TFTEI

Under the Convention on Long Range Transboundary Air Pollution

Technical Work on CH_4 Emissions from Waste and Natural Gas Network

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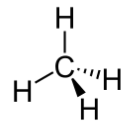
5th TFTEI Annual Meeting - Ottawa, Canada, October, 22-24, 2019 1

1

Agenda

- Methane as a new pollutant included in the mandate of TFTEI
- Transport system of natural gas and emissions in Europe
- Methane emissions from waste storage / landfills
  - ➡ Technical measures and costs of emission reduction
- Next steps and ongoing work on CH_4

Methane as a pollutant



❑ **Why relevant?**

✓ Precursor for ground-level ozone

✓ CH_4 second relevant greenhouse gas with a global warming potential (GWP) 25 times higher than that of CO_2

✓ Natural gas plays an increasing role in energy supply (heat, electricity) due to comparatively low emissions / clean burning, flexibility of power plants

GREENHOUSE GAS EMISSIONS in Mt CO_2 equivalents	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Net CO_2 emissions/removals	4 212	3 936	3 870	3 986	3 830	3 492	3 615	3 482	3 424	3 333	3 176	3 208	3 198	3 245
CO_2 emissions (without LULUCF)	4 478	4 225	4 189	4 315	4 171	3 833	3 949	3 804	3 746	3 658	3 489	3 522	3 505	3 523
CH_4	740	679	618	557	523	511	501	491	487	476	469	469	465	466
N_2O	401	360	323	303	283	267	257	253	250	250	254	250	254	256
HFCs	29	44	55	77	97	98	104	106	109	111	114	110	107	105
PFCs	26	17	12	7	5	3	4	4	4	4	3	4	4	3
Unspecified mix of HFCs and PFCs	6	6	3	1	1	2	1	1	1	1	1	1	1	2
SF_6	11	15	11	8	7	6	6	6	6	6	6	6	6	7
NF_3	0.02	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05
Total (with net CO_2 emissions/removals)	**5 425**	**5 058**	**4 891**	**4 939**	**4 746**	**4 380**	**4 488**	**4 343**	**4 281**	**4 181**	**4 023**	**4 047**	**4 036**	**4 084**
Total (without CO2 from LULUCF)	**5 691**	**5 346**	**5 210**	**5 268**	**5 087**	**4 721**	**4 822**	**4 665**	**4 603**	**4 507**	**4 335**	**4 361**	**4 343**	**4 363**
Total (without LULUCF)	**5 660**	**5 318**	**5 179**	**5 238**	**5 058**	**4 692**	**4 794**	**4 636**	**4 573**	**4 479**	**4 307**	**4 337**	**4 313**	**4 333**

Notes: CO_2 emissions include indirect CO_2

Source: Annual European Union greenhouse gas inventory 1990–2017 and inventory report 2019

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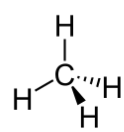

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✓ Natural gas plays an increasing role in energy supply (heat, electricity) due to comparatively low emissions / clean burning, flexibility of power plants

✓ Emitted by both natural and man-made source

❑ **Since 2018 new pollutant included in the mandate of TFTEI and TFRN**

✓ Focus of TFTEI activities at KIT in 2019/2020

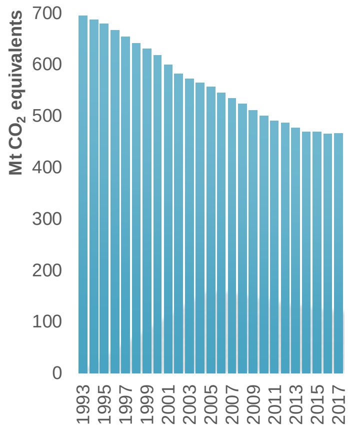
✓ Work in progress → beginning of research in May 2019, adjustments possible

➡ **Goal: Development of a draft technical document as a basis for further discussions within an expert group**

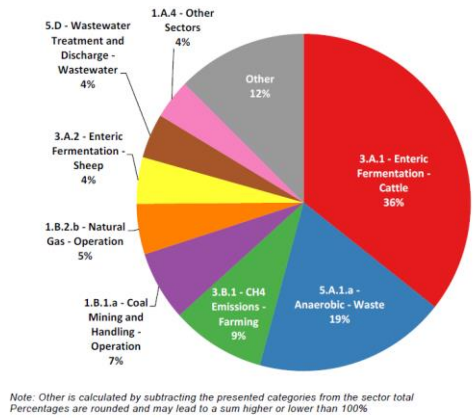
Sources of methane emissions in Europe

Focus on European emissions in a first step:

