BIO-OXIDATION SYSTEMS FOR LANDFILL GAS

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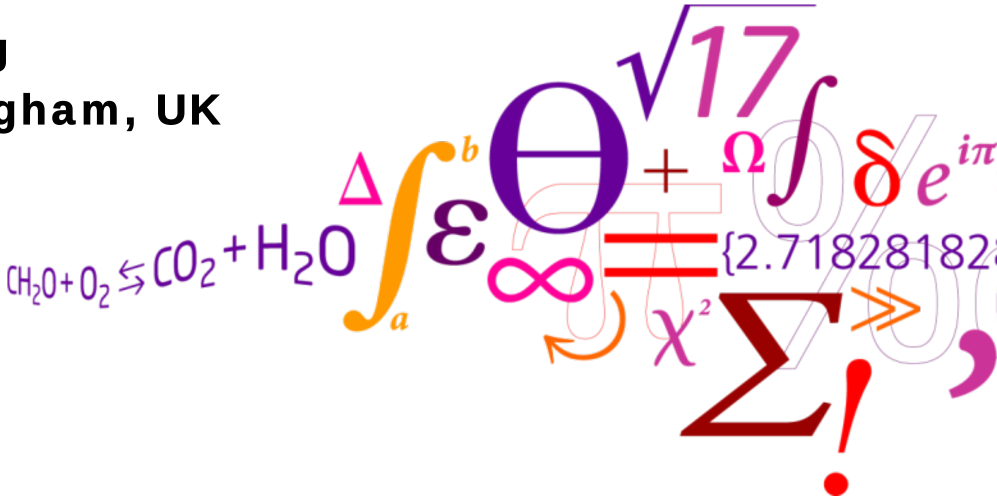
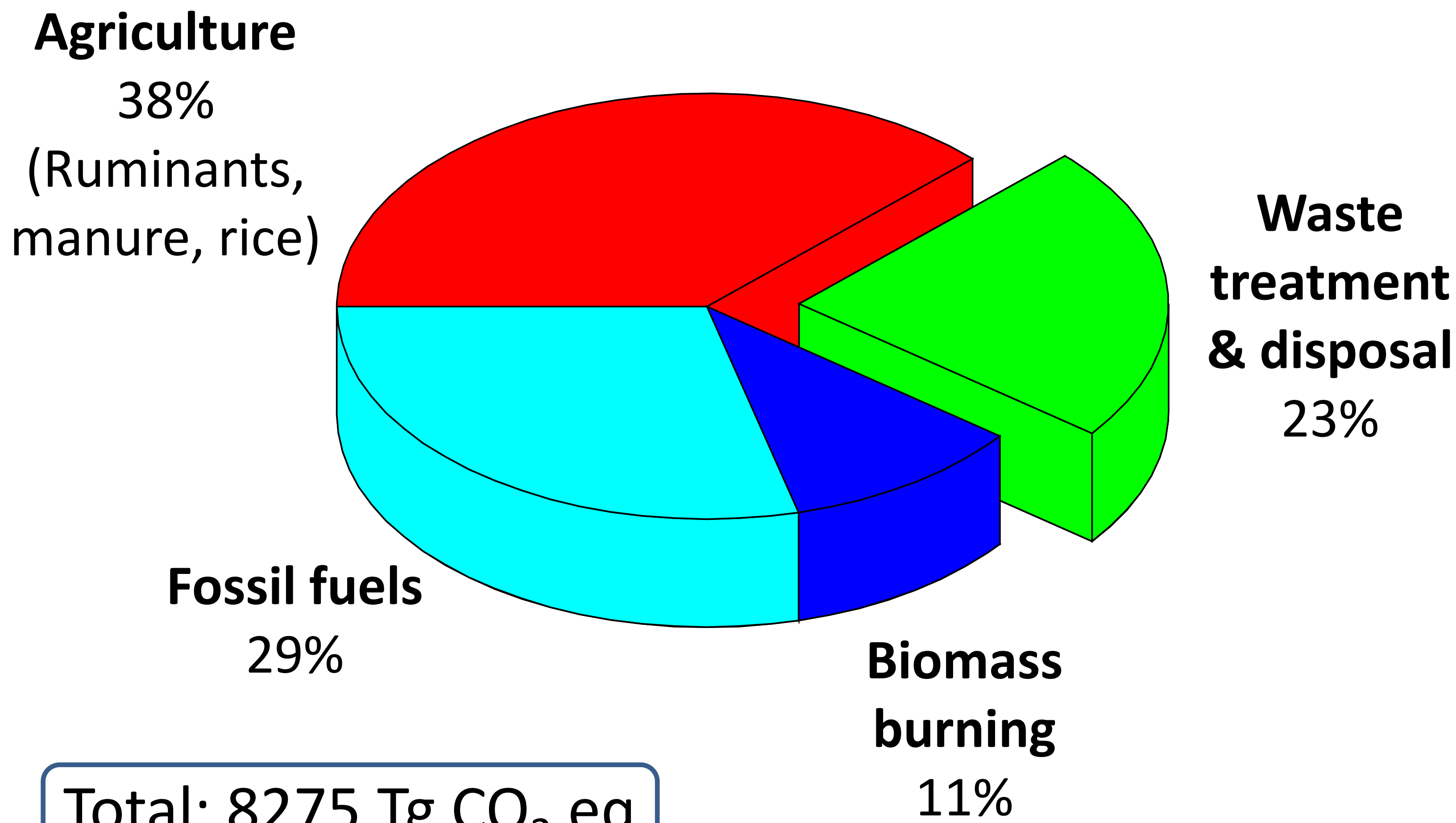


