Landfill Aeration as a Contribution to Landfill Stabilization and Climate Protection

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These Landfills are now mostly closed

Deponiebetrieb in Hangzhou, China

Tägliche Ablagerungsmenge ca. 6000 t/d

Potential of Landfills in the Aftercare Phase

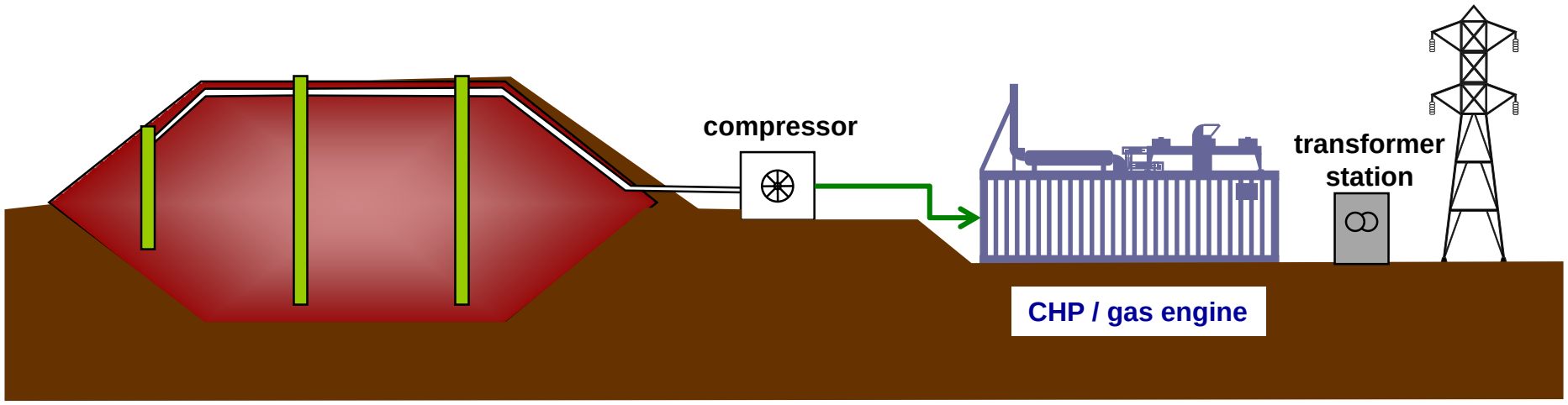
Larger closed Landfills in Germany:

- ca. *400 – 600 landfills* with relevant gas production
- *Gas collection and treatment systems* in general existing, may need repair or reconstruction
- ***Gas utilization phase*** is already or will be shortly completed
- Climate gas emission potential still 8 - 10 Mio. Mg CO_2-Äq./a
- *Gas collection efficiency* 20 – 60% (ca. 40-60% at „younger“ landfills)

Landfill Gas Collection and Utilization

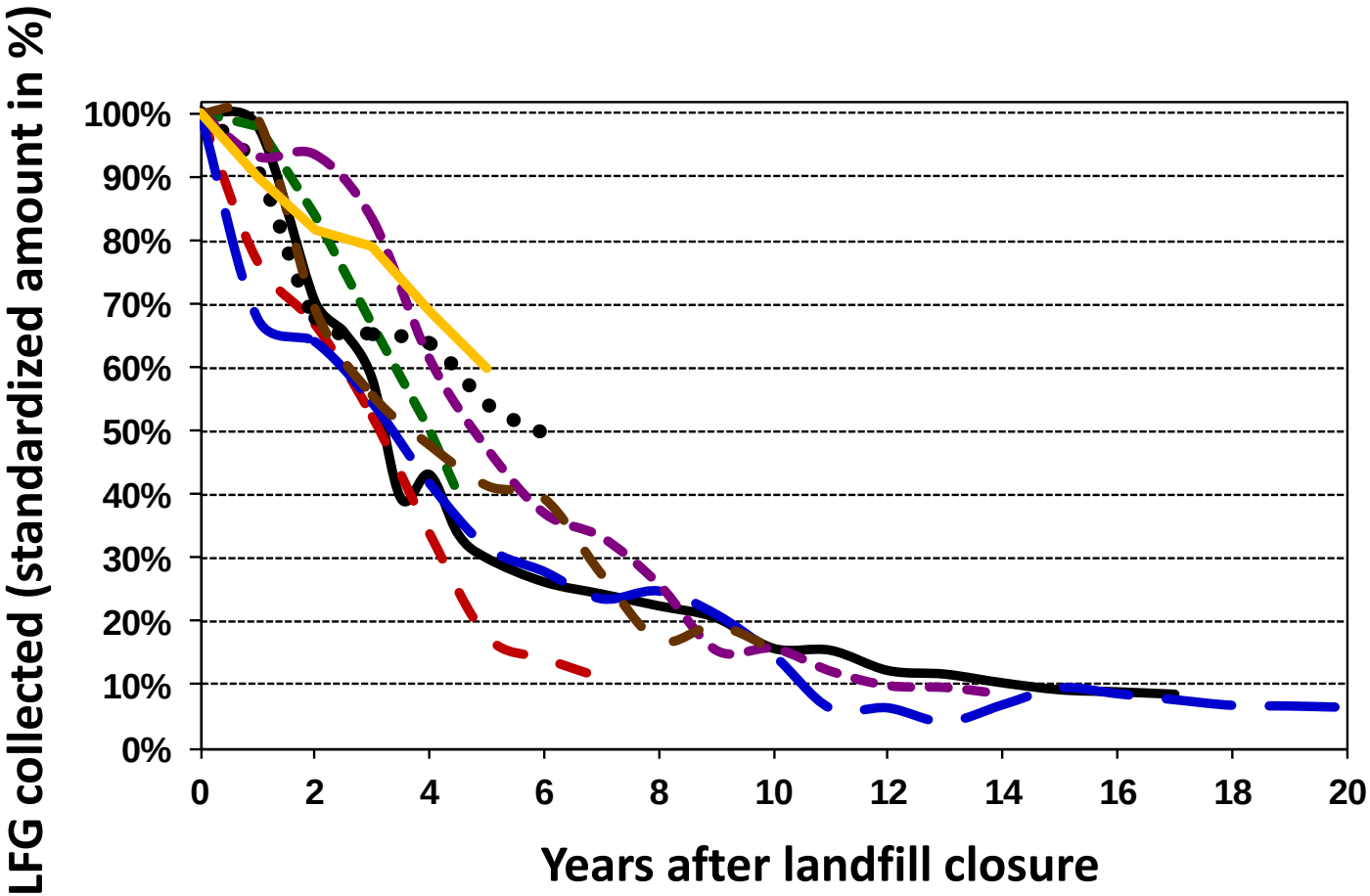
Is required due to landfill regulation in Germany/Europe (state of the art)

- Landfill gas collection via horizontal pipe system or vertical wells and gas transportation pipes
- Mostly CHP, gas engines/turbines for energetic gas utilisation