Development of methane emissions in the EU



Emissions by source in 2017



Note: Other is calculated by subtracting the presented categories from the sector total
Percentages are rounded and may lead to a sum higher or lower than 100%

Source: Annual European Union greenhouse gas inventory 1990–2017 and inventory report 2019

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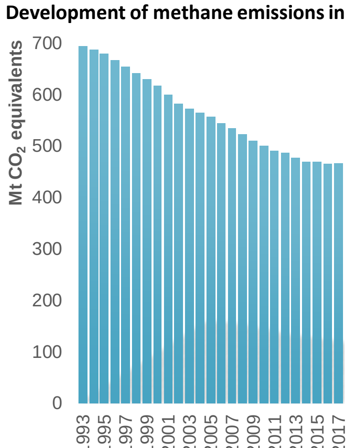
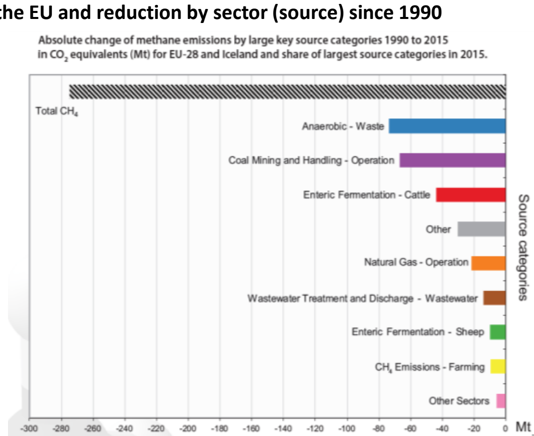
Sources of methane emissions in Europe

Focus on European emissions in a first step:

Development of methane emissions in the EU and reduction by sector (source) since 1990





Source: Annual European Union greenhouse gas inventory 1990–2017 and inventory report 2019

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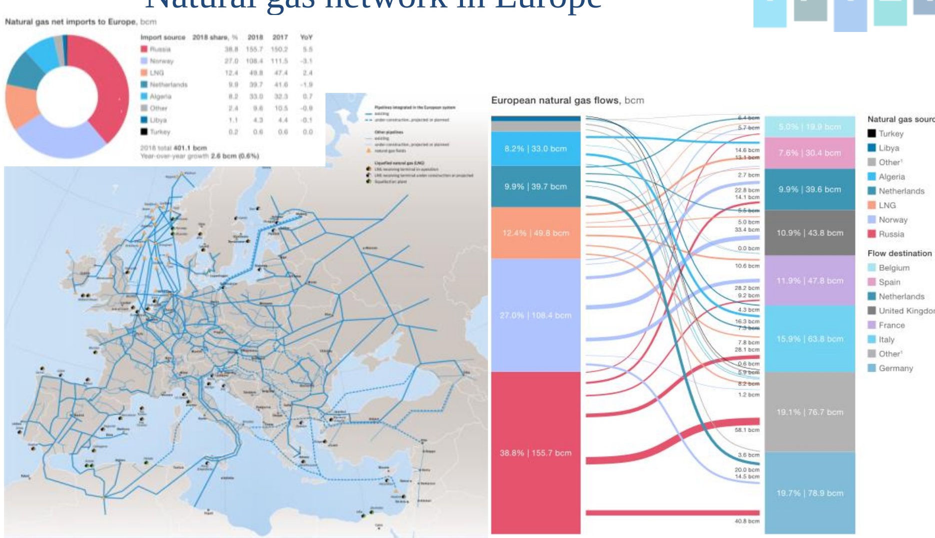
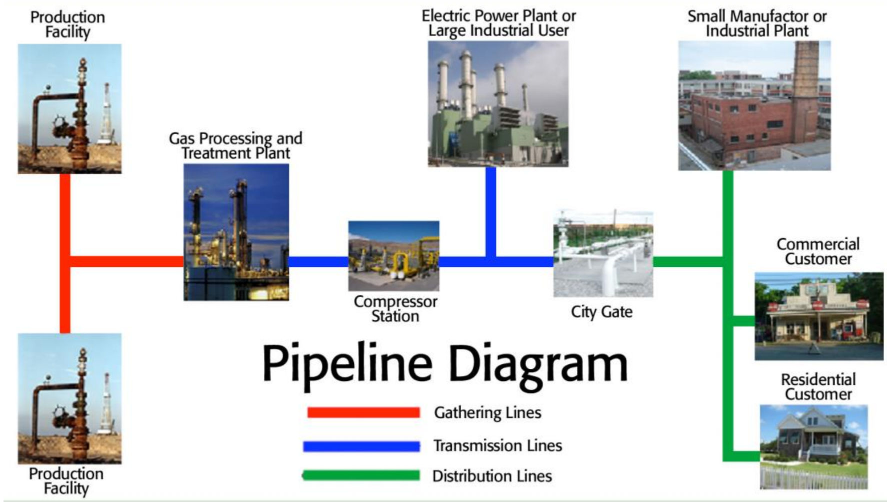
Natural gas network in Europe