Introduction

- Landfills containing organic wastes produce biogas (landfill gas) containing methane (CH_4)
  - typically 50-60 vol.%
- If untreated, landfill gas emission has several environmental impacts, amongst them the contribution to global warming
- CH_4 in air is explosive: on-site safety requires attention, in cases of gas migration also off-site safety

Global anthropogenic CH_4 sources: Share by category



Total: 8275 Tg CO_2 eq.

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Based on data from IPCC, 2013, 5th Assessment Report, WG 1

Global CH_4 mass balance

Significant reduction of emissions from waste sector or halving leakage from fossil fuel extraction would close CH_4 balance without need to reduce rice cultivation or cattle farming!

Natural sources	Wetlands, freshwater, geological sources, termites, hydrates, permafrost	347
Anthropo-genic sources	Fossil fuel use	96
	Ruminants	89
	Landfills and waste	**75**
	Rice farming	36
	Biomass burning	35

$\boxed{331}$

Sinks	Troposphere and atmosphere	604
	Soils	28

Mass balance	Total sources	678
	Total sinks	632
	Imbalance	**46**

$\boxed{\text{7\% of sources}}$

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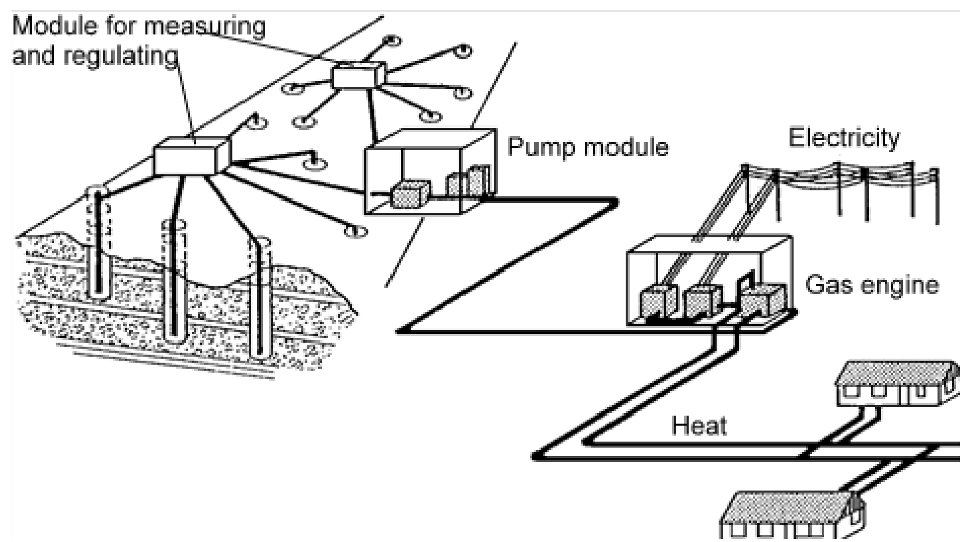
Data from IPCC, 2013, 5th Assessment Report, WG 1

Landfill gas management

- Landfill gas (LFG) can be utilized for energy purposes by installation of gas extraction wells and gas engine facility
- LFG generation degreases with time and utilization becomes non-feasible
- LFG management by methane oxidation could be an alternative



