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TECHNICAL ASSOCIATION
OF THE EUROPEAN NATURAL GAS INDUSTRY

WG-ME-17-25

SURVEY METHANE EMISSIONS FOR GAS DISTRIBUTION IN EUROPE

Update 2017

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1. SUMMARY

The impact of Greenhouse Gases on climate change has been recognized for some time which has led to measures aimed to reduce global warming. Methane (CH_4) which is the major component of Natural Gas and identified as a Greenhouse Gas (GHG).
As Natural Gas is a major source of energy for the society, it is the role of the gas network operators to deliver continuous and safe service whilst managing responsibly the impacts on the environment.

MARCOGAZ, the Technical Association of the European Gas Industry, considers that it is important for the Gas Industry to understand and quantify its emissions of Natural Gas. It is also important to be transparent about the methodology used to calculate the emissions and to demonstrate that best practices are used across the European Gas Industry.

This study is an update of the 2014 study (based on a 2009-2013 dataset). A new set of data from 2015, more relevant and more accurate, has been added to the available dataset of 2013 to study the contribution of the Methane emissions from the natural gas distribution network in the EU28. Further emission factors for the different type of materials are calculated in their total contribution to the greenhouse gasses of the EU28.

The total amount of Methane emitted in Europe via the Natural Gas distribution network was estimated by MARCOGAZ reusing and enhancing the statistical methods used in 2014 report.
The representative dataset of 2013-2015 is representing and 43% of the European distribution network pipeline length. It is reasonably assessed as globally representative of the European distribution Network, although further improvements can be made in the data collection methods

Nevertheless, MARCOGAZ continues through its Working Group Methane Emissions to investigate better methods to measure and estimate Methane emissions in the gas supply chain.

Based on that study:

- ✓ The total estimated amount of Methane emissions from distribution grid is in the range of **339 – 553 kT Methane.**
- ✓ On that base the methane emissions from distribution grids are estimated to be in the range of **9.492 and 1.549 kT CO_2eq** [1]
- ✓ Considering these figures, the total distribution network losses [(2)(3)] are calculated to be in the range of **0,1% to 0,2%.** In this figure the losses of the grid, but also the losses from service lines and the City Gate stations are included.
- ✓ The maximal yearly Methane emission rate on the EU28 distribution network is:

Pipeline material	Maximal emission rate	Share of the EU28 grid
Cast iron	1.388 kg CH_4 / km	2,5 %
Steel	198 kg CH_4 / km	39 %
Polyethylene	61 kg CH_4 / km	51 %
P.V.C.	34 kg CH_4 / km	5 %
Service lines	1,52 kg CH_4 / customer	

- ✓ The total amount of GHG emissions caused by the Methane emissions from Natural Gas distribution grids is estimated to be **between 0,2% - 0,3%** of the total of anthropogenic[4] GHG emission in Europe (EU28)[5].

[1] GWP: Global Warming Potential; GWP100 of CH4 (= 28) is used according to the Fifth Assessment Report (AR5) - IPCC.

[2] Compared to the total of natural gas sales in Europe - EU28 inland gas sales: EUROGAS Statistical report 2015.
[3] Please note that such a comparison is valid only at a European level, as, at a country level, not all the gas contained in the network at a moment in time will be sold in that particular country

[4] Anthropogenic emissions: emissions originating in human activity
[5] Approximated European Union greenhouse gas inventory: Proxy GHG emission estimates for 2015, EEA report No 23/2016, page 76

2. INTRODUCTION

In the past five years an increasing number of reports from reputable institutions have highlighted the environmental impact of global warming and the accelerating effect that the continued release of Greenhouse Gases to atmosphere is having on this phenomenon.
This changing attitude of governments, regulatory bodies and the general public has resulted in increasing attention being paid to the Methane releases from the gas networks across Europe.

Significant literature has been published which proposes various methods of estimation. This is further complicated by the differences in the different Countries.

MARCOGAZ developed and published (2005) a methodology using all existing knowledge available within the group of European gas infrastructure operators.

As Countries have differences in their operating regimes, the common methodology would allow a common approach to the estimation of Methane emissions available.

In 2007 a first assessment was made to derive a range for emission factors for gas transmission and distribution. In 2014 this assessment was repeated to look at developments of the emission factor, but also to give an estimate of the total Methane emissions from Natural Gas Industry.

The 2014 Survey on Methane emission for gas transmission and distribution (Ref. WG-ME-14-26_D096), has explored several statistical scenarios, and defined the best option to give an estimate of the total Methane emissions from natural gas industry, based on 2009 to 2013 data.
The following study updates the 2014 survey, using a significant set of updated data from 2013 – 2015.

Only Methane emissions from gas distribution networks are considered here.

3. LIST OF DEFINITIONS

In order to obtain comparable objective emission calculations or estimations, the use of identical definitions is necessary. For this reason, a number of definitions are given hereunder.

3.1. Emissions: sources of Methane

- ✓ *Fugitive emissions:* All residual leaks from flanges, pipe equipment's, valves, joints, seals and seal gas systems etc. that are more or less continuous sources.

- ✓ *Pneumatic emissions*: All emissions caused by gas operating valves, continuous as well as intermittent emissions.

- ✓ *Vented emissions:*
  - o *Maintenance vents*: Methane emissions from or planned operating conditions where significant volumes of Natural Gas can be released to atmosphere from the gas network for maintenance purposes.
  - o *Incident vents*: Methane emissions from unplanned events. This will normally be from failures of the system due to third party activity and external factors normally outside of the control of the gas company.
  - o *Operation vents*: i.e. starting and stopping of the compressors.

- ✓ *Incomplete combustion emissions*: Unburned Methane in the exhaust gases from gas turbines, gas engines and combustion facilities and flares.

3.2. Gas system

- ✓ *Transmission system*: High-pressure gas transport over long distance including pipelines, compressor stations, metering and regulating stations and a variety of above-ground facilities to support the overall system. Underground gas storage and LNG are excluded. Transport from production companies to the distribution companies and to the industries. Operating pressure is normally equal or greater than 16 bar.

- ✓ *Distribution system*: Medium to low pressure transport including distribution pipelines, service lines and a variety of above-ground facilities to support the overall system. Local transport from transmission system to customer meters. Pressure normally ranges less than 5 bar. But new polyethylene systems up to 10 bar are now developed in some EU countries. Medium pressure: 0,200 – 5 bar. Low pressure: less than 200 mbar.

<u>Note</u>: The part of the system under 16 bar and above 5 bar can be considered in transmission or distribution, depending on the system boundaries adopted by each company and/or on the techniques used (steel, polyethylene…).

3.3. Emission measurement methodology

To obtain these results, different leak measurement techniques are used in Europe to determine the total leak rate of pipelines.

Each technique to measure gas leaks is a combination of a sampling method and a sensor technique which are used for the leak rate computation.