Source: McKinsey & Company: How did the European natural gas market evolve in 2018?

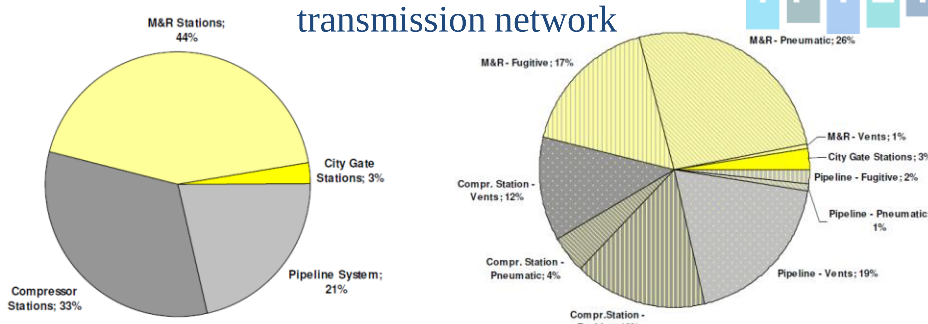
Key components of the natural gas network



The gas pipeline transportation system from production to consumption

Source: Pipeline Safety Trust (2015): Pipeline Basics & Specifics About Natural Gas Pipelines

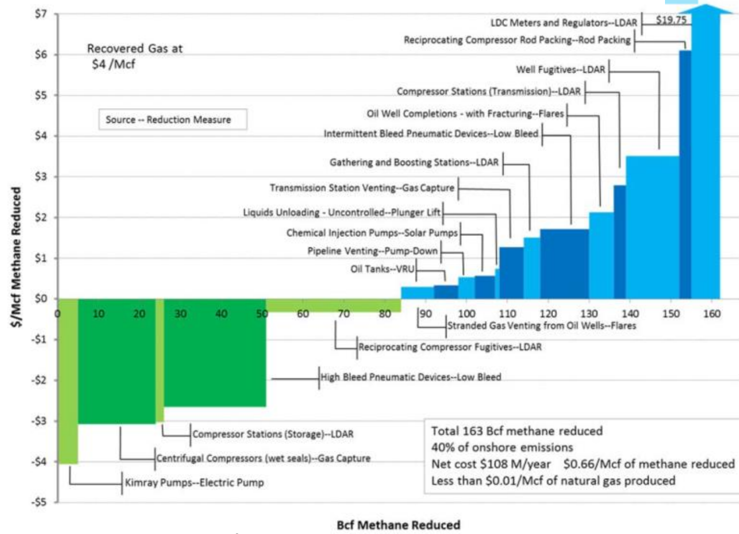
Sources of emission in the European transmission network



- ✓ Fugitive emissions are all small leaks from flanges, pipe equipment, valves, joints, etc. that are more or less continuous sources.
- ✓ Vented emissions include intended vents for maintenance or operational reasons and vents from incidents, when the content of the gas equipment is released to the atmosphere.
- ✓ Pneumatic emissions are all emissions caused by gas operating valves and other devices, continuous as well as intermittent emissions.