Collected Amounts of LFG after Closure

Data from different German landfills



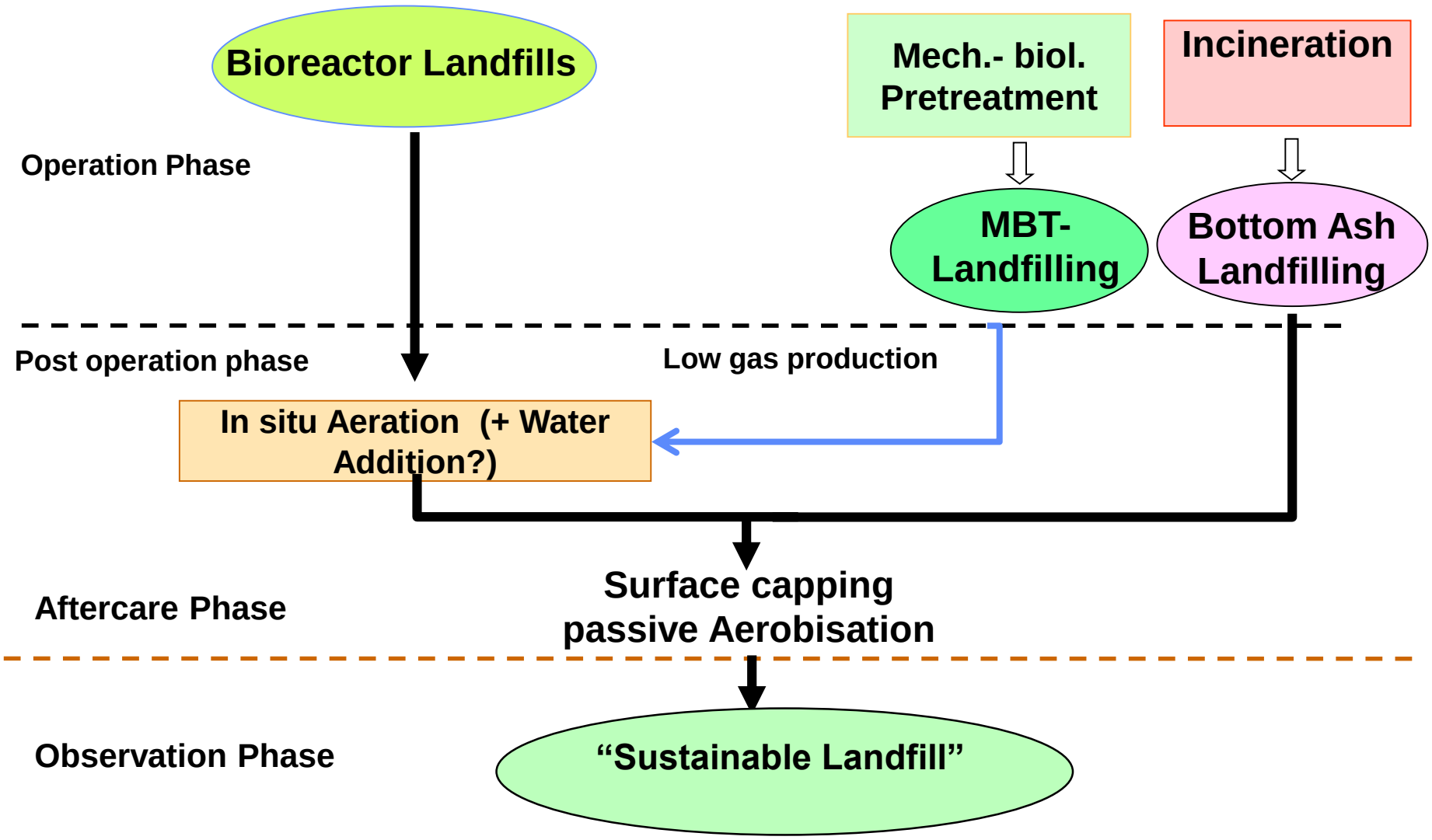
Source: K.-U. Heyer (IFAS, Hamburg)

Prediction of Time until Leachate has reached its final Discharge Quality

Parameters	Required value C_E [mg/l]	Initial concentration C_0 [mg/l]	Period required until C_E is reached [a]
COD	200		
Domestic waste landfill		1200 – 3800	75 – 120
MBP landfill		450 – 2000	35 – 100
Landfill with ashes from WIP		15 - 600	0 – 50
Construction waste landfill		100 - 250	0 – 10
$N_{tot.}$	70		
Domestic waste landfill		400 – 800	110 – 160
MBP landfill		150 - 250	45 – 80
Landfill with ashes from WIP		4 – 200	0 – 65
Construction waste landfill		20 - 200	0 – 65
Cl	100		
Domestic waste landfill		1000 – 2100	110 – 150
MBP landfill		420 - 980	70 - 110
Landfill with ashes from WIP		290 – 12000	50 – 230
Construction waste landfill		100 - 600	0 – 90

WIP: waste incineration plants
Assumptions: Deposition thickness: 20 m; new formation of leachate: 250 mm/a
Initial concentration C_0: range of leachate concentrations of different landfill types during the operating phase, respectively at the beginning of the closing phase

Sustainable Landfill Concept



Landfill Aeration

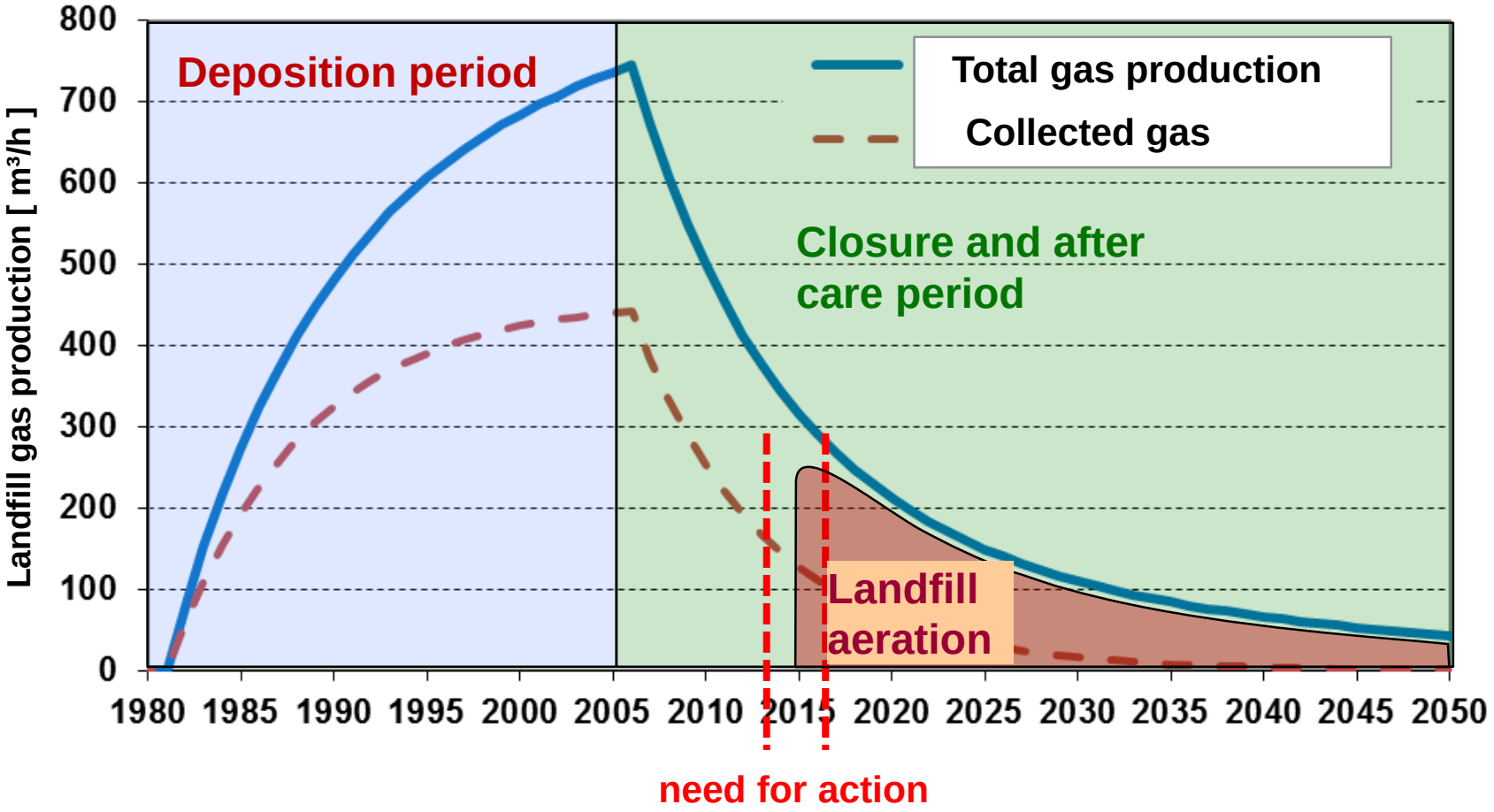
By converting an *anaerobic into aerobic* MSW landfill, biological *degradation of the residual organics will be enhanced* by factor 2-3 and resulting in a *biologically stabilized landfill* with a low emission potential in about *8-10 years:*

- Significant reduction of the emission potential
- Reduction of the aftercare phase
- Avoidance of GHG emissions (about 10% - 20% of the total CO2 and CH4 production)
- Improvement of the leachate quality (mainly with regard to organic pollutants and ammonia-nitrogen)
- Acceleration and completion of the main landfill settlements
- Earlier recovery of landfill space

Avoidance of Residual LFG Emissions

After gas utilization , residual gas (10-20% of total gas potential) emits into the atmosphere for several decades.