'Sampling methods' are:

1) **Leak flow capturing**: capturing the leaking gas as completely as possible, by encapsulating the leaking components.
2) **Full suction method**: capturing as much of the leakage by (partial) enclosing the leaking components, diluting the leakage using excess suction
3) **Partial suction method**: capturing the leakage partially, diluting the leakage using excess flow suction
4) **Direct method, optical**: no explicit sampling, but using optical path concentration sensors
5) **Direct method, pressure decay**

Methods 1, 2 and 3 can also be modified by adding a tracer gas (e.g. He or SF_6) to the leaking flow. This can improve sensitivity and/or accuracy using suitable tracing gas/sensor combinations.

'Sensor techniques' are based upon a variety of sensors that measure a specific property of a gas mixture. The most common techniques are: 'flame ionization', 'thermal conductivity measurement', 'catalytic oxidation' (calorific value measurement) and 'infrared absorption' (spectral methods)

For the optical direct method, infrared absorption methods are available. There are active methods using infrared light beams (leds and laser, lidar) or passive methods using thermal or spectral imaging cameras.

The pressure decay method is special in the sense that it is not based on measuring any gas mixture composition, but only pressure (and sometime temperature) as function of time.

Measurement of underground leaks come with additional challenges caused by the soil.

Each measurement technique has its own pros and cons in regard of time, effort and reliability however there is no comparative research available.

(Source: Kiwa Technology, the Netherlands)

3.4. Geographical boundaries

The estimations for Methane in this report for transmissions companies in Europe are based on the MARCOGAZ Members representing the Countries shown in paragraph 7.2 (APPENDIX II: MARCOGAZ members).

4. RESULTS

4.1. Data collection

MARCOGAZ started a survey among its Members in September 2016 with the question to fill in the form of the MARCOGAZ method (see 7.1 - APPENDIX I: MARCOGAZ forms Methane emission). With the forms returned and the data already available from the year 2013, the survey was performed.

The dataset covers the equivalent of 46% in length of the European (EU28) distribution network.

4.2. Description of the method

The evaluation of total emissions is based on the following equation:

$$\textbf{\textit{Methane emission}} = \sum(\boldsymbol{AF} \times \boldsymbol{EF})$$

Where:

AF = activity factor
EF = emission factor

The **activity factors** are the population of emitting equipment's such as length of pipelines from different materials used in gas distribution grids, the pressure of the pipelines, the number of service lines or distribution stations.

The **emission factors** are defined as the quantity of Methane emitted from each emitting source. Some can be evaluated on the basis of estimating the emissions from incidents in the grid. Other are based on the measurement of the fugitive emissions characteristics per kilometre of pipeline, material and pressure class.

4.3. Evaluation of the quality of the data set

In the period between 2013-2015, 9 companies provided data: the declared categories are summarized in Table 1:

Legend

- Green: Value declared or 0
- Red: Nothing declared

	Companies										
	A1	A2	A3	B	C	D	E	F	G	H	I
Grey cast iron	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Ductile cast iron	Green	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green
Steel	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Polyethylene	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
PVC	Red	Green	Red	Green	Red	Red	Red	Green	Green	Red	Green
Not specified	Red	Green	Green	Green	Green	Red	Red	Green	Green	Red	Green
Service lines	Green	Green	Green	Green	Green	Green	Green	Red	Green	Red	Green
City Gates	Red	Green	Red	Green	Green	Red	Green	Green	Green	Red	Red

Table 1: Datasets distribution

The companies that have declared data, have declared most of the fields (about 80% of requested field declared)

The declaring companies are representing 870.000 km of pipelines which is roughly corresponding to 50% of the EU 28 distribution pipeline length. If 80% of the fields have been declared, the full set could be considered as representative, allowing to apply the first scenario (see §4.4.1).

4.4. Emission factors distribution networks

4.4.1. Correlation

The analysis has confirmed, with a more complete dataset the assumption made in 2014 and the total emission were derived as a first approach from a first order polynomial in which the total Methane emission was calculated directly from the total pipeline length. In this report, a second approach has been developed considering 3 different sets of activity and emission factors related to:

- The length of the pipelines with a subdivision of the pipeline materials.
- The number of City Gates / pressure regulating stations
- The number of Service Lines were the distribution grid is connected to the households and the industry.

In the 2014 report 4 scenarios were distinguished, i.e.:

1) **Average emission factor** in which the emission factor is derived as the average factor from polynomial fitting including uncertainty of the coefficients.
2) **Median emission factor** in which the emission factors is calculated as the median emission factor of the sample population.
3) **Worst case emission factor** where the largest emission factors from the sample population is used for the estimation of the Methane emission.
4) **Most representative emission** factor, in which the most representative values are used. These are from the companies who delivered complete datasets.

The average emission factors and 95% UCL (upper Control Limit) (see §5) of this emission factors are finally found to be the more efficient for this second study.

The correlation of the CH_4 emission with the pipeline total length without distinction of pipe materiel is only of 51%, the second approach will be used (see §4.4.2), this is a TIER 2 approach.

If the declared set could be representative in term on length or completeness, the correlation between the activity factors and the associated emissions are globally poor:

- as an example, the correlation between polyethylene emission and polyethylene pipeline declared length which is representing 51% of the declared distribution pipeline length is only of 57%.

Based on this fact, it has been decided to provide the following results on emission factors considering not only the average of the emission for each activity factors but also the 95% UCL.

The UCL is define such as, according to the available dataset, for a given activity factor value, the resulting emission will have a probability of 95% to be below the UCL, having say so the, 95% Upper Control Limit line factor is a reliable maximum of the activity factor (see following figures).

4.4.2. Analysis of the emission factors by pipeline materials

Emission factors were derived for different type of materials of the transmission grid. Different types of materials can have significant different emission factors. For example, grey cast iron is a material with large emission losses in the grid. Most distribution companies in the EU28 have replaced or are replacing, their gas grid grey cast iron fraction by more modern materials as polyethylene.