Source: E.ON Ruhrgas: REDUCTION OF METHANE EMISSIONS IN THE EU NATURAL GAS INDUSTRY

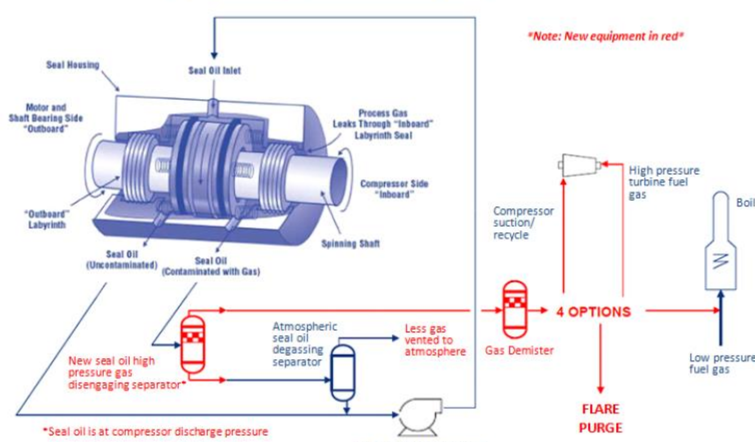
Key components of the natural gas network



ICF International: Economic Analysis of Methane Emission Reduction Opportunities in the U.S. Gas Industries

Wet seal degassing recovery system for centrifugal compressors

Wet seal degassing recovery system for centrifugal compressors - Source: U.S. EPA



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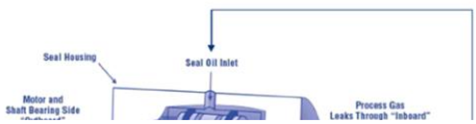
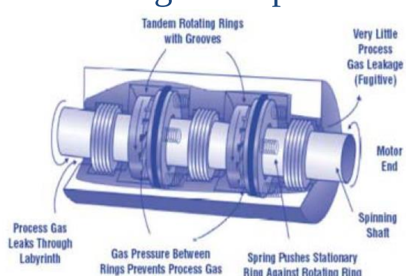


Environmental Effectiveness and Key Factors: Wet Seal Recovery System for Centrifugal Compressors

Environmental Effectiveness	CO_2	CH_4	N_2O
Typical abatement efficiency for key GHGs (primary abatement metrics), %	Up to 100% (Assuming recovered gas is not flared)	Up to 99%	N/A
Factors affecting efficiency	Depending on the use of the recovered degassing emissions.	Depending on the use of the recovered degassing emissions.	
Limits of technical feasibility	"Knock-out" vessels to recover any seal oil mist from the recovered gas, if the gas is to be used as fuel. Piping capacity must exist to use recovered degassing emissions.		

ICF International: Economic Analysis of Methane Emission Reduction Opportunities in the U.S. Gas Industries

Dry seals on centrifugal compressors

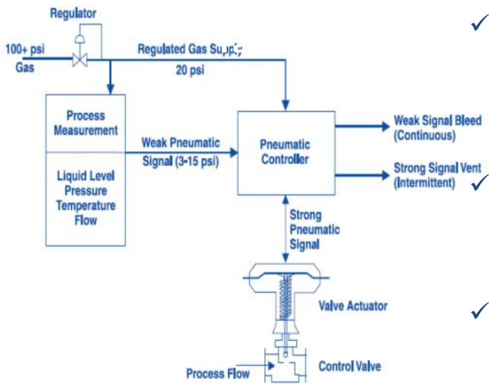


Environmental Effectiveness and Key Factors: Replacing Wet Seals with Dry Seals on Centrifugal Compressors

Environmental Effectiveness	CO_2	CH_4	N_2O
Typical abatement efficiency for key GHGs (primary abatement metrics), %	97%	97%	0%
Factors affecting efficiency	See below	See below	
Limits of technical feasibility	The compressor pressure must be below 3,000 psi and the temperature must be below 300° F. Furthermore; compressors should not be towards the end of their life.		

ICF International: Economic Analysis of Methane Emission Reduction Opportunities in the U.S. Gas Industries

Modifications of pneumatic controllers and devices



Replacement of high bleed devices while maintaining safety regulation

- ✓ Pneumatic devices powered by pressurized natural gas are used widely in the natural gas industry as liquid level controllers, pressure regulators, and valve controllers.
- ✓ Pneumatic devices release or bleed natural gas to the atmosphere and, consequently, are a major source of methane emissions.
- ✓ The actual bleed rate or emission level largely depends on the design of the device.
- ✓ Significant emission reductions through replacement, retrofit, and maintenance of high-bleed pneumatics possible.