Landfill aeration can avoid these climate gas emissions.



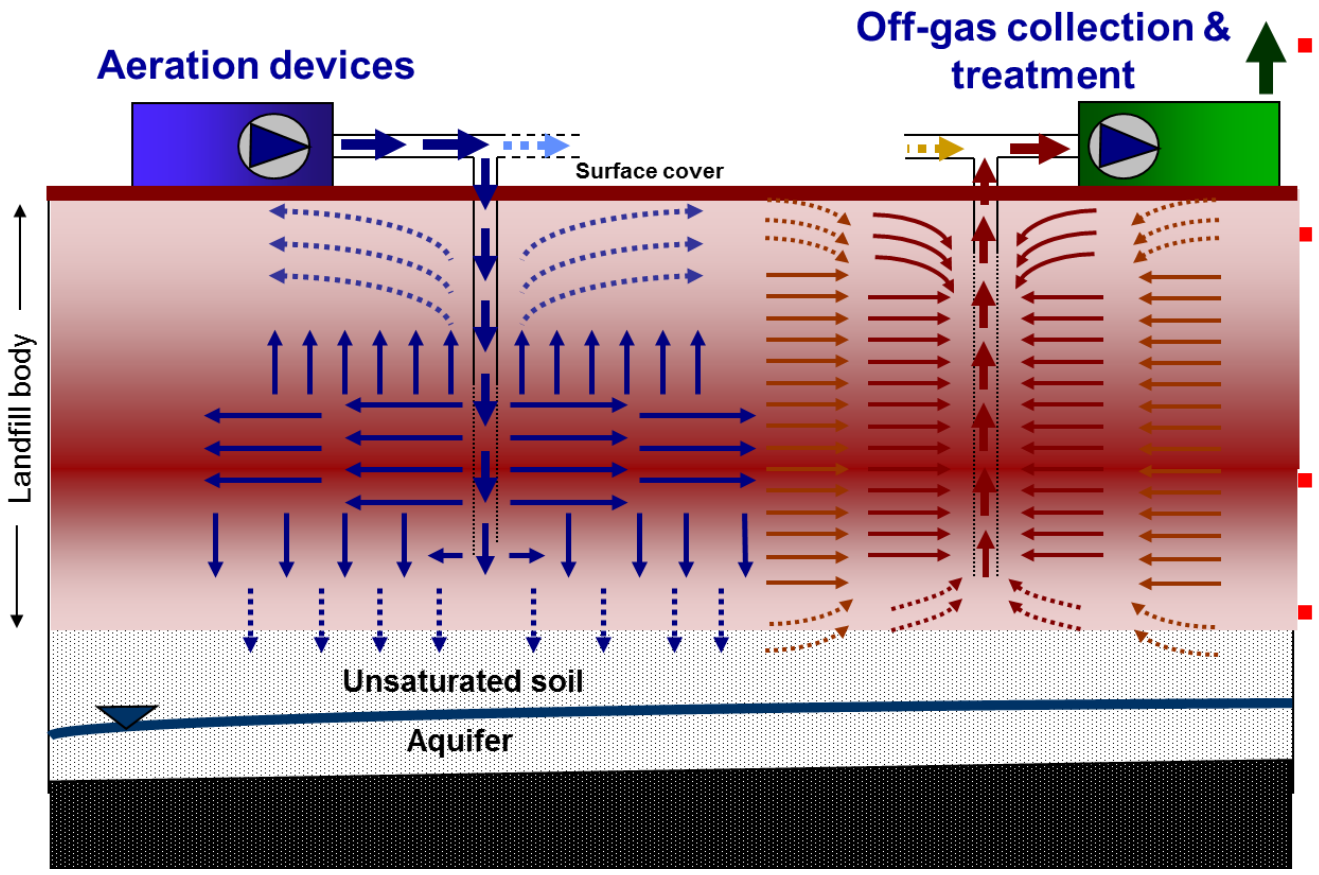
Landfill Aeration Methods

- Low pressure aeration with off-gas treatment
- Landfill aeration through over suction with off-gas treatment
- Medium pressure aeration without off-gas capturing and passive exhaust air treatment in methane oxidation layer
- High-pressure aeration

Landfill Doerentrup
Aeration

Barsbüttel
Oversuction

Low Pressure Aeration AERO*flott*®



Source: Heyer et al.

AERO*flott*®

- Continuous aeration with low pressure (20 to 80 mbar)
- Air distribution in the landfill body by convection und diffusion
- Parallel aeration and off-gas extraction
- Off-gas treatment in non catalytic thermal oxidation, lean gas flares or biofilter (different efficiencies)

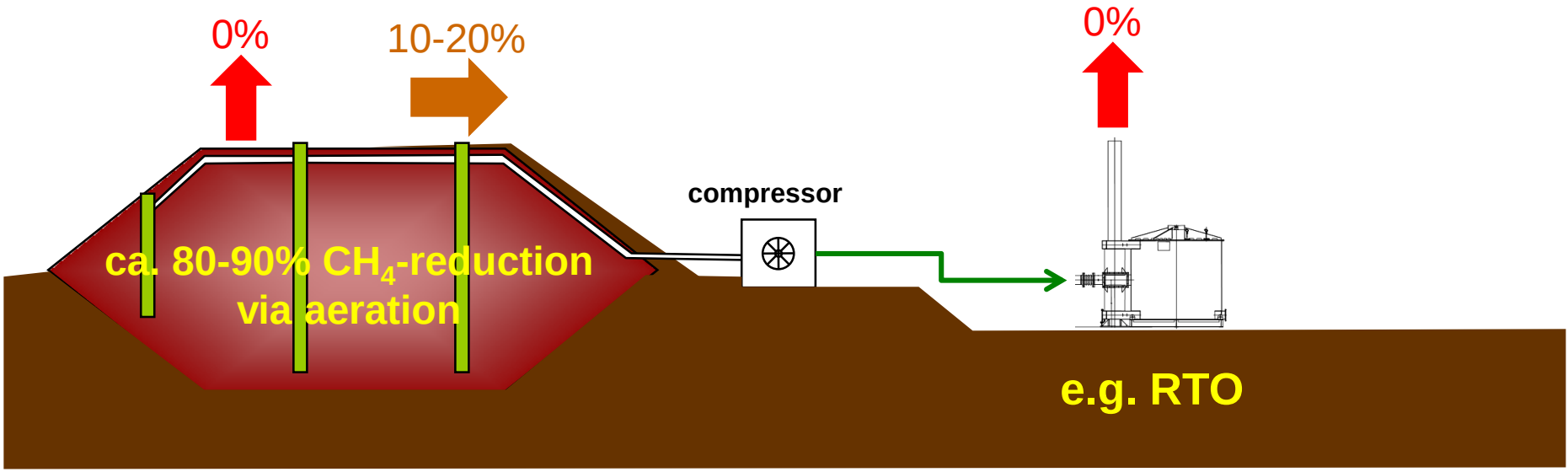
Low Pressure Landfill Aeration

Landfill aeration:

80 – 90% of methane reduction in landfill body

Exhaust air treatment (e.g.:RTO / high temperature oxidation):

