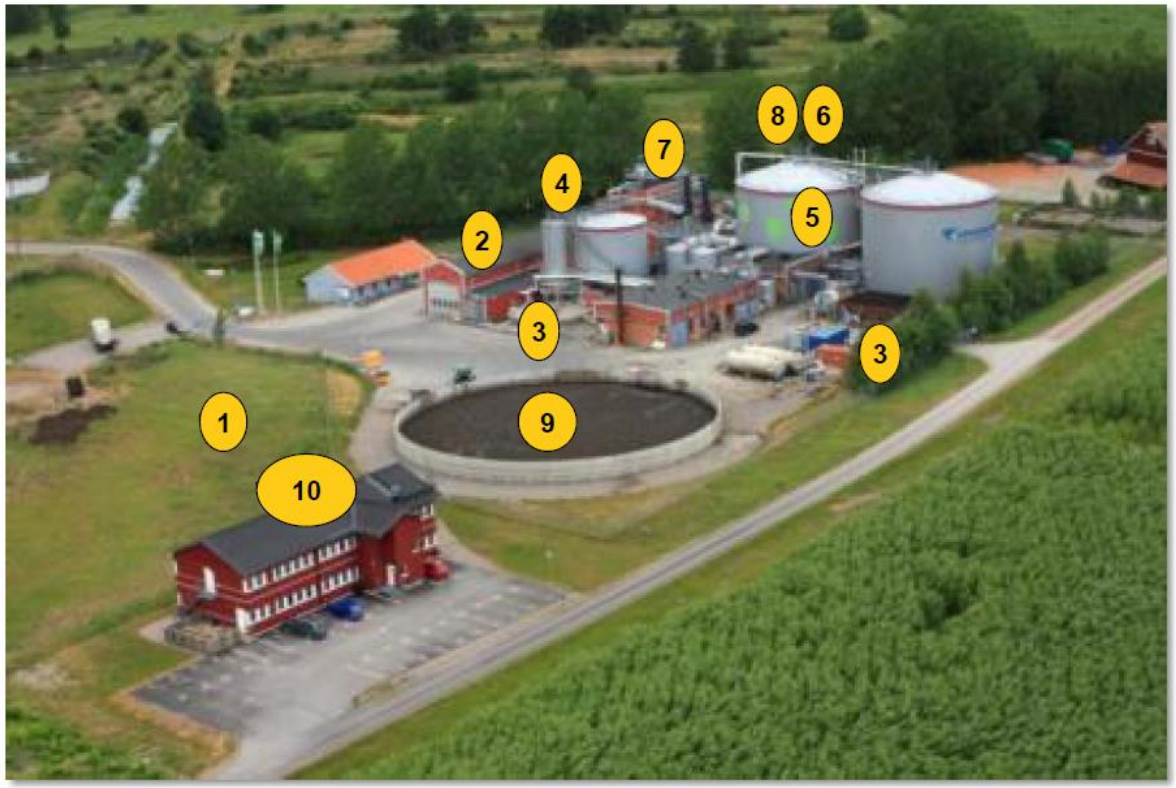
Evaluation of method

- According to the project description the selected/developed method must be evaluated and tested towards another (reference) method
- Comparative measurements at Linköping Biogas Plant, Sweden
- AgroTech and DGC perform individually quantification of methane losses by the same method and type of equipment

Linköping Biogas Plant

Figur 2 Flyfoto över biogasanläggningen i Linköping med principskiss över anläggningen.

Linköping Biogas Plant



1 Pre.treatment of household waste
2 Recieving hall
3 Recieving tank
4 Hygienisation tank
5 Digesters
6 Gas storage
7 Gas upgrading system
8 Flare
9 Manure well
10 Control room and office

IGRC 2014 poster

Abstract title

- Methane Emission from Danish Biogas Plants – Developing a method for identification and quantification of methane losses

Authors

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Purpose

- The project will aim to reduce greenhouse gas emission from biogas plants in terms of methane losses. This will be done by developing a operational method for identification and quantification of leakages from biogas plants. This knowledge will motivate and enable plant owners to reduce the leakages, and thereby increase the environmental and economic impact of biogas production.

Thank you for your attention!

Any questions?