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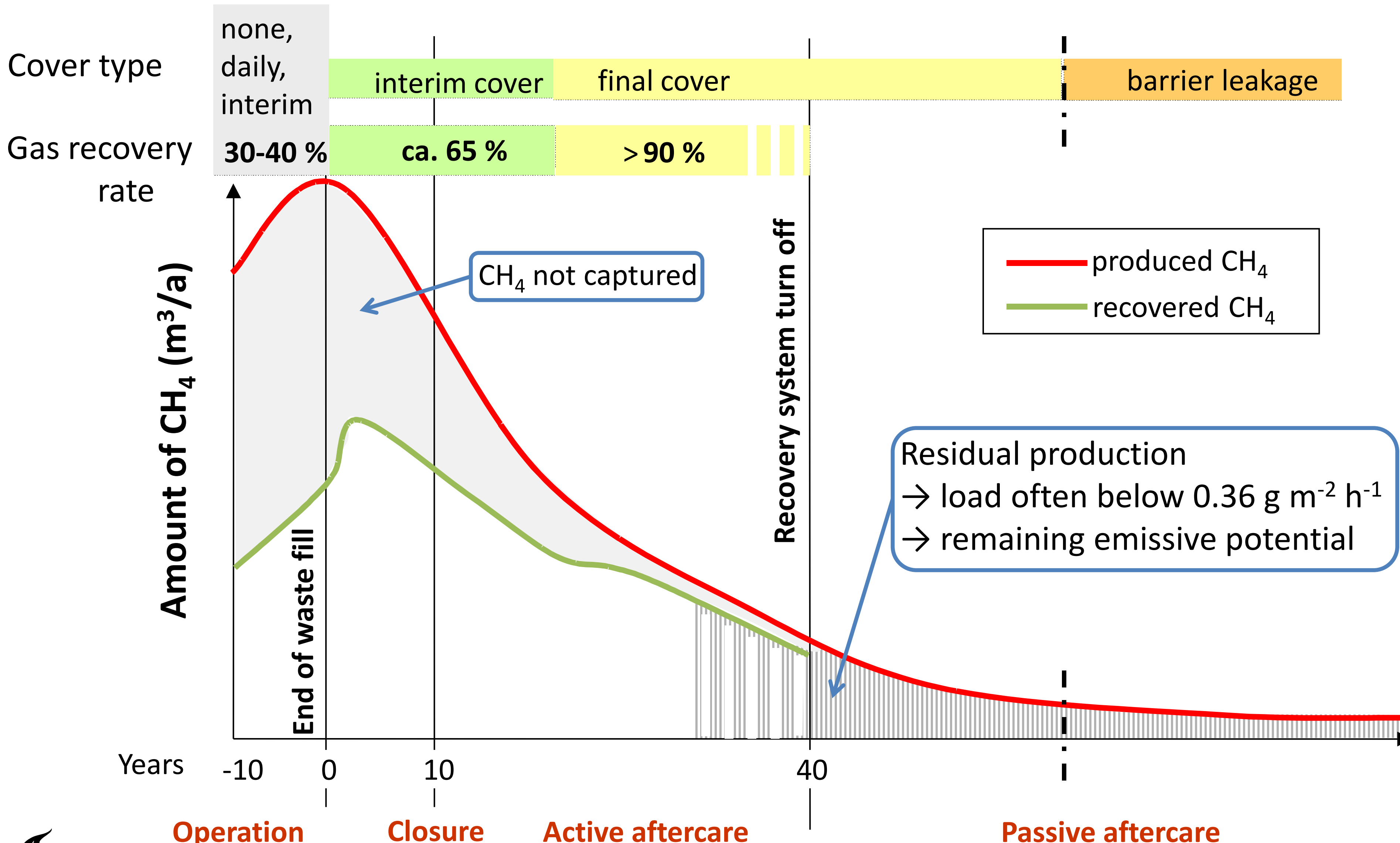
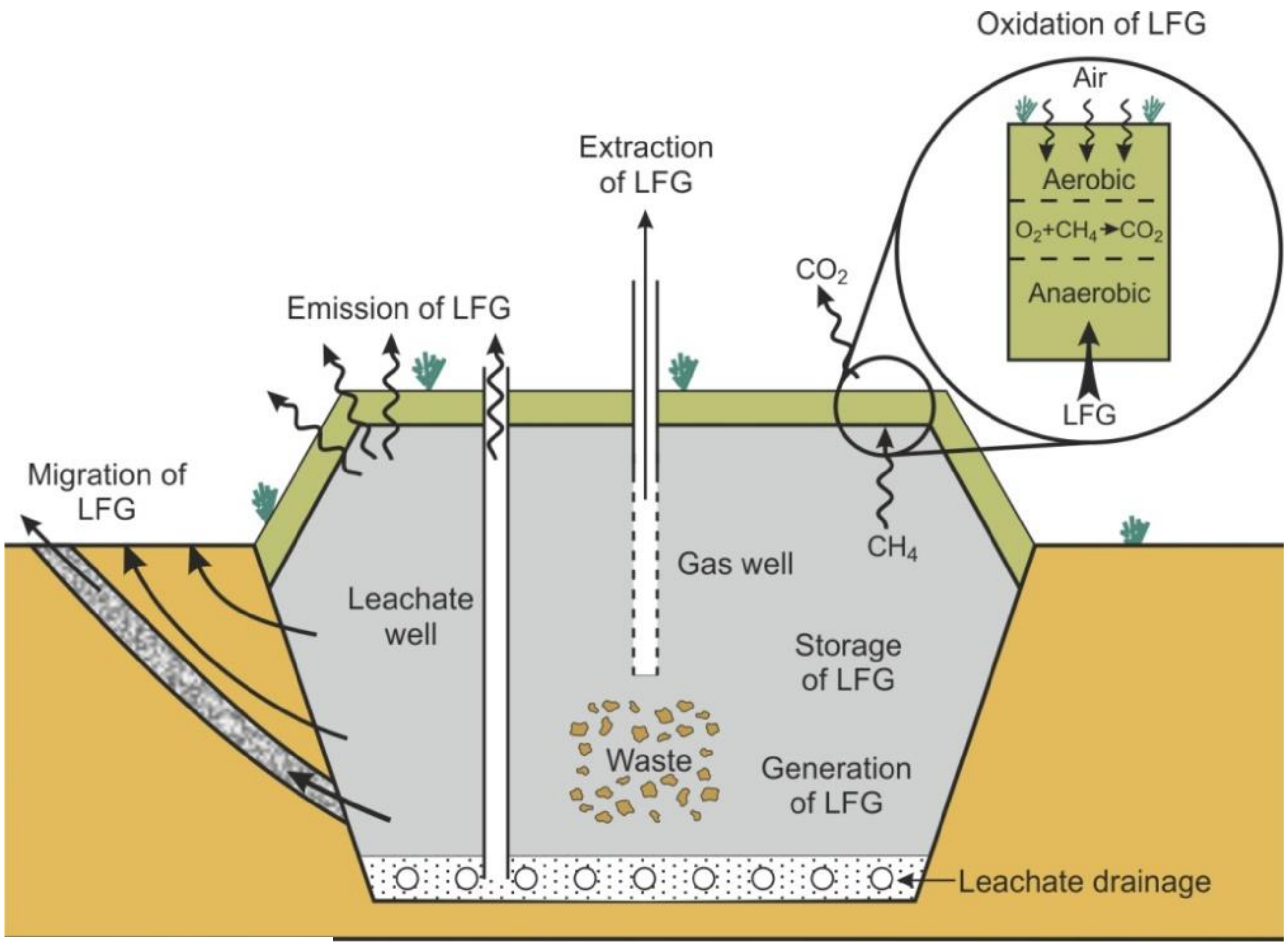
CH_4 in the lifetime of a landfill