Cast iron

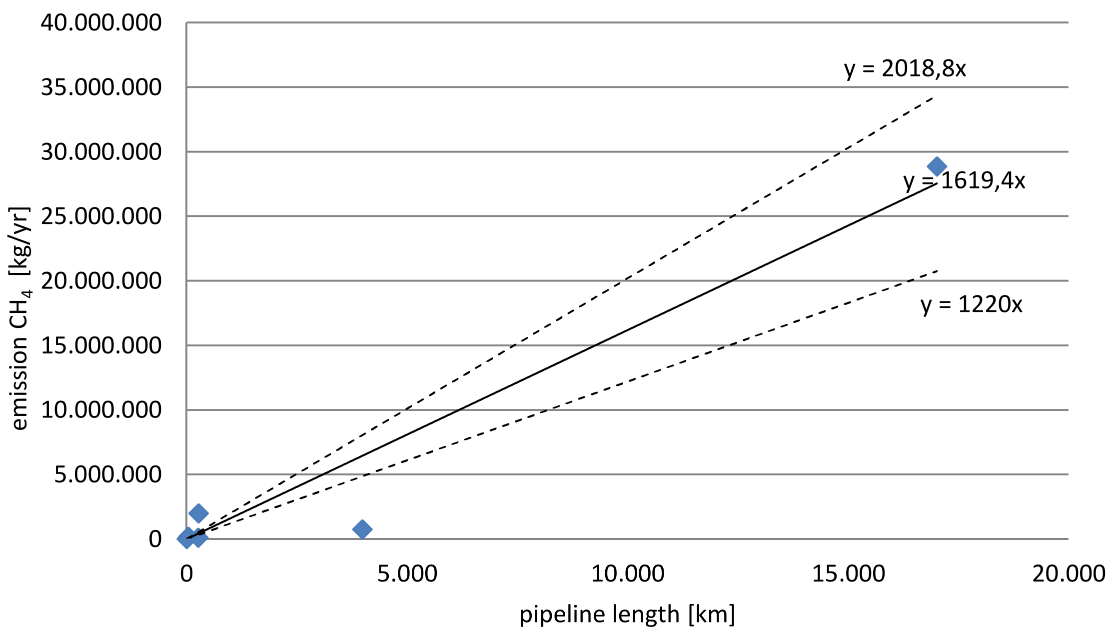

Figure 1: Regression analysis CH4 emissions vs. grey cast iron pipelines length

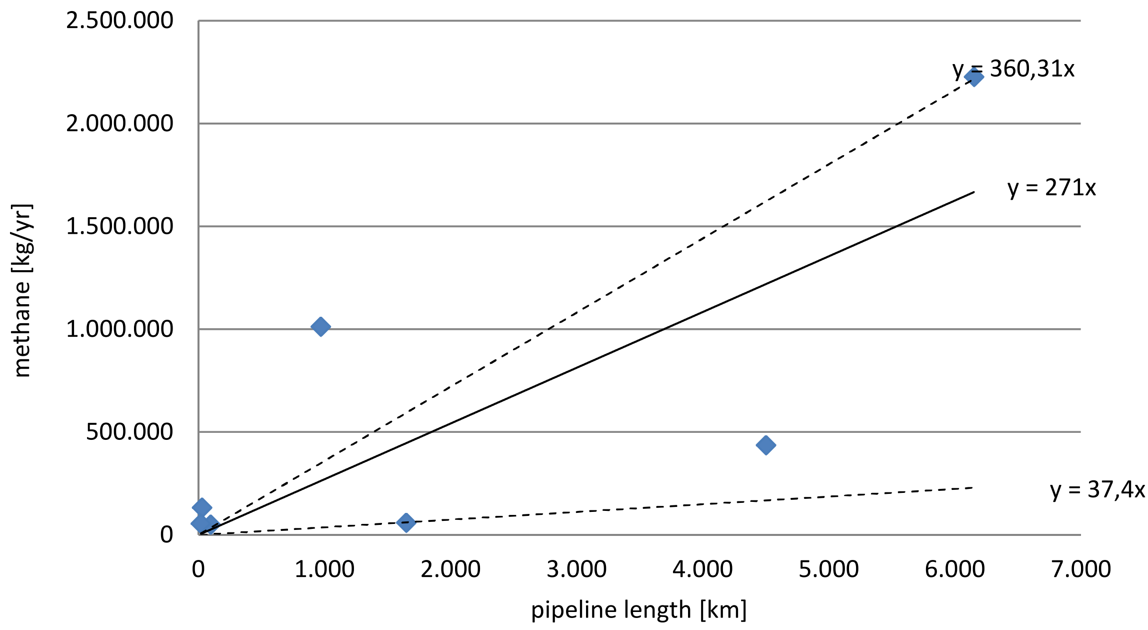

Figure 2: Regression analysis ductile cast iron CH_4 emission vs. pipeline length.

Material	Average emission factor	95% UCL
Grey cast iron	1.619 kg CH_4 / km	2.019 CH_4 / km
Ductile cast iron	198 kg CH_4 / km	360 CH_4 / km

Table 2: Emission factors for cast iron

As grey cast iron is representing 62% of the cast iron of the declaring company, we can derive the following emission factor for the cast iron in general:

Emission Factor cast iron average
= 0,62 * 1.619 + 0,38 * 198 = 1.079 kg CH_4 / km

Emission Factor cast iron UCL
= 0,62 * 2019 + 0,38 * 360 = 1.388 kg CH_4 / km

Grey cast iron has graphite flakes entwined with the rest of the structure, which create areas of weakness in the metal where fractures can begin that will split the metal. This form of the graphite flakes and the resulting propensity to fracture is why grey iron has low tensile and impact strength.

As a result, the pipe can be subject to a "guillotine fracture" in case unauthorized movements are applied, f.i. by movements of soil, heavy traffic, heavy construction works. For such reasons, the grey cast iron replacement at least in sensitive areas, is considered as best practice by European companies, most of them have already replaced their grey cast iron network by more suitable material. Only 2,5% in length of cast iron is remaining in the EU28 distribution grid.

A further possible weakness of those pipes is their coupling: it can be made by a sleeve using cord and lead or with a rubber sleeve. If no injections of moisture are realized, the transition from city gas to dry natural gas leads to shrinking of the cord and possible emissions at the joints. Since the elasticity of the grey cast iron pipe is very low, there is a risk of movement at the connection, and thus of more leaking.

Ways to limit those emissions are possible: fine pressure regulation, monitoring of the use of the ground, of ground movements and of heavy construction works near the pipes and replacing them if needed, moistening of the gas, deployment of internal sleeves, ….

In ductile cast iron, the graphite incrustations have a node form (created by using a small quantity of magnesium), eliminating the weaknesses typical for the presence of flakes. Compared to grey cast iron, ductile has better mechanical properties: tensile resistance ≥ 420 Mpa v ≥ 200, elasticity limit ≥ 270 Mpa v. ≥ 50, prolongation ≥ 10 % v O%, modulus of elasticity ≥ 170.000 Mpa v. ≥ 110.000. By this higher elasticity and tensile resistance most sources of emissions existing in case of grey cast iron are avoided.

This is explaining the difference in the 2 cast iron quality emission factors.

Steel

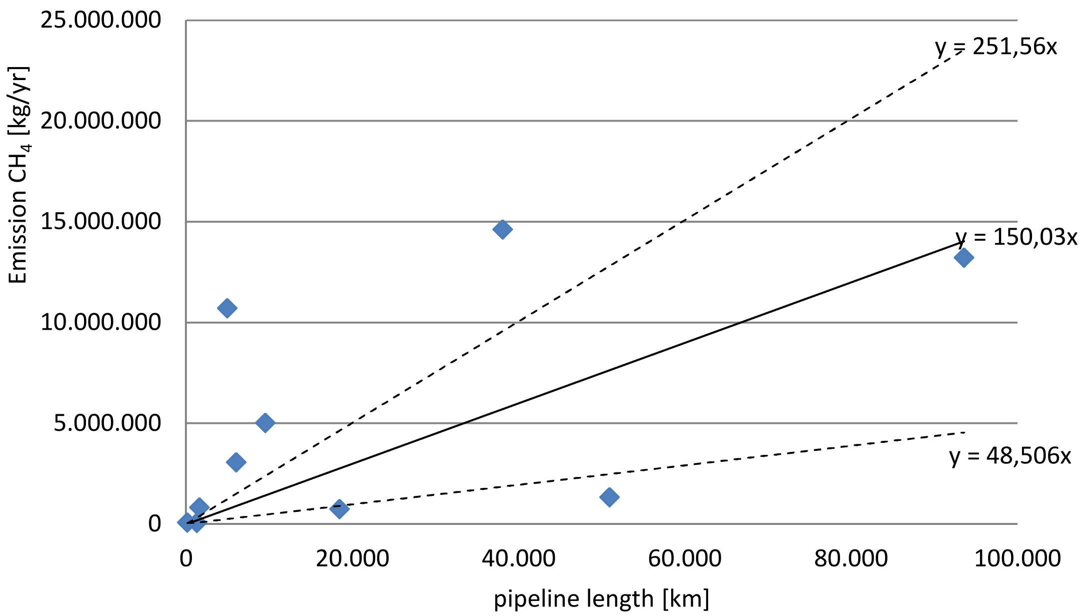

Figure 3: Regression analysis, steel CH_4 emission vs. pipeline length

Approximately 40% of the distribution grid is made of steel pipelines.