10 – 20% of methane reduction via exhaust air treatment



Technical Realization of Landfill Aeration in Germany

AERO*flott* low Pressure in-situ Aeration

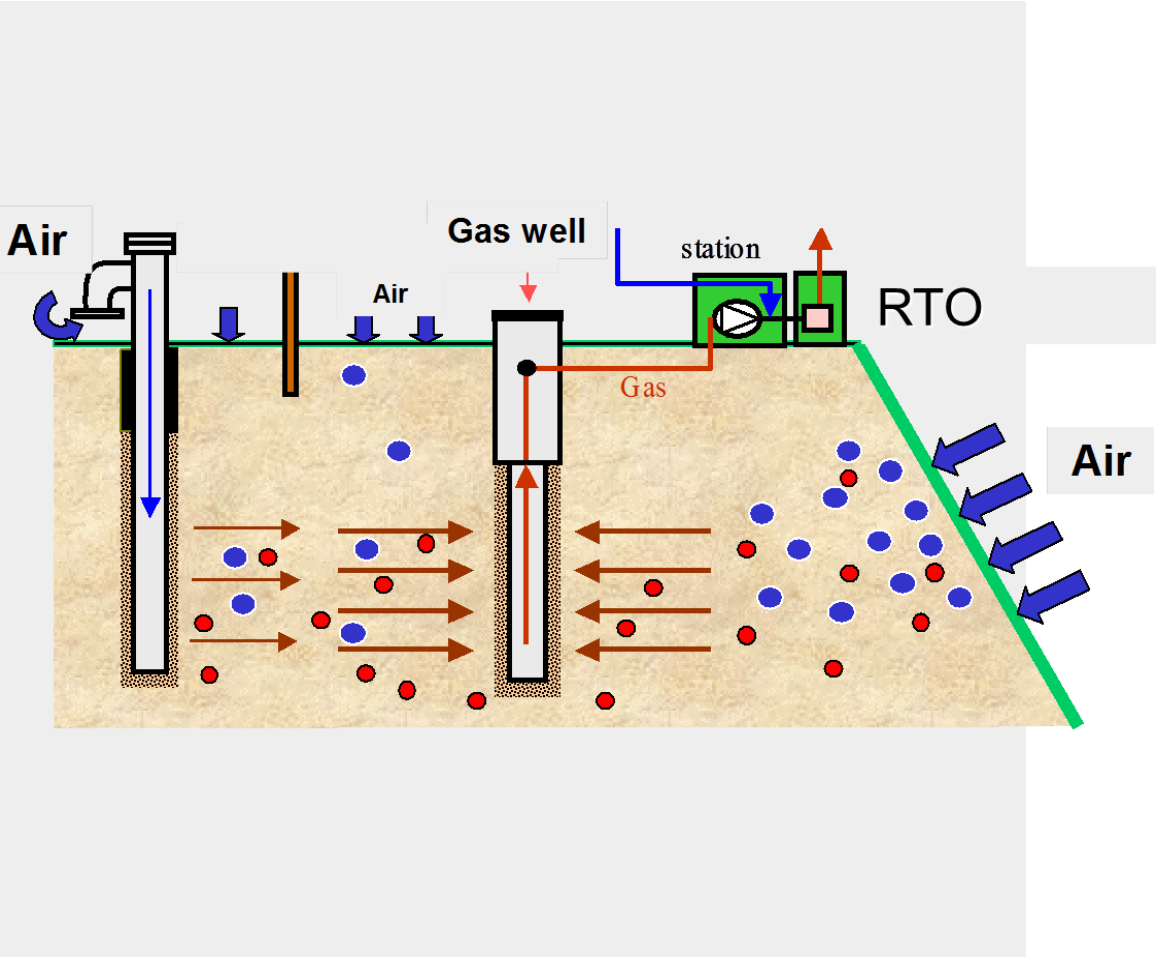
Successfully completed projects:

- Kuhstedt landfill, Rotenburg (Wümme) – Lower Saxony
  (UBA/BMBF-project with Institute of Waste Management, TUHH)
- Amberg-Neumühle landfill – Bavaria
- Milmersdorf landfill, Uckermark – Brandenburg

Actual projects:

- Dörentrup landfill, Lippe – North Rhine-Westphalia
- Süpplingen landfill, Helmstedt – Lower Saxony
- Schwalbach-Griesborn landfill – Saarland
- Halberbracht landfill, Olpe – North Rhine-Westphalia
- Landfill Tötensen, Lower Saxony
- Landfill Wolfenbüttel, Lower Saxony

Aeration with active Oversuction



- Air is sucked in through the landfill surface by means of an induced vacuum
- Gas wells are slotted in the lower part of the pipe
- „Passive“ aeration wells may increase the aeration efficiency
- Off-gas treatment thermal or in bio-filters
- Vacuum from low to high (50 -> 300mbar)
- Aeration effect lower compared to active aeration

Examples for active Oversuction of Landfills in Germany

Intensive residential and commercial utilization of closed landfills including building development

- Landfill Kiel Drachensee
- Landfill Schenefeld
- Landfill Barsbuettel
- Landfill Stemwarde (I), (II)
- Landfill Oher Tannen
- *Landfill Baldurstr-Bockholtstr./Kassenberger Str. (Bochum)*
- *Landfill Dorstener Straße (Oberhausen)*
- *…and some more projects from the 80ies*.

Civil Works and Installations

Gas wells for aeration and gas extraction

Northern gas distribution station

Operation area:

- Container with blowers for the aeration and gas extraction
- off gas treatment
- Workshop, lounge container