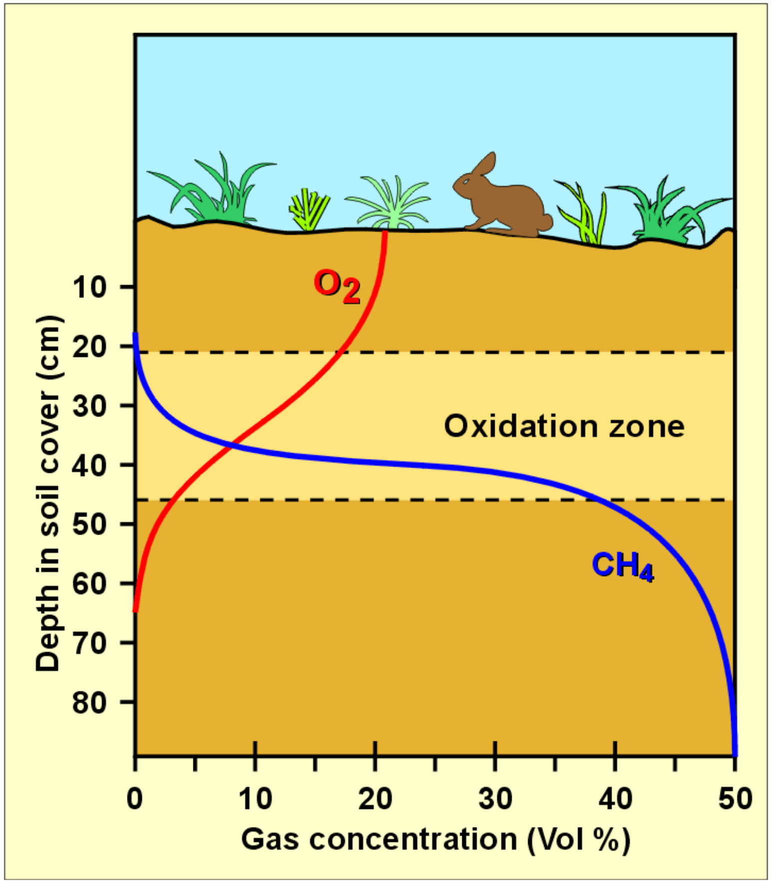
Adapted from Huber-Humer et al., 2008

Overview of the landfill methane processes



Mitigation by methane oxidation

- Landfill gas can be oxidized in covers, windows or biofilter installations on the landfill
- Experiments have documented very high methane oxidation rate in both soil and compost material
- Methane oxidation may be a very cost-effective supplementary mitigation method at landfills with landfill gas utilization
- For smaller and older landfills or landfills with low gas generation a biocover technology could be chosen as a stand-alone technology entirely based on methane oxidation