Material	Average emission factor	95% UCL
Steel	150 kg CH_4 / km	252 CH_4 / km

Table 3: Emission factors for steel

Polyethylene

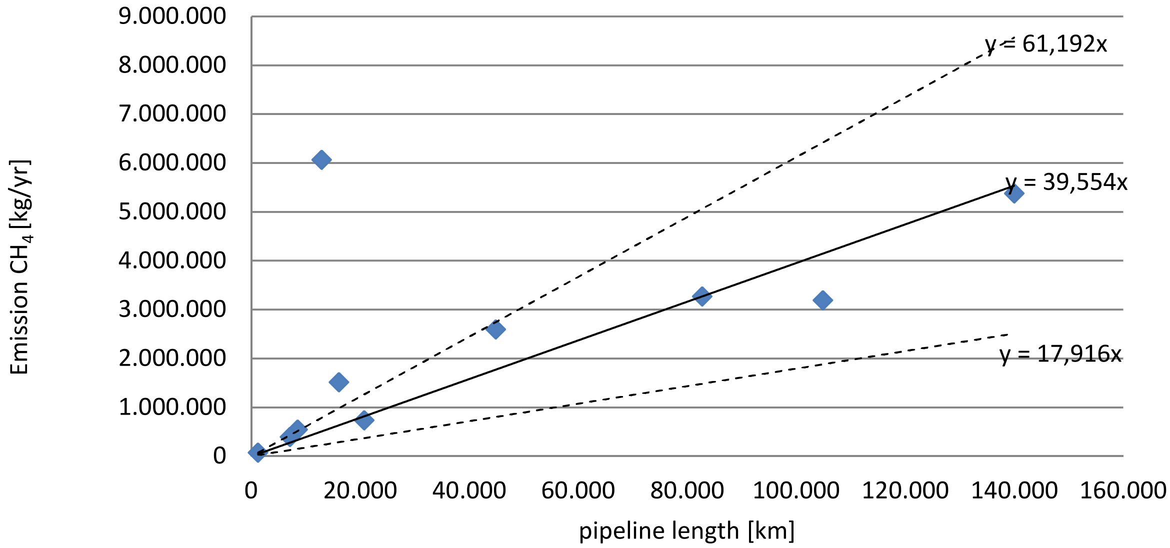

Figure 4: Regression analysis polyethylene (PE) CH_4 emission vs. pipeline length

The distribution grid in Europe consists of approximately 51% of polyethylene pipelines.

Material	Average emission factor	95% UCL
Polyethylene	40 kg CH_4 / km	61 CH_4 / km

Table 4: Emission factors for Polyethylene

PVC

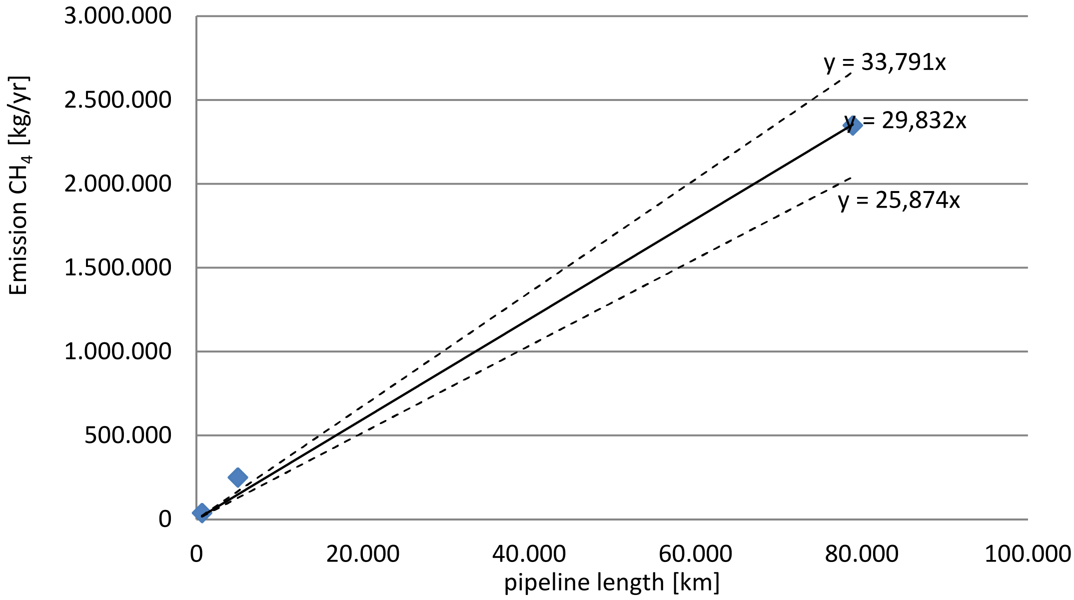

Figure 5: Regression analysis pipeline length PVC versus CH_4 emission.

Approximately 5% of the distribution grid is made of PVC pipelines.