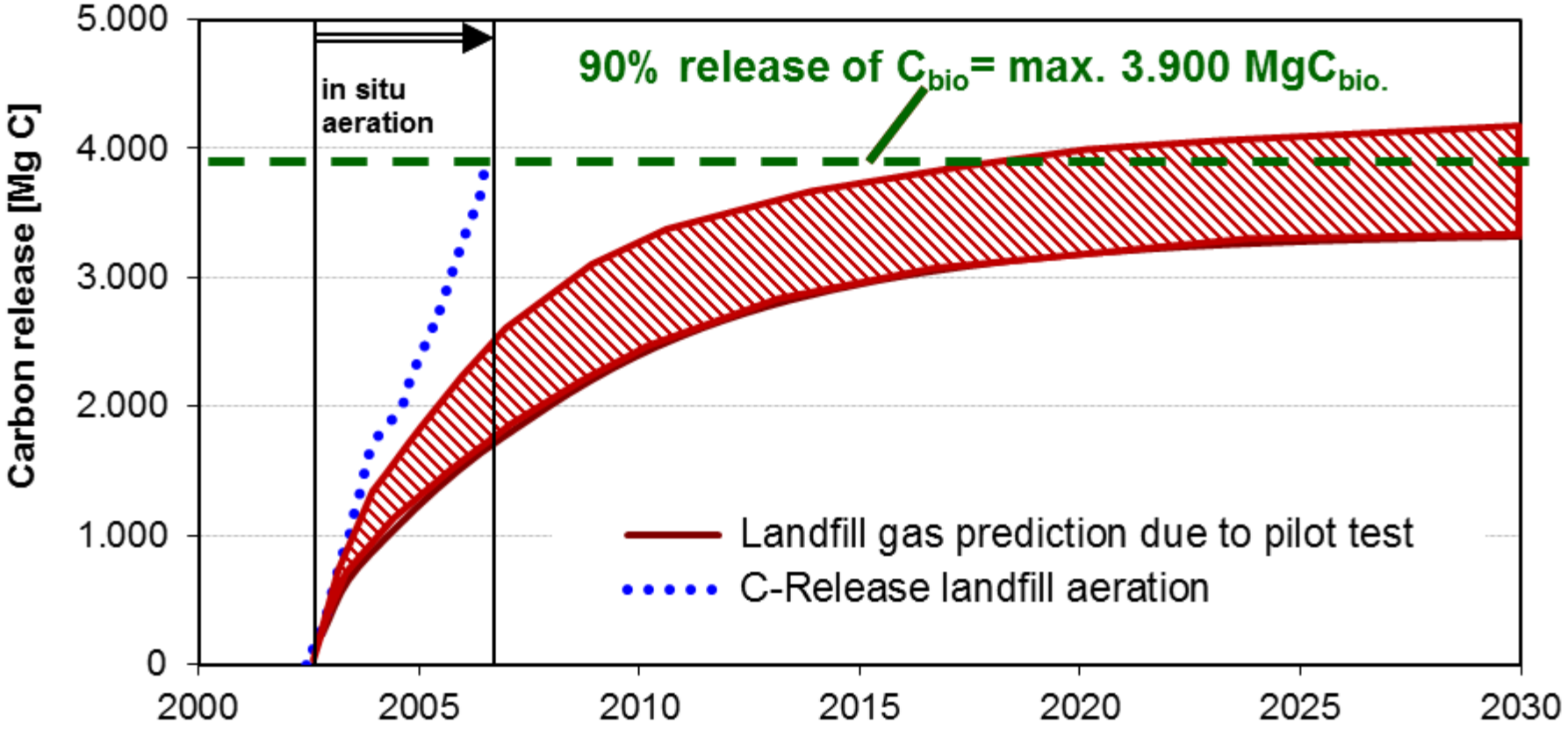
Southern gas distribution station

AERO*flott*®-system

Landfill Süpplingen - District Helmstedt

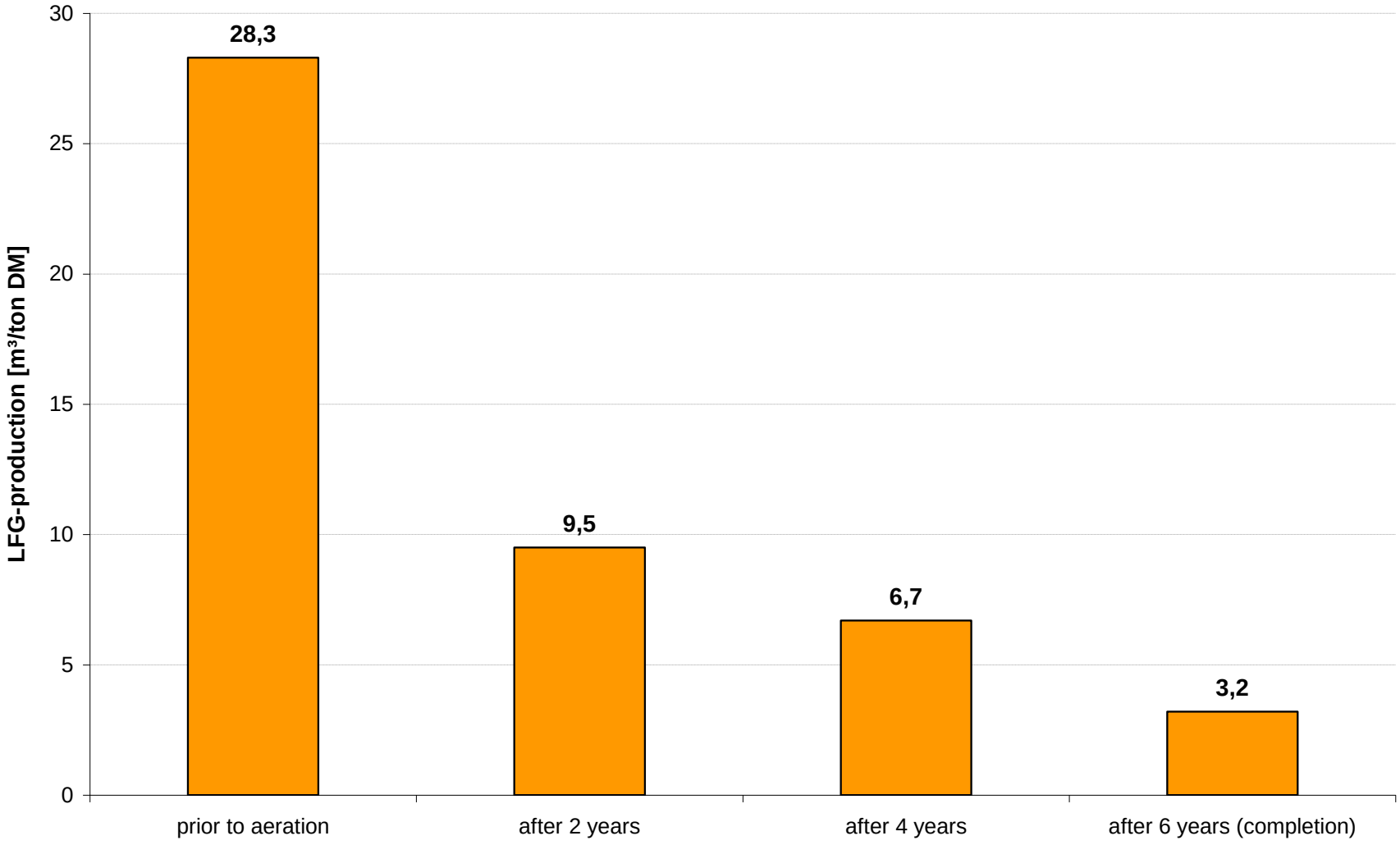
Carbon Reduction as a Result of Landfill Aeration

Comparison with the predicted carbon release under anaerobic milieu conditions (Milmersdorf Landfill, Brandenburg)



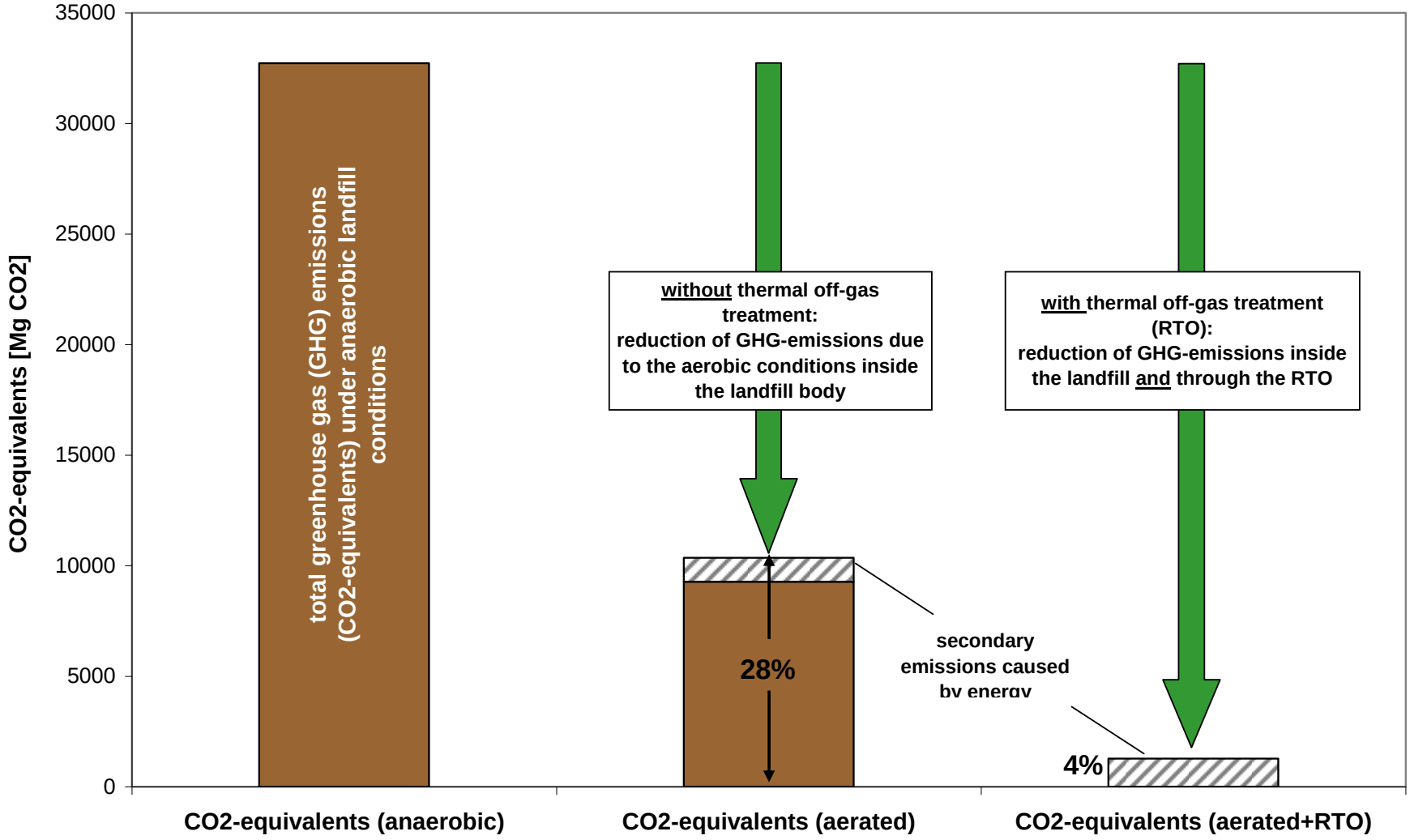
Reduction of the Landfill Gas Production