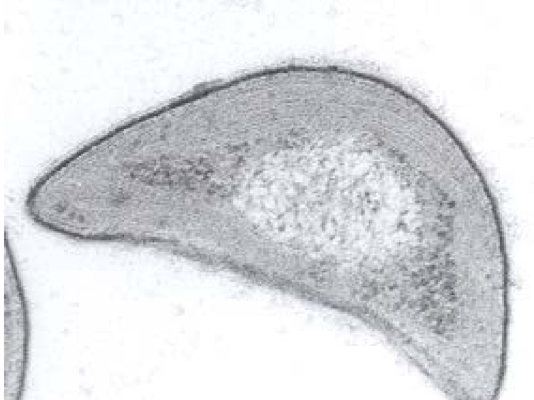


Introduction to the process

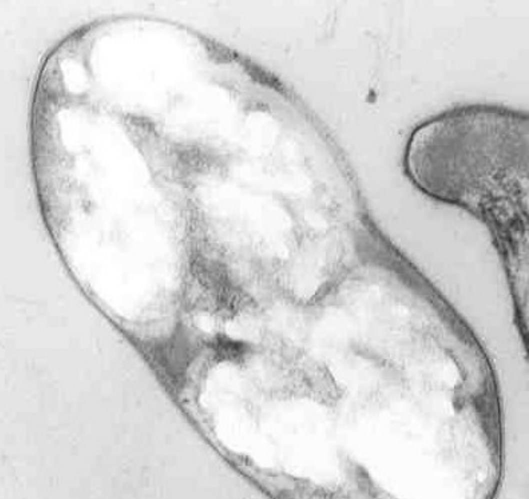
$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$ + energy

Highlights:

- Natural process
- Ubiquitous bacteria develop into highly specialized community adapted to high CH_4 fluxes
- Operate under a wide range of conditions