Material	Average emission factor	95% UCL
PVC	30 kg CH_4 / km	34 CH_4 / km

Table 5: Emission factors for PVC

Not specified

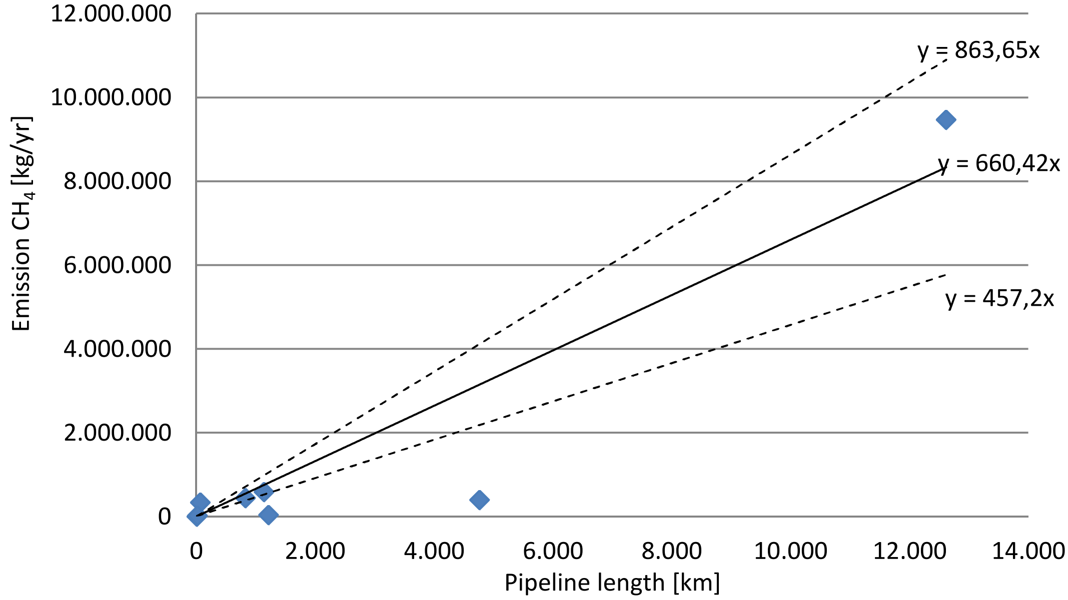

Figure 6: Regression analysis pipeline length 'not specified' vs. CH_4 emission.

In the questionnaire from MARCOGAZ also the length of the pipelines where the material is not specified can be given. The emission factors for these pipelines are estimated in Table 6. The emission factors here are not allocated to a certain type of material. They are representing 2,4% of the pipeline length.

Material	Average emission factor	95% UCL
Not specified	660 kg CH_4 / km	864 CH_4 / km

Table 6: Emission factors for pipeline in the category not specified

4.4.3. Emission factors for service lines and City Gate stations

Service lines are the pipelines which connects the households and the industry to the main distribution grid. In the MARCOGAZ method the Methane emissions of the service lines are calculated from either the number of customers or as a percentage from the total emission from the pipeline grid of the operator. In Table 7 the average emission factor from the datasets and the 95% UCL are given.

A similar approach is followed to calculate the emission factors from the City Gate stations. This emission factor is calculated from the number of City Gates. In Table 7 the average emission factor from the City Gate stations and the 95 UCL are given. It has to be emphasized that not all distribution grid operators do operate City Gate stations. In some cases, City Gate stations are operated by the national transmission companies.

Material	Average emission factor	95% Conf. Limit.
Service Lines	0,83 kg CH_4 / customer	1,52 CH_4 /customer
City Gates	198 kg CH_4 / City Gate	360 CH_4 / City Gate

Table 7: Emission factors for Service Lines and City Gate stations.

As explained previously, not all companies did deliver information from City Gate stations. Therefore, the datasets available for calculation was limited and caused a relative high standard deviation.

4.5. Activity factors EU28 distribution networks

To calculate emissions on a European level for distribution pipelines, Activity Factors on a European level are needed. In this report, Activity Factors are derived from different sources, but also from websites giving information about this issue. The three main sources used were the MARCOGAZ Statistics on the MARCOGAZ website, the available information from the Secretary of the International Gas Union Distribution Committee and the publications on the Eurogas website.

Country EU28	Distribution network length total (in km)	PE (km)	Steel (km)	Cast Iron (km)	PVC (km)	Other (km)	ref.	Connection points (#)	ref	City Gates (#)	ref
Austria	43.400	28.683	11.423	2	1.814	1.478	1	1.349.000	3		2
Belgium	71.609	52.561	16.971	430		1.647	1	3.156.000	1	190	2
Czech Republic	73.181	42.445	30.736	0	0	0	1	2.849.000	3	4.254	2
Denmark	18.229	15.677	2.552	0	0	0	1	421.117	2	502	2
Germany	498.500	254.235	218.343	11.964	13.958	0	1	20.979.000	3	49.119	report
Ireland	11.339	11.226	113	0	0	0	1	661.000	3	89	2
Italy	257.844	72.067	181.690	2.897		1.190	1	23.203.000	3	7.000	2
the Netherlands	125.000	21.250	18.750	3.750	78.750	2.500	1	7.152.000	3	1.009	2
Poland	170.900	68.360	102.540	0	0	0	1	6.852.000	3	751	2
Portugal	17.450	15.339	2.094	17	0	0	1	1.382.000	3	73	2
Slovakia	33.301	14.519	18.782	0	0	0	1	1.506.000	3	1.760	2
Spain	70.307	59.761	9.281	1.266	0	0	1	7.556.000	3		2
France	203.092	143.003	53.157	5.681		1.251	2	11.268.000	3	3.731	2
Finland	1.911	1.808	83	20		0	2	31.000	3	0	2
Slovenia(1)	4.342	2.229	1.700	108	235	70	2	136.000	3	68	2
UK	126.335	81.657	7.242	17.362		20.074	2	23.184.315	2	49	2
Greece	6.087	4.663	1.281	136		0	2	325.000	3	24	2
Romania	17.218	8.958	8.260	0		0	2	1.408.170	2		
Cyprus	0	0	0	0	0	0		0	3		
Latvia(1)	5.500	2.824	2.153	137	298	89	4	443.000	3		
Estonia (1)	2.150	1.104	842	54	116	35	5	52.000	3		
Lithuania(1)	8.300	4.261	3.249	207	449	134	6	562.000	3		
Croatia(1)	18.386	9.439	7.197	458	996	296	7	647.000	3		
Malta(1)	0	0	0	0	0	0		0	3		
Sweden(1)	2.720	1.396	1.065	68	147	44	8	37.000	3		
Bulgaria(1)	249	128	97	6	13	4	9	74.000	3		
Luxembourg(1)	1.962	1.007	768	49	106	32	10	86.000	3		
Hungary(1)	84.000	43.124	32.879	2.094	4.548	1.354	11	0	3		
Total	**1.873.312**	**961.723**	**733.246**	**46.706**	**101.431**	**30.198**		**115.319.602**		**68.619**	

(1) For all pipeline lengths were no material lengths were available the average distribution of the known data was assumed.

Table 8: Activity factors for EU28 DSOs

References	
1	Secretary of the International Gas Union Distribution Committee (available may 2017)
2	http://www.MARCOGAZ.org/index.php/statistics
3	http://www.eurogas.org/uploads/2016/flipbook/statistical-report-2015/mobile/index.html#p=10
4	http://www.kase.gov.lv/uploaded_files/Investor%20Presentation/Latvia-presentation_December_website.pdfhttp://www-pub.iaea.org/MTCD/publications/PDF/te_1541_web.pdf
5	https://www.mkm.ee/en/objectives-activities/energy-sector/gas-market
6	https://enmin.lrv.lt/en/sectoral-policy/natural-gas-sector
7	http://www.eesc.europa.eu/resources/docs/hupprezentacija1411.pdf
8	http://ei.se/Documents/Publikationer/rapporter_och_pm/Rapporter%202013/Ei_R2013_14.pdf
9	http://www.me.government.bg/files/useruploads/files/epsp/28.iii.2012.bg.sewrc.pdf
10	https://www.creos-net.lu/fileadmin/dokumente/downloads/rapport_annuels/pdf/gb_creos_facts_figures_2014.pdf
11	https://www.nve.no/Media/4864/3-c16-eqs-72-03_ceer-6thbr_ch5-7.pdf

Table 9: References DSO emission factors EU28

4.6. Methane Emissions for EU28 distribution networks

4.6.1. Emissions from distribution pipelines.

From the emission factors in §4.4.2 and the activity factors in §4.5 the total emission of the distribution grids of the EU28 are calculated. The calculations are performed for the average emission factors and their 95% UCL.