Landfill Kuhstedt, District Rothenburg



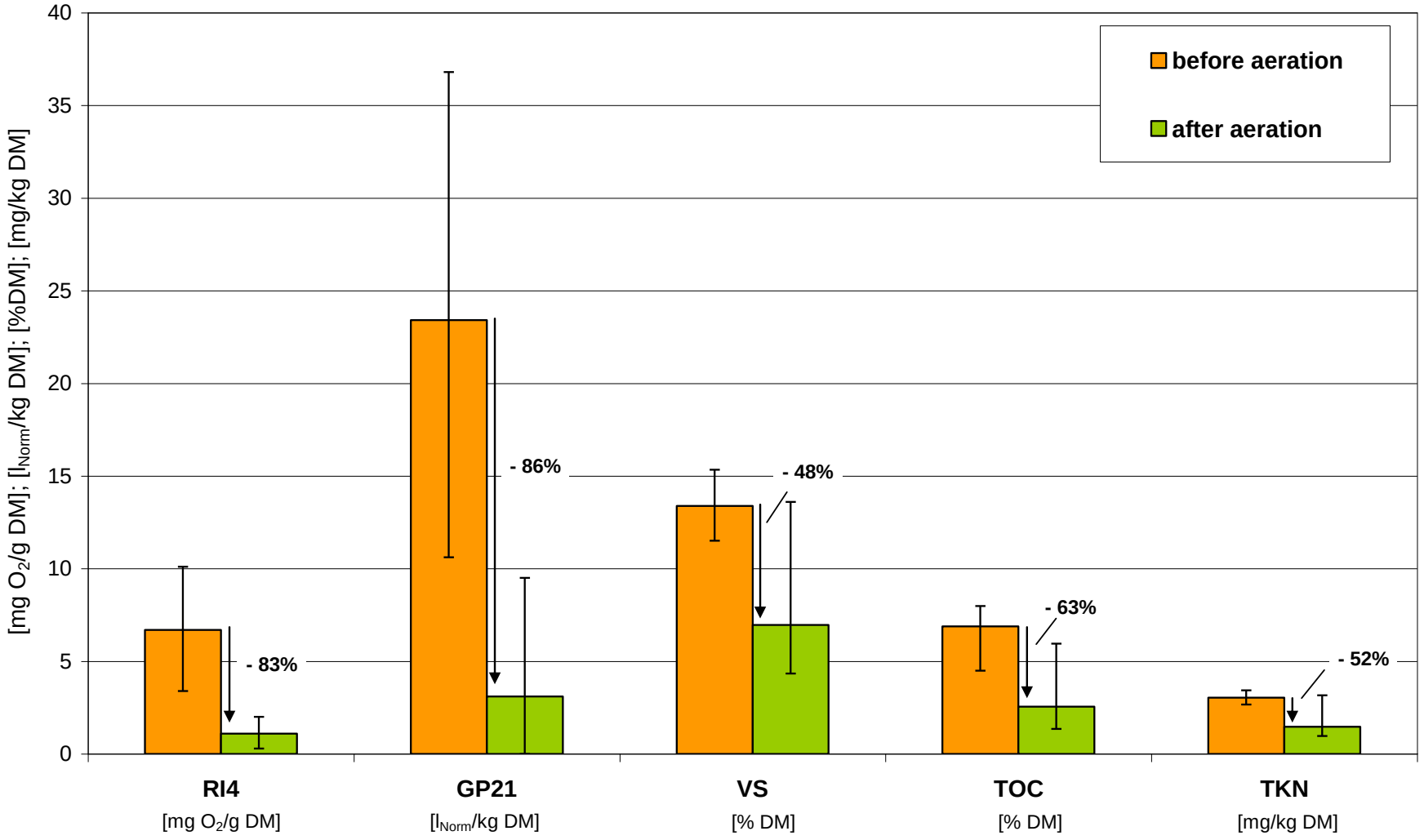
Reduction of GHG – Emissions

Landfill Kuhstedt, District Rothenburg



Change of Waste Characteristics due to Aeration

Landfill Kuhstedt, District Rothenburg



Landfill Settlement as a Result of Aeration Landfill Kuhstedt District Rothenburg

Change of Leachate Quality due to Aeration

Results from Lab. Scale Lysimeter Tests

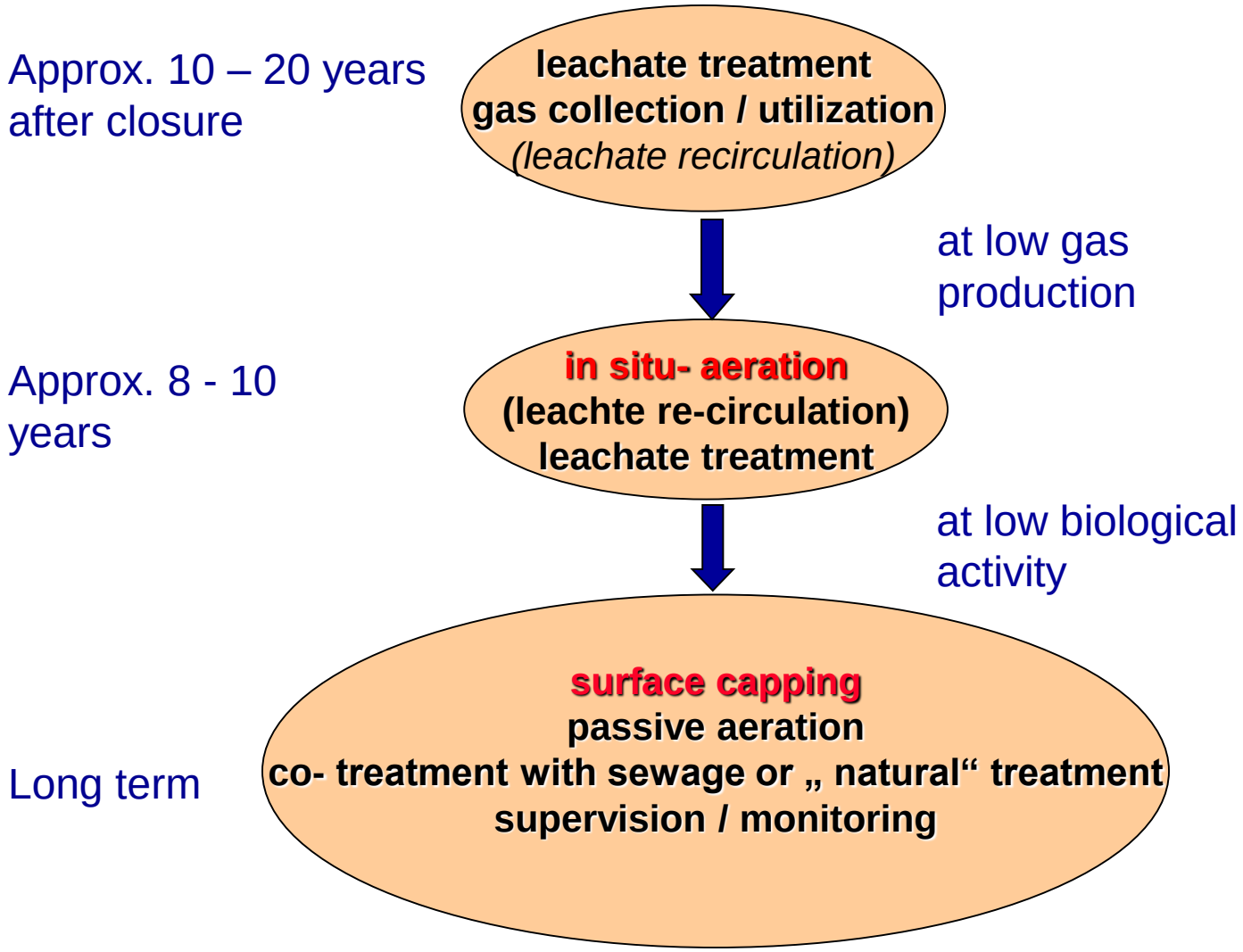
Parameter	Leachate (from LSR tests) before aeration (average)	Leachate (from LSR tests) after aeration (average)	Variation
NH_4-N [mg/l]	322	52	-84 %
BOD_5 [mg/l]	299	39	-87 %
TOC [mg/l]	456	114	-75 %