- Process controls
  → Keynote 1 (Gebert)
- Implementation of full-scale systems
  → Keynote 2 (Kjeldsen)



Methylosinus sp.



“Hungry” *Methylosinus* sp.

Methylobacter sp.

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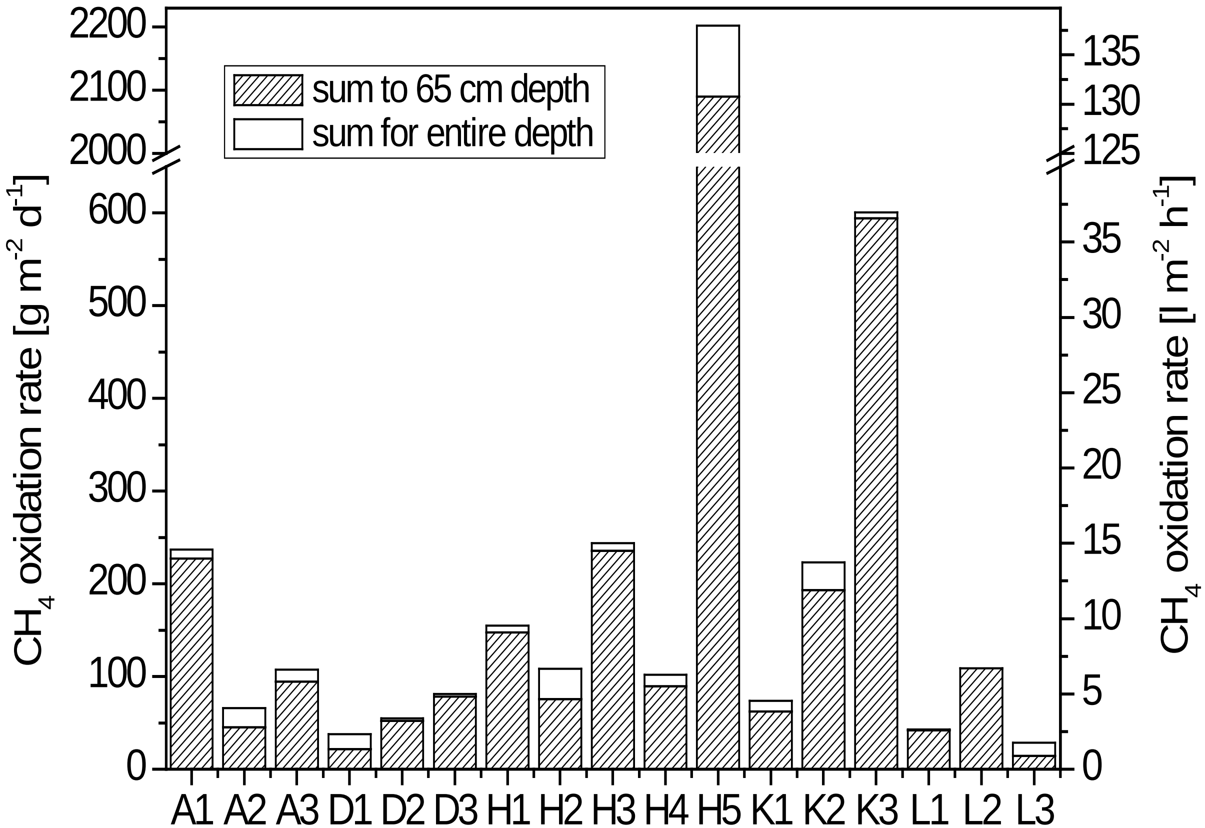
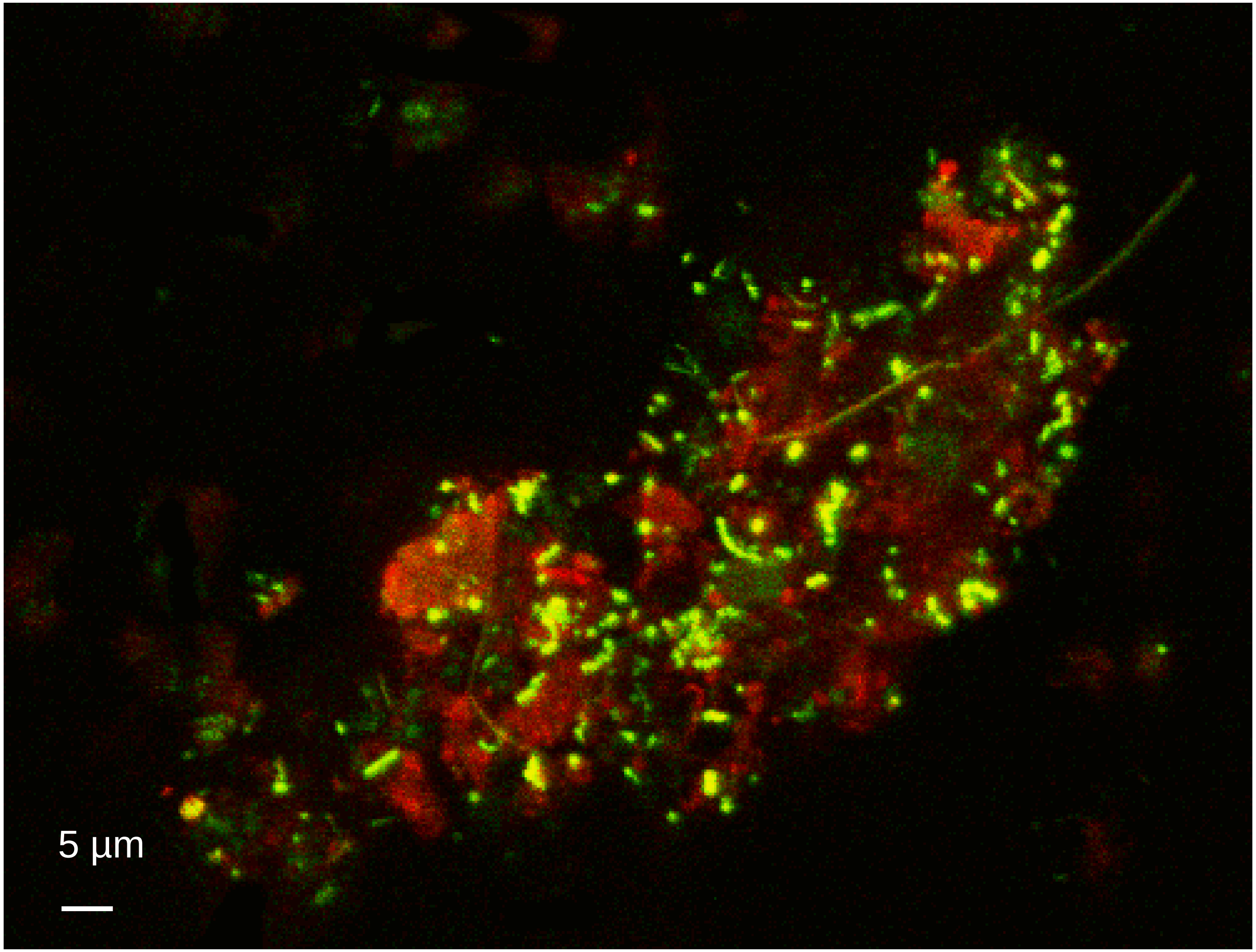
CH_4 oxidation landfill cover soils