Pipeline material	Statistics	Emission factor	unit	activity EU28	unit	CH_4 emission ton
Cast Iron	Average	1.079	kg/km	46.736	km	50.428
Steel		150		733.716		110.079
PE		40		962.339		38.064
PVC		30		101.496		3.028
Not specified		660		30.217		19.956
DSO pipelines		121		1.874.505		221.555

Table 10: EU28 Methane emissions from DSO pipelines (average)

Pipeline material	Statistics	Emission factor	unit	activity EU28	unit	CH_4 emission ton
Cast Iron	95% conf	1.388	kg/km	46.736	km	64.870
Steel		252		733.716		184.574
PE		61		962.339		58.887
PVC		34		101.496		3.430
Not specified		864		30.217		26.097
DSO pipelines		184		1.874.505		337.857

Table 11: EU28 Methane emissions from DSO pipelines (95%UCL)

Figure 7 and Figure 8 gives the same information as given in Table 11 in a graphical representation

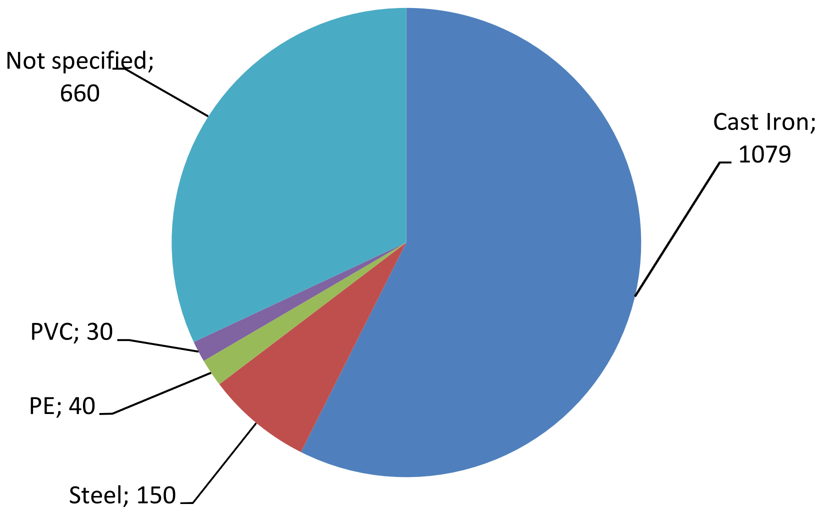

Figure 7: Average emission factors (in kg CH_4/ km) distribution pipelines per type of material.

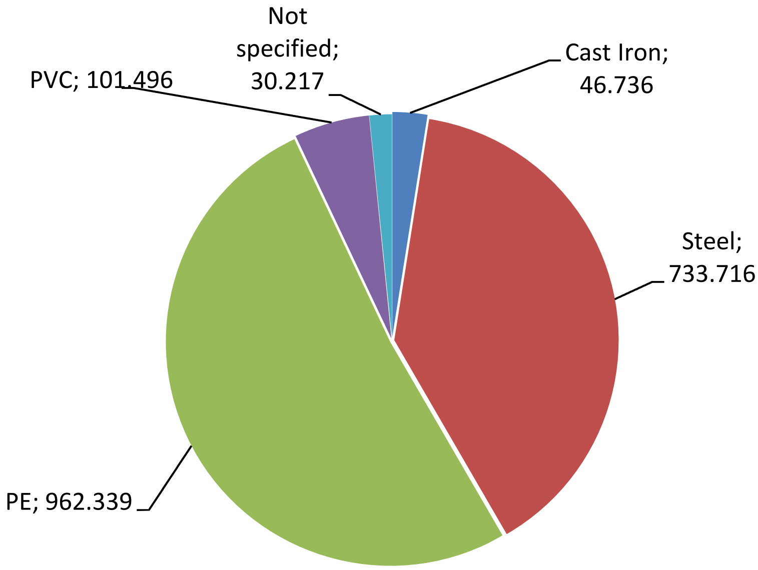

Figure 8: *Distribution pipeline length (in km) per type of material*

As a result of the relative large emission factors of cast iron and despite the relative small pipeline length (see Figure 8) the total emission of cast iron is approximately 24% of the total. In most countries distribution operators have a policy to replace grey cast iron networks by more modern materials with a better emission performance. Steel pipelines are responsible for about 48% of the CH_4 emissions from the distribution grid. Polyethylene covers approximately 1% of the total. Both steel and polyethylene cover respectively 39% and 5% of the length of the distribution network. When polyethylene covering 51% of the European network is only responsible for 17% of the methane emissions on the European distribution grid.

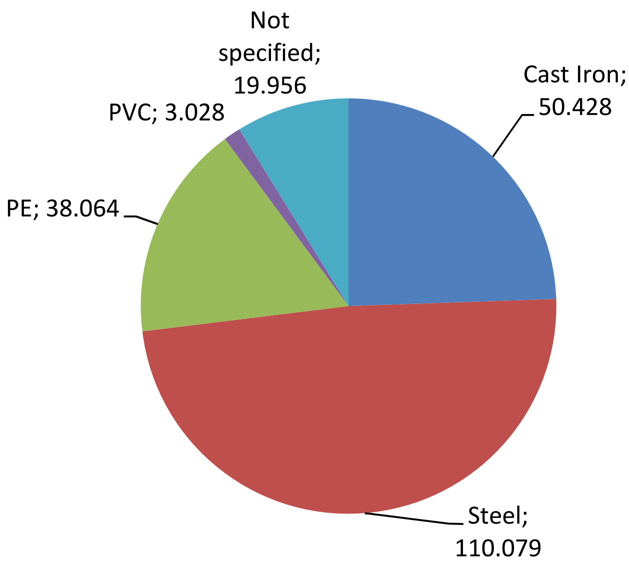

Figure 9: *Distribution pipelines CH4 emissions (in tons) EU28 per type of material.*

4.6.2. Emissions from service lines and City Gate stations.

The estimated average EU28 emission from service lines and City Gate stations are given in the following tables also the 95% upper control limits of these emission are given.

Description	Statistics	Emission factor	Unit	Activity EU28	Unit	Emission [ton]
DSO Service lines (SL)	Average	0,83	kg/SL	115.750.602	# SL	96.544
DSO City Gates (CG)	Average	178	kg/CG	87.150	# CG	15.538

Table 12: Average emission factors for service lines and City Gate stations.

Description	Statistics	Emission factor	Unit	Activity EU28	Unit	Emission [ton]
DSO Service lines (SL)	95% conf	1,52		115.750.602	# SL	175.371
DSO City Gates (CG)		384		87.150	# CG	33.481

Table 13: Average emission factors for service lines and City Gate stations.