US Environmental Protection Agency: Options For Reducing Methane Emissions From Pneumatic Devices In The Natural Gas Industry

Economic benefits of reducing pneumatic emissions

Exhibit 4: Economic Benefits of Reducing Pneumatic Device Emissions

Action	Cost[a] ($)	Bleed Rate Reductions[b] (Mcf/yr/device)	Annual Savings[c] ($/year)	Payback Period (months)	IRR[d] (%)
Replacement					
Level Controllers					
High-bleed to low-bleed	513	166	1,165	6	226
Pressure Controllers					
High-bleed to low-bleed	1,809	228	1,596	14	84
Airset metal to soft-seal	104	219	1,533	<1	>1,400
Retrofit					
Level Controllers					
Mizer	675	219	1,533	6	226
Large orifice to small	41	184	1,288	<1	>3,100
Large nozzle to small	189	131	917	3	>450
Pressure Controllers					
Large orifice to small	41	184	1,288	<1	>3,100
Maintenance					
All types					
Reduce supply pressure	207	175	1,225	3	>500
Repair leaks, retune	31	44	308	2	>900
Level Controllers					
Change gain setting	0	88	616	Immediate	—
Positioners					
Remove unnecessary	0	158	1,106	Immediate	—

[a] Implementation costs represent average costs for Fisher brand pneumatic instruments installed.
[b] Bleed rate reduction = change in bleed rate scf/hr x 8,760 hr/yr.
[c] Savings based on $7.00/Mcf cost of gas.
[d] Internal rate of return (IRR) calculated over 5 years.

Source: US Environmental Protection Agency (2006): Options For Reducing Methane Emissions From Pneumatic Devices In The Natural Gas Industry

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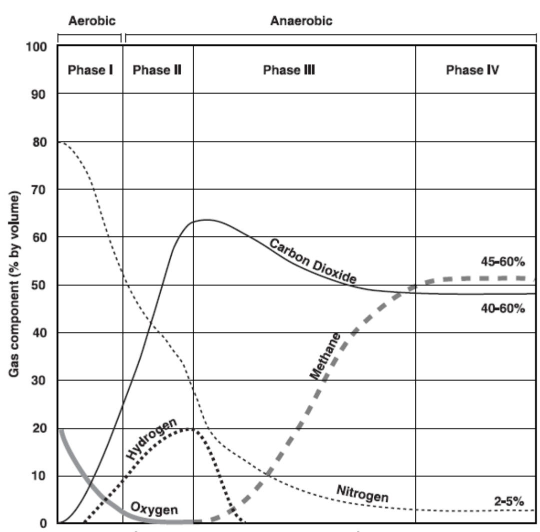
17

Landfill gas formation



Source: Landfill Gas Primer - An Overview for Environmental Health Professionals

- ✓ Most landfill gas is produced by bacterial decomposition, which occurs when organic waste is broken down by bacteria naturally present in the waste and in the soil used to cover the landfill.
- ✓ Volatilization (vaporization) and chemical reactions also play minor roles
- ✓ Methane is produced in the anearobic phase after several years
- ✓ Major source of anthropogenic methane emissions

18

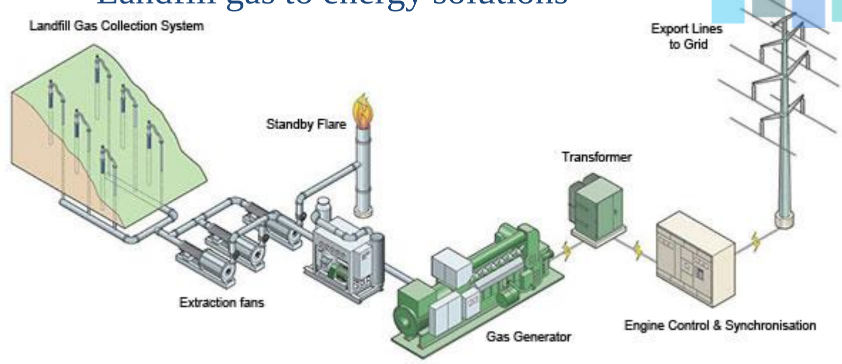
Landfill gas as an important source of methane emission