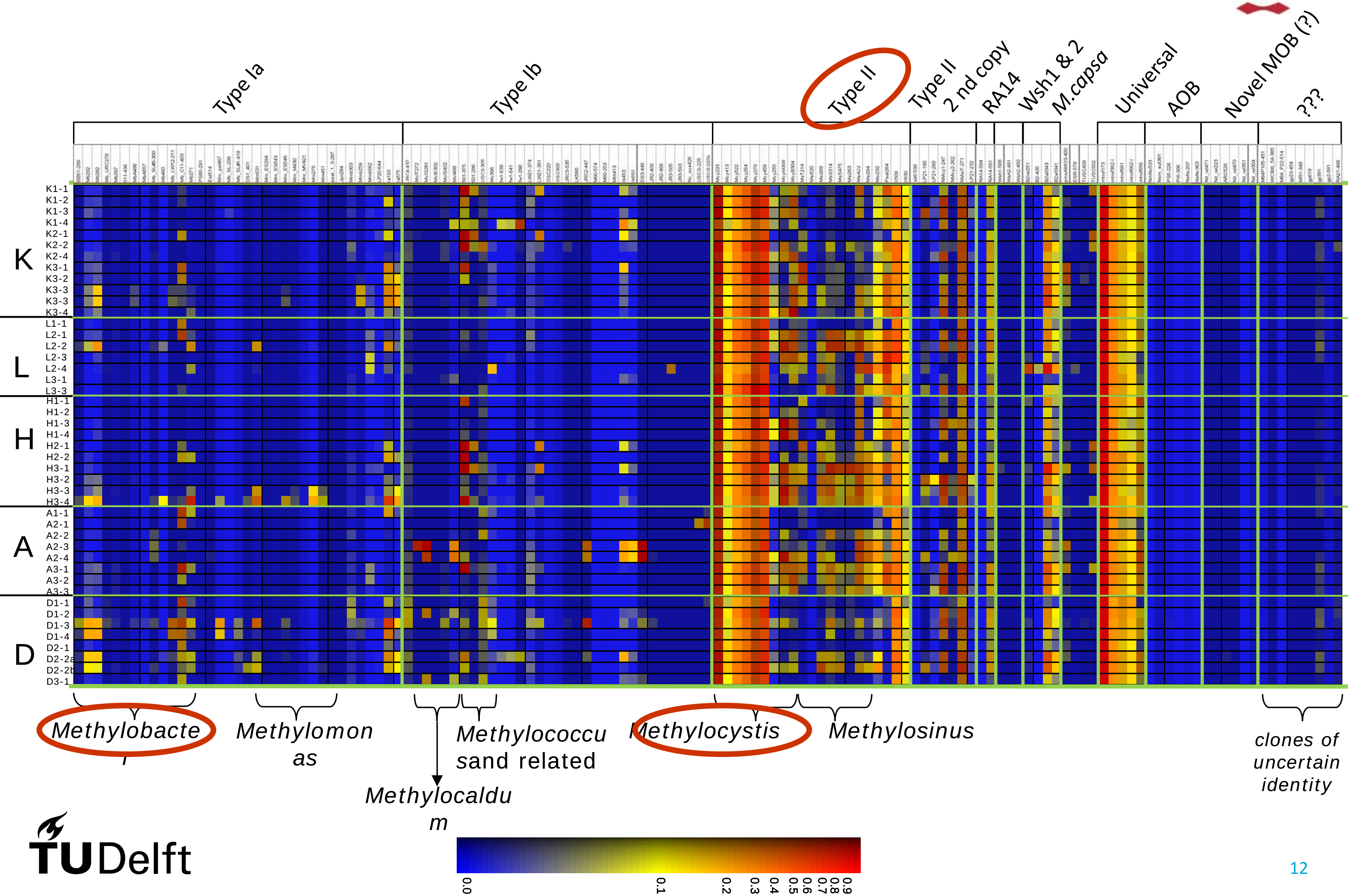
t et al., 2016

Factor 10^3 higher than in natural habitats
(rice paddies, peatlands, tundra)

Methanotrophs on porous clay



Type II dominate community composition



CH_4 oxidation in “anthropogenic sinks”

Filter

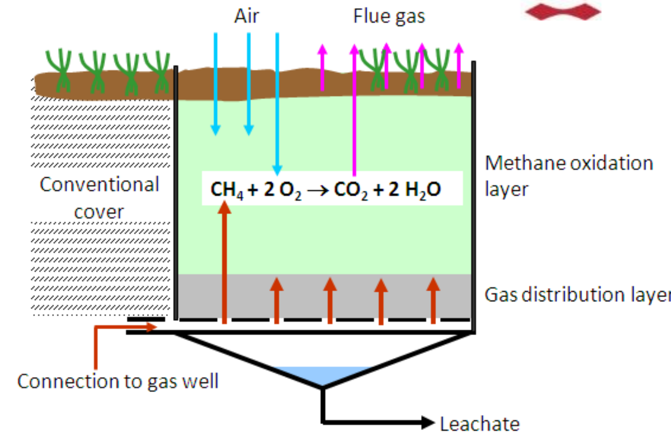
– Landfills with gas collection system, active or passive (Streese & Stegmann, 2003; Gebert et al., 2003; Gebert & Gröngröft, 2006 a, b)

– Stable exhausts from animal husbandry (Melse & van der Werf, 2005)

– Manure storage (Oonk & Koopmans, 2012)

– Coal mine ventilation (Du Plessis et al., 2003)

High load, but controllable

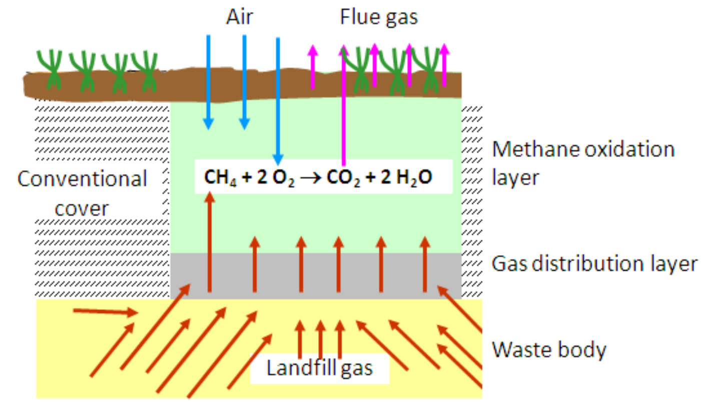


Window

– Landfills without gas collection and surface lining (Pedersen et al., 2010; Scheutz et al., 2011)

– Remediation of emission hotspots on old non-sanitary landfills (Röwer et al., 2012)