As stated below if considering the average emission factors, the EU28 emissions from distribution grid is 338.648 tons of CH_4, which means that service line emissions are representing 28,5% of the total emission, this is consistent with the results of the declaring companies (27,9%)

4.6.3. EU28 emission totals from distribution grids

From the tables in §4.6.1 and §4.6.2 the total emission from the EU28 and there 95% upper control limits are calculated. The results of this is given in Table 14 and Table 15. In this the emissions relative to the gas sales in the EU28 (EU28 inland gas sales: EUROGAS Statistical report 2015) and relative to the total anthropogenic CO_2 equivalents in the EU28 (Proxy GHG emission estimates for 2015, EEA report No 23/2016, page 76) are derived.

Description	Statistics	Emission factor	Unit	Activity EU28	Unit	Emission [ton]	Relative to sales	Relative to anthropogenic Methane emissions	Relative to EU28 CO_2eq
DSO pipelines	average	121	kg/km	1.874.505	Km	226.566	0,07%	1,23%	0,128%
DSO Service lines (SL)		0,83	kg/SL	115.750.602	# SL	96.544	0,03%	0,52%	0,055%
DSO City Gates (CG)		178	kg/CG	87.150	# CG	15.538	0,00%	0,08%	0,009%
Overall DSO						**338.648**	**0,11%**	**1,83%**	**0,192%**

Table 14: EU28 CH_4 emission DSO grids (Average)

Description	Statistics	Emission factor	Unit	Activity EU28	Unit	Emission [ton]	Relative to sales	Relative to anthropogenic Methane emissions	Relative to EU28 CO_2eq
Total pipelines	95% conf	184	kg/km	1.874.505	km	344.452	0,11%	1,86%	0,19%
DSO Service lines (SL)		1,52	0	115.750.602	# SL	175.371	0,05%	0,95%	0,10%
DSO City Gates (CG)		384	0	87.150	# CG	33.481	0,01%	0,18%	0,02%
Overall DSO						**553.304**	**0,17%**	**2,99%**	**0,31%**

Table 15: EU28 CH_4 emission DSO grids (95% UCL)

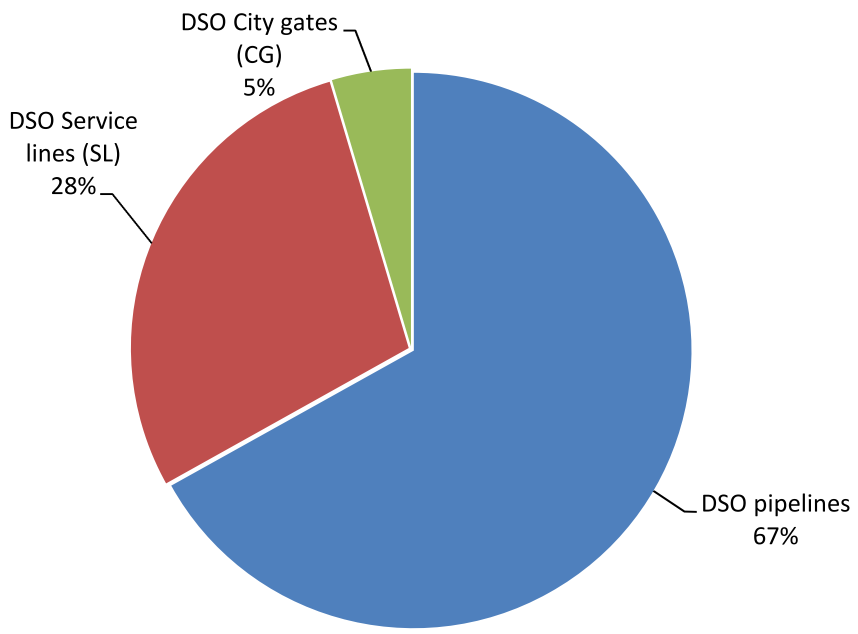

Figure 10: Distribution of CH_4 emissions depending on Activity factors in EU28

5. CONCLUSIONS

As a conclusion, a consistent dataset and complete dataset have been collected but low correlation between activity factors and emission factors was found. This is questioning the quality of the data and the way measurements are extrapolated locally. Considering this fact, the final results below are given, taking into account the emission factors issued from the average emissions but also from the UCLs (Upper Control Limit's), representing a maximization of the current CH_4 emissions on the EU28 distribution grids.

The distribution area has room for improvements. The ongoing research projects (GERG MEEM project) related to Methane fugitive emission estimations in distribution grid should enhance the situation for future reports. Some particular effort have to be made on the estimation of losses in the service lines regarding the importance of these data in the emission number. Nevertheless, this report is giving average and the UCL's of the CH_4 emission figures from EU28 distribution grid.

- ✓ The total estimated amount of Methane emissions from distribution grid is in the range of **339 – 553 kT Methane.**
- ✓ On that base, the methane emissions from distribution grids, expressed in CO_2 equivalent, are estimated to be in the range of **9.492 and 1.549 kT CO_2eq** [6]
- ✓ Considering these figures, the total distribution network losses [7][8] are in the range of **0,1% to 0,2%.** In this figure, the losses of the grid but also the losses from service lines and the City Gate stations are included.
- ✓ The maximal yearly Methane emission rate on the EU28 distribution network is:

Pipeline material	Maximal emission rate	Share of the EU28 grid
Cast iron	1.388 kg CH_4 / km	2,5 %
Steel	198 kg CH_4 / km	39 %
Polyethylene	61 kg CH_4 / km	51 %
P.V.C.	34 kg CH_4 / km	5 %
Service lines	1,52 kg CH_4 / customer	

[6] GWP: Global Warming Potential; GWP100 of CH4 (= 28) is used according to the Fifth Assessment Report (AR5) - IPCC.

[7] Compared to the total of natural gas sales in Europe - EU28 inland gas sales: EUROGAS Statistical report 2015.

[8] Please note that such a comparison is valid only at a European level, as, at a country level, not all the gas contained in the network at a moment in time will be sold in that particular country

- ✓ The total amount of GHG emissions caused by the Methane emissions from Natural Gas distribution grids is estimated to be **between 0,2% - 0,3%** of the total of anthropogenic[9] GHG emission in Europe (EU28)[10].