Solid Waste Samples before and after In- Situ Aeration

Waste sample before aeration

Waste sample after aeration

Operation Scheme for Closed Landfills



In Situ Aeration of the Bornum landfill, Germany


Photo: IFAS (Hamburg)

In operation since 08/2014
(with interruptions due to technical problems with the RTO)

Saving of up to
84,000 tons $CO_{2,e}$


Photo: IFAS (Hamburg)

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Photo: IFAS (Hamburg)

Data: IFAS (Hamburg)

Teuftal Landfill – Pilot Project in Switzerland

Operation (Bioreactor LF)	**1973 until 2000** **Waste deposition into a valley ; re-allocation of a stream** (side slopes of the valley with constant water head)

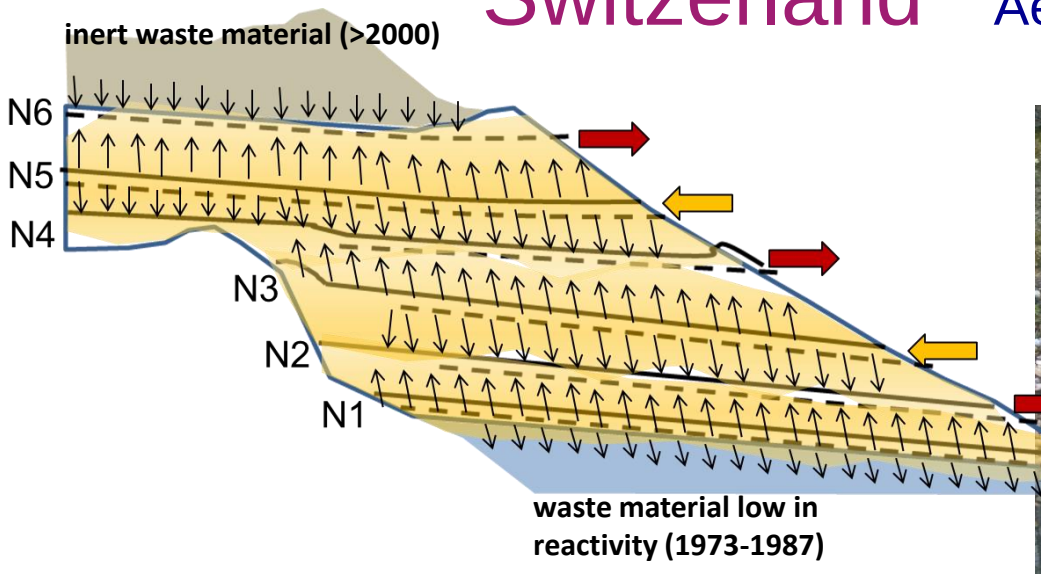
Deposited kinds of waste:	**Municipal solid waste, bottom ash, excavated soil, sludge** ***Waste emplacement in thin layers, high compaction***
Total area:	**approx. 12 ha**
Landfill height:	**up to 35 m of "reactive" waste; overlain by > 10m of soil**
Landfill mass:	**approx. 2.1 M tons TS**
Base liner:	**yes, with leachate collection**
LFG extraction:	**yes, horizontal drainage systems for combined LFG and leachate collection**
Surface cover:	**Liner (slope area) and soil (plateau)**

Photo: Deponie Teuftal AG

Data and photo: TUHH and Deponie Teuftal AG

In–Situ Aeration of the Landfill “Teuftal” Switzerland

Aeration Concept



- Scheduled air flow rate:

  1.000 – 2.000 m³/h (at 150 – 250 mbar positive pressure; based on pre-tests)

- Energy efficient screw blowers with high capacity

Goals for the Reduction of Climate Gases

European Union:

Until 2020:

- *20% climate gas* (CG) reduction (100%: 1990) as an independent commitment
- *30% CG- reduction* (100%: 1990) in the framework of an international agreement

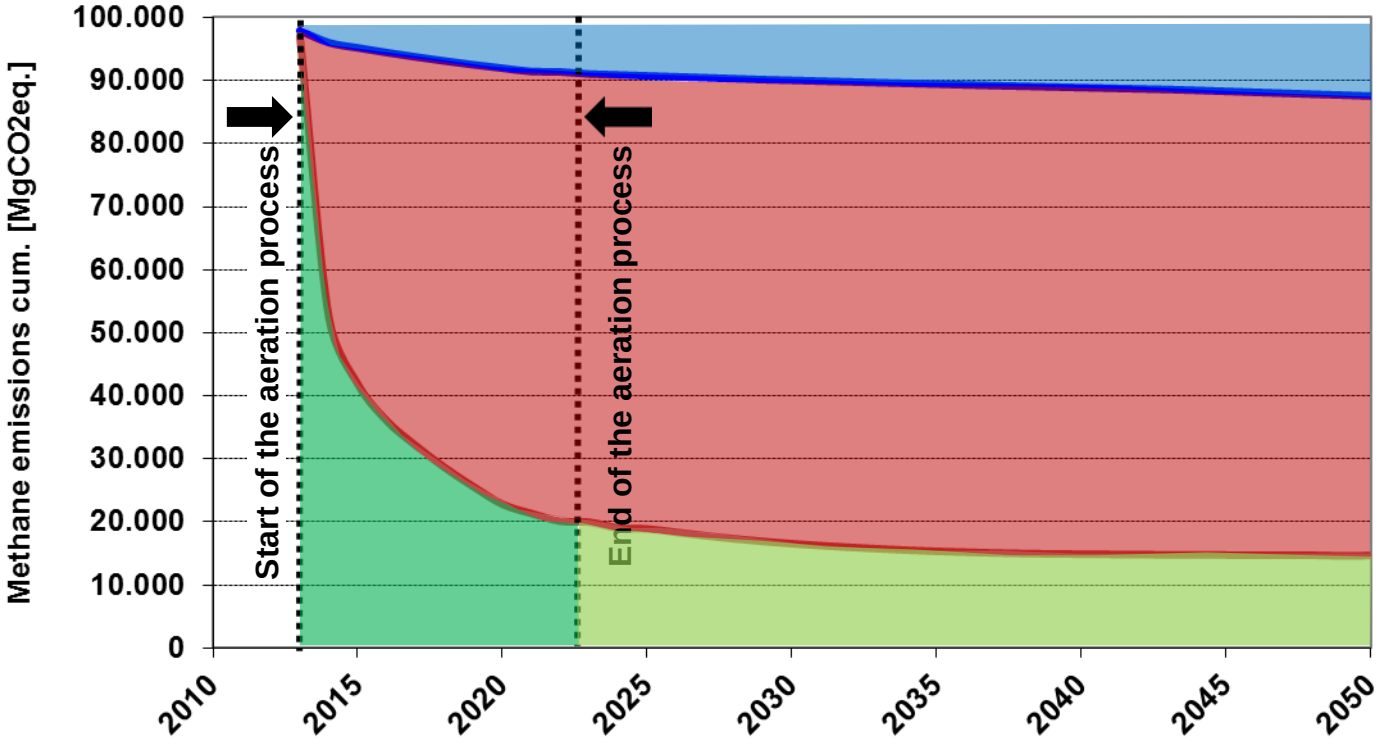
Until 2050:

- *60-80 % CG* – reduction (100%: 1990)

Germany

- German program to reduce the *CO2- emissions by 37% until 2020.*

Example for Expected Greenhouse Gas Emission Reduction during Landfill Aeration



Classical gas extraction szenario: trend of methane emissions

Landfill aeration: trend of methane emissions

Climate-relevant total emission potential from 2013

Methane emissions due to classical gas extraction

Climate-relevant methane emissions after finishing the landfill aeration process

Avoiding methane emissions due to landfill aeration and exhaust gas treatment

National Climate Initiative (NCI) of the German Ministry for the Environment.. (BMU)

Financial Investment Support of Landfill Aeration Projects as a Measure for Climate Protection

- Start January 2013,
- End: open

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Environmental Agency (UBA)

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Projektträger Jülich
Forschungszentrum Jülich

This initiative is based on the results of the research Project:

DBU-Project ORKESTRA (IFAS, GFA Envest, DUH) made decisive contribution to make landfill aeration gain recognition within the scope of the National Climate Initiative of the Federation, and contributed to its inclusion in the aid program

CO2 Avoidance Cost using Low Pressure Aeration

„Average landfill “: 1 Mio. ton municipal solid waste

Specific Aeration costs: ca. 1 €/t landfilled MSW
Total aeration costs: ca. 1 Mio. €
(Investments: 60-70%; operational costs: 30-40%)

Climate protection effect (CH_4 emission reduction):
5 kg CH_4/t Waste * 1 Mio.t Waste = 5.000 t CH_4
= 105.000 t $CO_{2\text{-eq}}$

CO_2-abatement cost of landfill aeration: about **13 €/t $CO_{2\text{-eq}}$**
In comparison: geothermal projects ~110 €/t $CO_{2\text{-eq}}$;
wind power: > 30 €/t $CO_{2\text{-eq}}$

Technical and Legal Requirements for NCI Application

- Pre-requisite: energetically landfill gas *utilisation is inefficient*
- *Biodegradable organic waste* content **(oTS) ≤ 12 kg/t**
- *Reduction potential* of at least 50% of the residual gas production potential (*Determination of the CO_{2eq} reduction potential is part of the Potential Study)*
- Landfill site belongs to a public body (district or city)
- Landfill aeration project has **permission** by the authority

Potential Study

Content:

- Determination of the **content of bioavailable organic material** in the deposited waste through investigations regarding the waste quality and biological activity
- **Evaluation of the emission potential** – application of the IPCC methodology (2006) for the assessment of methane emissions from landfills, based upon the First Order Decay (FOD) model, taking into account the site-related results of the waste solid investigations
- Presentation of the **optimization** potential of the existing **technical devices** for the gas collection and treatment (if this is relevant)
- Implementation of pre- investigations as a **suction and/or aeration test** over several weeks
- **Evaluation of the results** of the preliminary investigations

WIN-WIN-Situation

The environment and the landfill operator wins:

- Landfill aeration of landfills where LFG utilization has come to an end ("old" landfill) can contribute significantly to *climate protection*
- Average size "old" landfills (1Mio. t) have an *avoidance potential of* 100,000 to 150,000 tons CO_{2eq} (avoided methane emissions within 8 – 10 years) at *CO_2 avoidance costs of 13 €/t CO_{2eq}.*
- Until end of 2018 about 43 project have been granted with a 50% governmental support of about 10Milion €.
- In total about 2 million CO2 equivalents have been avoided
- Reduction of the emission potential by about 90%
- Reduced *aftercare cost* and reduced *aftercare period.*
- Earlier subsequent *landfill utilization*

Costs of Low Pressure Aeration

- Site specific (e.g. size, volume)
- Technical demands, duration and intensity of aeration
- Available infrastructure

TASi II landfills:

- **good conditions: ca. 0,5 - 1 EURO/m^3**
- **medium conditions: ca. 1 - 2 EURO/m^3**
- **(old landfills) difficult conditions: ca. 2 - 4 EURO/m^3**

Cost reduction: *Aerobic in situ stabilization as external service* (renting of technical equipment, know-how etc.)

Boundary Conditions of the NCI Investment Program

- Subject of the promotion: **aerobic in situ stabilisation** using the **suction and/or pressure aeration** method
- **Investment** support quota of up **to 50%** (subsidy - max: 500,000 €)
- Requirement : **CO_{2eq} reduction potential reduced >50%**
- Pre-requesite: "potential analysis / study“ (investigating the landfill conditions and emission potential) will be also be adequately financially supported

Investment cost for:

- Technical **equipment** necessary for **aeration**
- Technical **equipment** necessary for **exhaust air** treatment
- Systems for **monitoring** and control


Bundesministerium
für Umwelt, Naturschutz
und Reaktorsicherheit

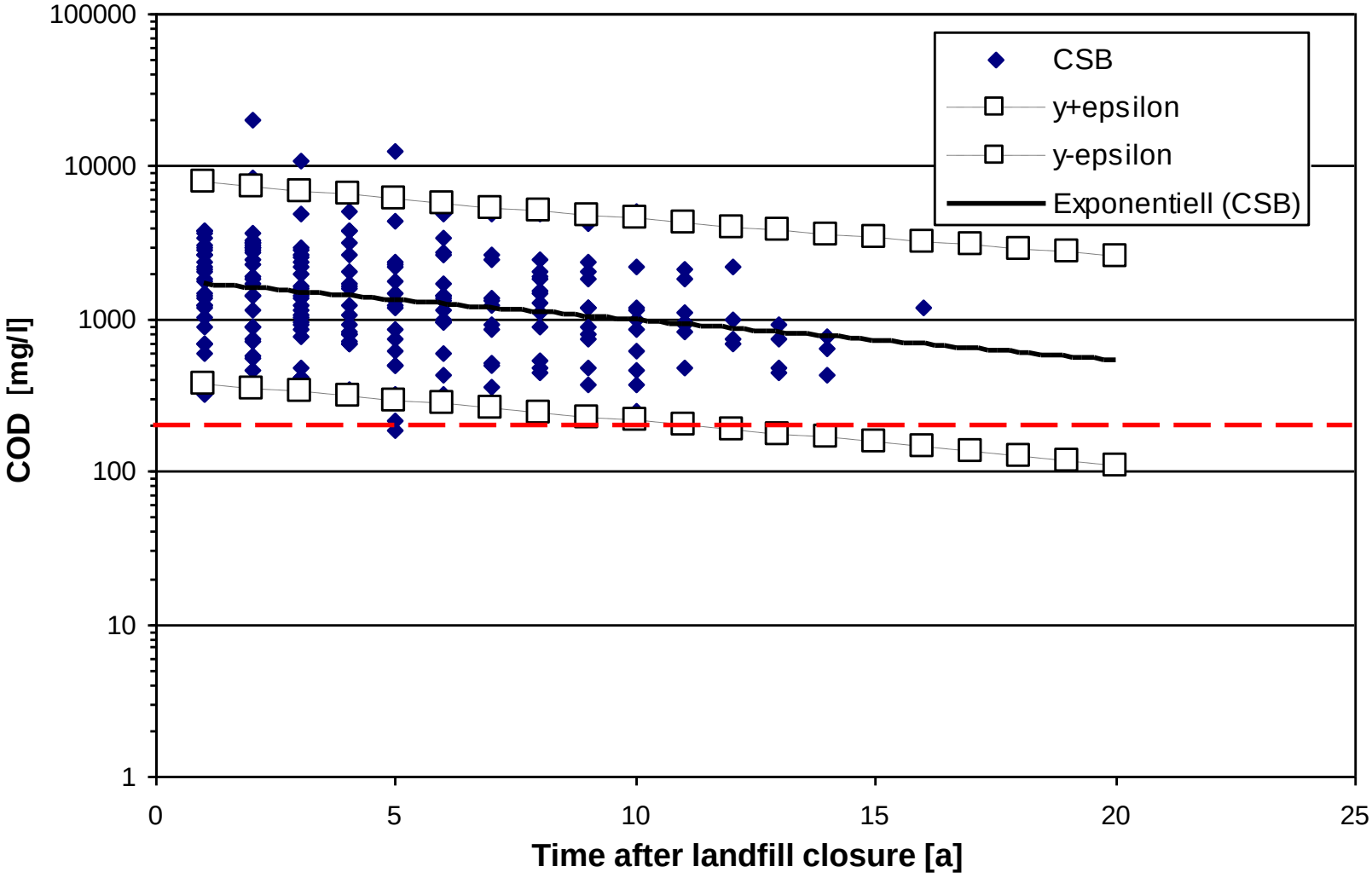
Richtlinie zur Förderung von Klimaschutzprojekten in sozialen, kulturellen und öffentlichen Einrichtungen im Rahmen der Klimaschutzinitiative

Merkblatt
Investive Maßnahmen, die zu einer Treibhausgas-Emissionsminderung führen

Hinweise zur Antragstellung

Fassung vom 17.10.2012

Emissions under Anaerobic Conditions: Leachate



Source: I. Krümpelbeck (2000); Data from German landfills