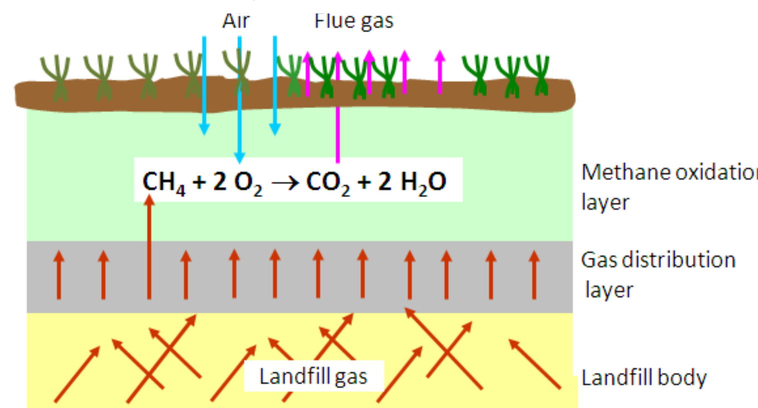
Lower load, uncontrollable



Cover

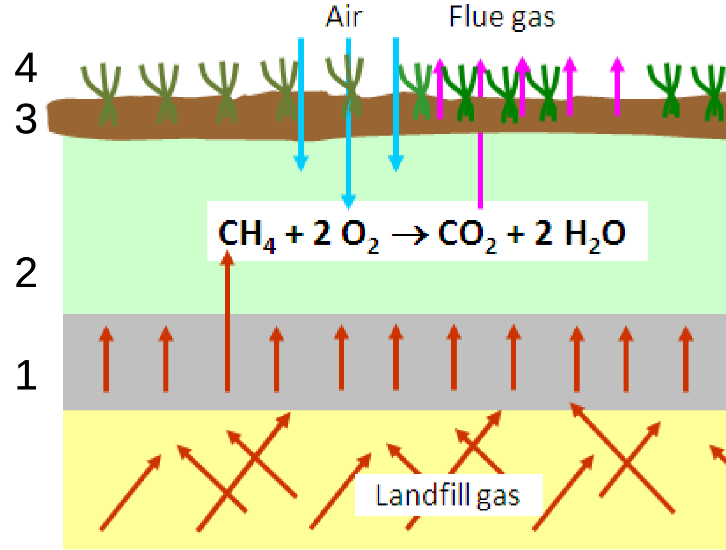
– Landfills with or without gas collection and surface lining (Scheutz et al., 2014; Geck et al., 2016; Cassini et al., 2017)

Low load, uncontrollable



General setup

1. **Gas distribution layer**: optimizes spatial distribution of load to system
2. **Subsoil**: Main methane oxidation layer (MOL), in case of frost or drought process is translocated deeper into subsoil, redundancy (thickness) desired to provide space for process an harmonize spatial load
3. **Topsoil**: Sustains vegetation and MOB (water, nutrients), homogenizes conditions for underlying layers, top part of MOL
4. **Vegetation**: prevents erosion, enables optical unity with surrounding landfill cover



– Filter stability between all layers must be warranted
– Capillary effects between layers should be avoided

→ Filter layers can be necessary

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History CH_4 oxidation research

- Early research dates back to 1985, maybe earlier
  Mancinelli, R.L. & McKay, C.P. (1985) Methane-oxidizing bacteria in sanitary landfills. Proc. First Symposium on Biotechnological Advances in Processing Municipal Wastes for Fuels and Chemicals.
- Topic boosted in the light of the climate change debate
- CH_4 oxidation listed as key mitigation technology by IPPC WG III AR (Bogner et al., 2007)
- 2002: **CLEAR** was formed: Consortium for Landfill Emissions Abatement Research
- Today CLEAR is a task group of the International Waste Working Group IWWG

international waste working group

CLEAR output

- 2008: Review paper: Huber-Humer, M., Gebert, J., Hilger, H.: **Biotic systems to mitigate landfill methane emissions**. WM&R 26, 33-46.
- 2009: Review paper: Scheutz C., Kjeldsen P., Bogner J.E., De Visscher A., Gebert J., Hilger H.A., Huber-Humer M., Spokas K.: **Microbial methane oxidation processes and technologies for mitigation of landfill gas emissions.** WM&R 27, 409-455.
- 2011: Special issue “Landfill Gas Emission and Mitigation”. Waste Management 31.
- In the making: 2 review papers on design of CH_4 oxidation systems, their monitoring and pertaining methods

Recent workshop report from 2017: Guiding documents for CH_4 oxidation systems

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IWWG News and Views

Compiled by Marco Ritzkowski

In this issue: Introduction of new IWWG Board members, Workshop report by the IWWG Task Group CLEAR, and details on future IWWG events.

CLEAR people & contact

http://www.tuhh.de/iue/iwwg/task-groups/clear.html

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Bio-oxidation systems for landfill gas

- Keynote 1:
  Factors impacting the process and system performance,
  Julia Gebert

- Keynote 2:
  Overview of full-scale engineered systems and Danish Biocover Initiative,
  Peter Kjeldsen