[9] Anthropogenic emissions: emissions originating in human activity

[10] Approximated European Union greenhouse gas inventory: Proxy GHG emission estimates for 2015, EEA report No 23/2016, page 76

6. BIBLIOGRAPHY

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7. APPENDIX

7.1. APPENDIX I: MARCOGAZ forms Methane emission

METHANE EMISSION Calculation for Distribution

Organisation			**Natural Gas Composition**		
Company:		Name	Average Methane Content of Natural Gas:	81,3	% (Vol.)
Emissions for the Year:			Density of Methane:	0,7175	kg/m³
Responsible Person:		Name	Conversion Factor from m³ Nat.gas to g CH4:	583,33	g CH4 / m³ Gas

Calculation

			Activity Factors		Emission Factors						Total Emissions		Source for own factor			
						Marcogaz Range*			Company		Nat.Gas	Methane				
No.	System Category	Pressure	Data	Unit		Minimum	Maximum		Data	Unit	m³/a	g/a	Measurement	Literature	Estimation	Remark (please specify, if possible)
1.	**Distribution Lines**															
1.1.	Grey cast iron with lead joint	Low		km	M			M		m3/km	0,0E+00	0,0E+00				
		Medium		km	M			L		m3/km	0,0E+00	0,0E+00				
		(1)		km						m3/km	0,0E+00	0,0E+00				
1.2.	Ductile cast iron	Low		km	L			L		m3/km	0,0E+00	0,0E+00				
		Medium		km	M			L		m3/km	0,0E+00	0,0E+00				
		(1)		km						m3/km	0,0E+00	0,0E+00				
1.3.	Steel	Low		km	L			L		m3/km	0,0E+00	0,0E+00				
		Medium		km	L			L		m3/km	0,0E+00	0,0E+00				
		(1)		km						m3/km	0,0E+00	0,0E+00				
1.4.	Steel with cathodic protection	Low		km	L			L		m3/km	0,0E+00	0,0E+00				
		Medium		km	L			L		m3/km	0,0E+00	0,0E+00				
		(1)		km						m3/km	0,0E+00	0,0E+00				
1.5.	Steel without cathodic protection	Low		km	L			M		m3/km	0,0E+00	0,0E+00				
		Medium		km	M			M		m3/km	0,0E+00	0,0E+00				
		(1)		km						m3/km	0,0E+00	0,0E+00				
1.6.	Plastic Polyethylene PE	Low		km	L			M		m3/km	0,0E+00	0,0E+00				
		Medium		km	M			L		m3/km	0,0E+00	0,0E+00				
		(1)		km						m3/km	0,0E+00	0,0E+00				
1.7.	Plastic PVC	Low		km						m3/km	0,0E+00	0,0E+00				
		Medium		km						m3/km	0,0E+00	0,0E+00				
		(1)		km						m3/km	0,0E+00	0,0E+00				
1.8.	Material in general not specified	Low		km	M			M		m3/km	0,0E+00	0,0E+00				
		Medium		km	M			L		m3/km	0,0E+00	0,0E+00				
		(1)		km						m3/km	0,0E+00	0,0E+00				
1.9	Total of Distribution Lines (1.1-1.8)										0,0E+00	0,0E+00				
2.	**Service Lines (2)**															
2.1.	No. Of Customers			No.	M			M		m³/No./a	0,0E+00	0,0E+00				
2.2.	Percentage of Total of Distribution Lines		0,0E+00	m³/a	L			L		%	0,0E+00	0,0E+00				
2.3.	Total Emissions Service Lines										0,0E+00	0,0E+00				
3.	**City Gate and Customer Supply Stations for Metering and Regulating**															
	Number of Stations			No	M			M		m³/No/a	0,0E+00	0,0E+00				
4.	**Other (please specify)**															
											0,0E+00	0,0E+00				
5.	**Total Emissions**									Nat. Gas	0,0E+00	0,0E+00	Methane			
										Mio. m³	0,0	0	t/a			

7.2. APPENDIX II: MARCOGAZ members

7.1. APPENDIX III: EU28

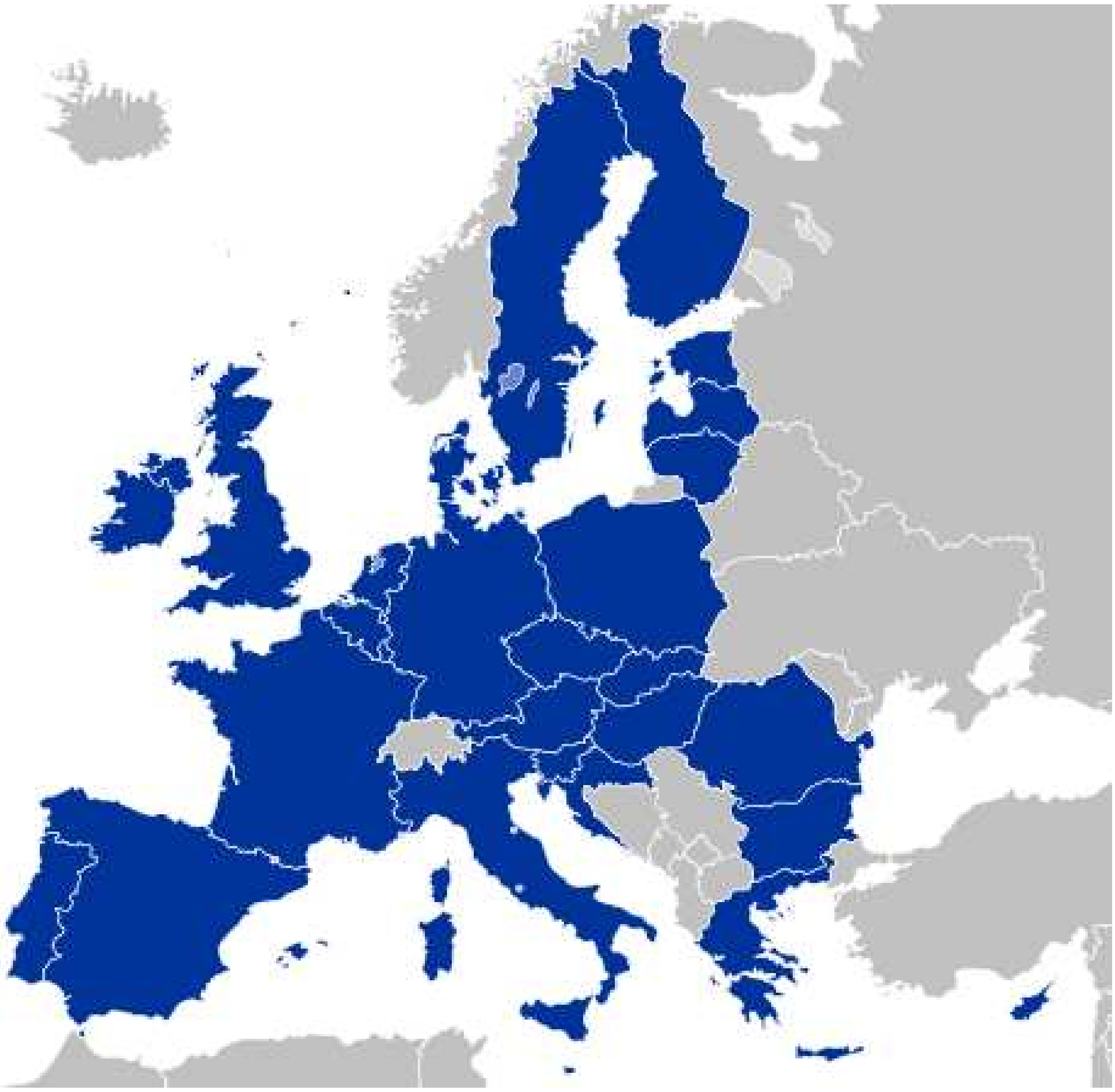

Figure 11: EU28