Table 2-1: Typical Landfill Gas Components		
Component	**Percent by Volume**	**Characteristics**
methane	45–60	Methane is a naturally occurring gas. It is colorless and odorless. Landfills are the single largest source of U.S. man-made methane emissions.
carbon dioxide	40–60	Carbon dioxide is naturally found at small concentrations in the atmosphere (0.03%). It is colorless, odorless, and slightly acidic.
nitrogen	2–5	Nitrogen comprises approximately 79% of the atmosphere. It is odorless, tasteless, and colorless.
oxygen	0.1–1	Oxygen comprises approximately 21% of the atmosphere. It is odorless, tasteless, and colorless.
ammonia	0.1–1	Ammonia is a colorless gas with a pungent odor.
NMOCs (non-methane organic compounds)	0.01–0.6	NMOCs are organic compounds (i.e., compounds that contain carbon). (Methane is an organic compound but is not considered an NMOC.) NMOCs may occur naturally or be formed by synthetic chemical processes. NMOCs most commonly found in landfills include acrylonitrile, benzene, 1,1-dichloroethane, 1,2-cis dichloroethylene, dichloromethane, carbonyl sulfide, ethylbenzene, hexane, methyl ethyl ketone, tetrachloroethylene, toluene, trichloroethylene, vinyl chloride, and xylenes.
sulfides	0–1	Sulfides (e.g., hydrogen sulfide, dimethyl sulfide, mercaptans) are naturally occurring gases that give the landfill gas mixture its rotten-egg smell. Sulfides can cause unpleasant odors even at very low concentrations.
hydrogen	0–0.2	Hydrogen is an odorless, colorless gas.
carbon monoxide	0–0.2	Carbon monoxide is an odorless, colorless gas.

- ✓ Landfill gas is composed of a mixture of different gases.
- ✓ By volume, landfill gas typically contains 45% to 60% methane and 40% to 60% carbon dioxide.
- ✓ Landfill gas also includes small amounts of nitrogen, oxygen, ammonia, sulfides, hydrogen, carbon monoxide, and non methane organic compounds (NMOCs) such as trichloroethylene, benzene, and vinyl chloride.

Source: Landfill Gas Primer - An Overview for Environmental Health Professionals

Landfill gas to energy solutions



- ✓ Regulation for gas collection depends on size and age of the landfill and the estimated emissions
- ✓ Landfill gas to energy solutions have been installed at larger landfills (see reduction since 1990)
- ✓ Small scale energy plants and micro reaction technology are important technological developments for further emission reduction in Europe

LRTAP

Sources of methane emissions in Europe

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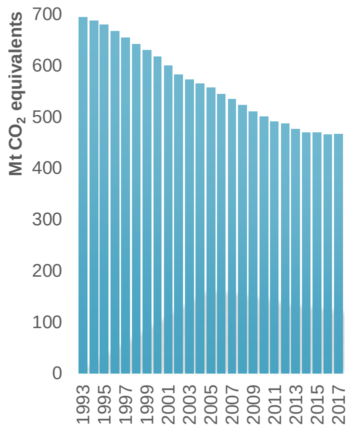
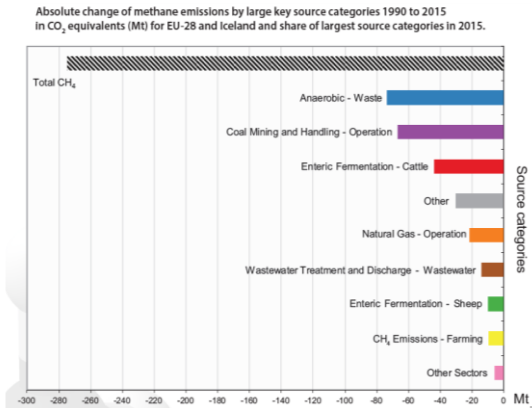
Focus on European emissions in a first step:

Development of methane emissions in the EU and reduction by sector (source) since 1990





Source: Annual European Union greenhouse gas inventory 1990–2017 and inventory report 2019

LRTAP

Conclusions, next steps

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- ❑ **Conclusions**
- ✓ Methane emissions from natural gas network show high diversity (fugitive emissions, emissions from pneumatic devices, venting)
  - ✓ Reduction measures include technical and organizational components
  - ✓ Particularly replacement of high bleed pneumatic devices and new concepts for centrifugal compressors (seal oil degassing) are promising solutions
- ✓ Landfill gas collected at larger sites for energy production, small scale solutions have potentials for further emission reduction → focus of technical report

- ❑ **Next steps**
- ✓ Development of a draft technical document as a basis for further development
- ✓ Establishment of a working group
- ✓ Cooperation with TFIAM planned for the prioritization of emission control measures and their implementation in the respective models

Thank you very much for your attention! Questions?

TFTEI Technical Secretariat

23